This is to certify that the

dissertation entitled

College Students' Perceptions of Interpersonal Relationships Related to the Development of Their Interest in Science

presented by

Li-hsuan Yang

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Educational Psychology

Douglas R. Campbell
Major professor

Date November 13, 1999

COL

COLLEGE STUDENTS' PERCEPTIONS OF INTERPERSONAL RELATIONSHIPS RELATED TO THE DEVELOPMENT OF THEIR INTEREST IN SCIENCE

By

Li-hsuan Yang

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Counseling, Educational Psychology
and Special Education

1999

ABSTRACT

COLLEGE STUDENTS' PERCEPTIONS OF INTERPERSONAL RELATIONSHIPS RELATED TO THE DEVELOPMENT OF THEIR INTEREST IN SCIENCE

By

Li-hsuan Yang

This study investigated the origin and development of student interest in science with the focus on students' perceptions of interpersonal relationships related to their development of interest in science. The following research questions were examined: (1) What do college students mean when they say they are interested in science or uninterested in science? (2) Do college students who are interested in science attribute their interest to interest-raising interactions with influential figures who were also interested in science and with whom they had a good relationship? (3) Do college students who are uninterested in science perceive a lack of interest-raising interactions with influential figures who were interested in science and with whom they had a good relationship? (4) What perceived characteristics are associated with relationships that facilitated the development of their interest in science? What perceived characteristics are associated with relationships that hindered the development of their interest in science?

Twenty-four college students were interviewed. The findings indicate that interest in science is a rich and complicated entity. Most students had different levels of interest in different areas of science. All participants in the interested group reported interest-raising experiences with an influential figure(s). Nine out of the twelve students mentioned influential figures who were interested in science and/or practiced in a science-related field, and with whom the student had a good relationship. Seven students in the uninterested group also mentioned interest-raising relationships similar to those mentioned by the students in the interested group. One student in the interested group

and thr

with in

influen

influen

influen

did scie

existed

Interest

and three students in the uninterested group mentioned interest-lowering relationships with influential figures.

Four qualities were 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 s/he did science with the student. (4) Between the influential figure and the student there existed a personal relationship which was characterized by caring, sharing, and launching. Interest-lowering relationships were characterized as lacking these qualities.

To my

guidanc

and sug

researc

To my

through

To my

researc

what it

To my

me to t

To my

Ph.D.

To my

achiev

hearte

To my

highe

ACKNOWLEDGMENTS

To my dissertation director, Dr. Douglas Campbell, for your caring attitude, skillful guidance, and unconditional support. Your thoughtful and thought-provoking insights and suggestions on every single draft were invaluable for my development as a researcher.

To my chair, Dr. Stephen Yelon, for your wise advice and step-by-step guidance throughout every phase of my dissertation research.

To my committee member, Dr. Jere Brophy, for opening my eyes to the world of research on motivation, and helping me develop an understanding and appreciation of what it means to be a researcher.

To my committee member, Dr. Don Hamachek, for your questioning, which challenged me to think further and deeper on various issues related to my dissertation.

To my former advisor, Dr. David Wong, for your guidance at the earlier stage of my Ph.D. program.

To my husband, Tzyh-chyang Cherng, for listening to my struggles patiently, sharing my achievement proudly, providing me with support unconditionally, and loving me whole-heartedly.

To my parents, for being a strong motivating force in my life-long journey of reaching higher goals.

To m

stron

To th

well

Dr. C

Dr. F

Dr. R

Dr. E

To m

Franc

Hyeso

Li-we

throug

writin

To my

suppor

To all

sharing

the ins

To my parents-in-law and other family members, for your encouragement, support, and strong faith in my ability.

To the professors whose caring attitudes and powerful ideas have shaped my personal as well as intellectual growth: Dr. Charles (Andy) Anderson, Dr. Betsy Becker, Dr. Christopher Clark, Dr. Barbara Davis, Dr. James Gallagher, Dr. James Gavelek, Dr. Frederick Lopez, Dr. John McKinney, Dr. Evelyn Oka, Dr. Penelope Peterson, Dr. Richard Prawat, Dr. Stephen Raudenbush, Dr. Kathy Roth, Dr. Deborah Smith, Dr. Edward Smith, Dr. John (Jack) Smith, Dr. Paul Stemmer, and Dr. Cho-yee To.

To my friends, Phone-mei Chou, Zongyi Deng, Marcia Fetters, Shwu-yu Huang, Francisca Kidder, Ailing Kong, Inkyung Lee, Ming-cheng Lo, Nicol Liu, Ai-hsuan Ma, Hyesook Park, Deborah Sleight, Pei-fen Sung, Paul Vellom, Jian Wang, and Li-wei Wang, for the heart-warming and intellectually stimulating conversations throughout the various phases of planning and conducting the research as well as the writing of my dissertation.

To my many friends, whose names are not mentioned here, for your encouragement, support, and prayers.

To all the participants in the study who told me their stories. Without the generous sharing of your ideas and experiences, it would have been impossible for me to develop the insights discussed in this dissertation.

To my friend, Eunice Loeweke, whose painstaking proof-reading of the multiple drafts supported me to develop and clarify my ideas in this dissertation as well as to express them in a way that makes sense to others.

To my family's very special friend, Hui-ying Tang, whose encouragement of my academic effort from childhood to graduate school years provided the fertile ground for all the intellectual fruit I shall bear.

Thank you!

TABLE OF CONTENTS

LIST OF TABLES

educ

prom

abou

interp

in sci

incluc

constr

relatio

relatio

anothe

develo

percep

(e.g., a

of the

nature,

factors

intervi

CHAPTER 1

INTRODUCTION

Striving to understand what motivates people to learn is an enduring challenge in educational psychology. Interest has long been recognized as a powerful motivator to promote learning (for review, see Hidi, 1990). This study seeks to forward understanding about the origin and development of student interest in the particular domain of science.

The focus of this study was to examine how college students perceived interpersonal relationships related to the development of their interest in science. Interest in science refers to a relatively stable and enduring preference for learning science, which includes learning the canon of knowledge and also learning the process of participation to construct scientific knowledge both in and outside of school. The aspect of interpersonal relationships that was addressed in this study was an individual's perception of his/her relationship with another person. An individual's perception of his/her relationship with another person was hypothesized to mediate the extent to which the individual would develop an interest similar to that other person's interest. Therefore, an individual's perception of his/her relationship with someone who bears a certain relation to science (e.g., a science teacher, a scientist parent) was hypothesized to mediate the development of the individual's interest in science.

Twenty-four college students were interviewed to examine how they described the nature, origin, and development of their interest or lack of interest in science, and what factors they attributed their interest or lack of interest to. Patterns were sought across the interviewees' responses in relation to the focus of this study.

Statement of the Problem

One objective shared among science educators and classroom teachers is to help students become interested in science. Yet it is clear that many students are not interested in science (Harms & Yager, 1981; Hueftle, Rakow & Welch, 1983; Mullis & Jenkins, 1988; Simpson & Oliver, 1985) and there is a need to increase their interest. The need is strong and urgent for two reasons. First, the future of our people, our nation, and our world depends largely on the wisdom with which humans use science and technology (Rutherford & Ahlgren, 1989). I believe that this wisdom will only come as a result of students learning science well. Empirical evidence suggests that high student interest in a domain enhances the quality of their learning in that domain (e.g. Asher, 1979, 1980; Asher, Hymel & Wigfield, 1978; Asher & Markell, 1974; Estes & Vaughan, 1973; Fransson, 1977; Hidi, 1990; Prenzel, 1988; Renninger, 1988; Schiefele & Krapp, 1988). Therefore, fostering student interest in science carries the potential to enhance the quality of science learning by the student. Second, how much students can learn in classrooms is always limited due to practical constraints. By developing student interest in science, we can increase the likelihood that the student will continue to learn science outside the classroom.

In order to foster student interest in science, we need to understand how people's interest in science starts and develops. However, little is known about this topic. Although several factors have been identified to facilitate situational interest in various contexts, few studies have explored factors related to the development of long-term domain-specific interest. Deci's self-determination theory offers a potentially fruitful framework for examining this issue (Deci, 1992). In self-determination theory, interest is closely linked to intrinsic motivation, but can become associated with extrinsically motivated activities to the extent that their regulation has been integrated with one's intrinsic self (Deci & Ryan, 1991). Integration occurs as a result of internalization, the

process through which external regulation is actively transformed into internal regulation. In other words, interest is a person's dispositional preference toward a particular domain of activities either for an intrinsic reason (i.e., enjoying the activity itself) or for a self-determined instrumental reason (i.e., the activity leads to something the person truly values, rather than being coerced to value). Self-determination theory hypothesizes that three psychological needs are intrinsic to the self --- the needs for competence, autonomy, and relatedness. It is hypothesized that social contexts that allow the satisfaction of these three basic needs will promote intrinsic motivation, internalization, and interest. Numerous studies have shown that competence-promoting information enhances interest, whereas competence-diminishing information undermines interest (e.g., Boggiano & Ruble, 1979; Deci, 1971; Deci & Cascio, 1972; Harackiewicz, 1979; Harackiexicz, Abrahams, & Wageman, 1987; Ryan, 1982; Sansone, 1986, 1989; Vallerand & Reid, 1984). Empirical work has also shown that autonomy-supportive contexts tend to enhance interest, whereas controlling contexts tend to diminish interest (e.g., Amabile, DeJong, & Lepper, 1976; Deci & Cascio, 1972; Deci, Driver, Hotchkiss, & Robbins, 1993; Deci & Ryan, 1985; Deci, Schwartz, Sheinman, & Ryan, 1981; Zuckerman, Porac, Lathin, Smith, & Deci, 1978; Koestner, Ryan, Bernieri, & Holt, 1984). However, little has been done to understand the relationship between "relatedness" and the development of domain-specific interest. The current investigation was undertaken to provide such information.

Purpose of the Study

This study had three purposes: (1) to understand the nature of college students' interest in science, (2) to explore whether college students perceived their interpersonal relationships affected their development of interest in science, and (3) to investigate what

qualities of perceived interpersonal relationships had what effects in the development of student interest in science.

Research Questions

To accomplish the above-mentioned purposes, the following research questions were posed to guide the collection of data for this study:

1. What do college students mean when they say they are interested in science or uninterested in science? (Four areas of interest in science were explored: (1) interest in learning more about the canon of science knowledge in school, (2) interest in learning more about the canon of science knowledge outside of school, (3) interest in figuring out scientific knowledge in school, (4) interest in figuring out scientific knowledge outside of school.)
2. Do college students who are interested in science attribute their interest to interest-raising interactions with influential figures who were also interested in science and with whom they had a good relationship?
3. Do college students who are uninterested in science perceive a lack of interest-raising interactions with influential figures who were interested in science and with whom they had a good relationship?
4. What perceived characteristics are associated with relationships that facilitated the development of their interest in science? What perceived characteristics are associated with relationships that hindered the development of their interest in science?

Methodological Limitations

This study involved interview processes based on perceptions and self-reported retrospective data. I recognize two limitations of the method. First, the participants'

memories might not have been completely accurate. Second, while hearing the interview questions the participants might have attempted to guess what the researcher wanted and constructed their responses to please the researcher.

The first limitation reminds us that a participant's perception of another person and their relationship might not reflect the objective truth about that person or how they actually interacted. The interview data can better tell us how the participant makes sense of his/her relationship with another person and how s/he sees it influence his/her development of interest in science, than it can tell us the objective truth about what the other person actually did to the participant or what actually happened between the two. Yet I believe the former is important to understand, because whether or how a certain relationship affects an individual's development of interest in science ultimately depends on how this individual makes sense of that relationship and comes to shape his/her interest in science in the context of this relationship.

The second limitation can never be completely eliminated. Yet two steps were taken to address the limitation. First, the interview questions were arranged in an order so the broader questions were asked before the more specific questions. This was done to make it harder for the participant to "guess what the researcher wanted." Second, before each interview, the participant was informed that there were no "correct answers" to the interview questions, there was not a certain kind of response that the researcher was looking for, his/her performance in the interview would not be "evaluated," and s/he should be free to say whatever s/he felt honest to say.

Based on the reasons discussed above, I believe that the method used in the study was a legitimate approach to further our understanding about how college students perceive interpersonal relationships related to their development of interest in science. The goal of this study was to explore the potentially existing patterns in the development of student interest in science as affected by perceived interpersonal relationships, and to

generate directions for future investigation. Slight inaccuracy of memory should not hinder the pursuit of this goal. Even though the interview questions might have led the participants to talk about certain aspects of their experiences more than other aspects, this does not necessarily mean that they would be untruthful. Even though the participants might have tried to please the researcher, their responses were more likely based on some concrete experiences.

A further limitation of the study lies in the method by which the study group was recruited. The participants were 24 college students taking certain psychology courses. The participants were not randomly selected from a certain population. The study reflected the experiences and perceptions of the students who chose to participate. Students who chose not to participate might have had different experiences and perceptions regarding their development of interest in science. Although I believe the participants have captured a certain degree of diversity in the college population at Michigan State University, the results of the study can not be generalized to a larger population. Nevertheless, the study can be "generalized to a theory" through analytic generalization (Firestone, 1993). According to Firestone, "to generalize to a theory is to provide evidence that supports (but does not definitively prove) that theory." Through analytic 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.

CHAPTER 2

REVIEW OF LITERATURE

This chapter contains a review of literature pertinent to the topic under investigation, and my own thinking in relation to the existing literature is woven into the discussion. These two components together provide a conceptual background that has motivated and helped to frame the current study. In the following sections, I will first describe how the conceptualization of science and the conceptualization of interest in this study were constructed based on the literature and on my observations of related phenomena. Then I will discuss how existing research suggests that it is critical to investigate the role of interpersonal relationships in mediating the development of student interest in science, and how interpersonal relationships were conceptualized in this study.

Conceptualization of Science

Anderson described learning science as involving mastery of both *a canon of knowledge* and *norms for participation* (Anderson, 1992). The canon consists of the collected works of present and past members of the scientific community. The shared norms for participation form the basis to allow a community of people to work together to build the canon of knowledge. 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.

Mastering the canon of knowledge in science involves what is commonly called "science content knowledge learning." Examples of content knowledge learning include understanding the basic structure of a cell, the principle of floating and sinking, the process of a chemical reaction, and so forth. Mastering ways that scientists use to

generate knowledge involves what Lemke describes as "talking science," which means "observing, describing, comparing, classifying, analyzing, discussing, hypothesizing, theorizing, questioning, challenging, arguing, designing experiments, following procedures, judging, evaluating, deciding, concluding, generalizing, reporting, writing, lecturing, and teaching in and through the language of science" (Lemke, 1990). Scholars have argued that the essence of all these scientific activities is "coordinating theories and evidence" (Kuhn, 1989; Carey & Smith, 1993).

Since learning science contains the two components described above (i.e., mastering the canon of knowledge and the norms for participation), there is no guarantee that one would always be equally interested (or uninterested) in both of them. Some students might be interested in knowing and understanding science "facts" and "concepts" without being interested in participating in the process of "figuring out" the knowledge. These students might seek to read science books, and be eager to tell others about the knowledge they acquired from reading books, while at the same time they might rarely ask a question or try an experiment to find out the answer to their question. Some other students, while being less interested in science book reading, might be indeed very interested in trying out experiments to figure out answers to their own questions. Therefore, this study included the distinction in its design that some students might be interested in one aspect of science but not in the other.

Another distinction that was made in the study was the distinction between science in school and science outside of school. Some students might not be very attentive during their science lessons in school. However, they would go to a library and seek to read science books for their own interest. I myself was not enthused about the high school science experiments we had to conduct in our lab, but I was very curious about things around the house and often designed experiments to figure out answers to my own questions.

Based on the distinctions discussed above, four aspects of student interest in science were addressed in this study: (1) interest in learning more about the canon of science knowledge in school (e.g., listening to science lectures, reading science textbooks, etc.), (2) interest in learning more about the canon of science knowledge outside of school (e.g., seeking to read science books or magazines, watching TV programs about cancers, polymers, outer space, animals and plants, etc.), (3) interest in figuring out scientific knowledge in school (e.g., doing experiments in school to figure out answers to some questions, participating in classroom discussions about science topics, etc.), (4) interest in figuring 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 device such as 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, etc.).

Let me explain a little more why I chose to make the above described distinctions in this study. I see the importance of learning science not only lies in preparing future scientists, but also in preparing future citizens and enriching the life of current citizens so they can generate and use scientific knowledge in wise ways when they participate in a democratic society. In order to reach this goal, science needs to be learned not only as sets of facts to be understood and remembered, but also as processes of inquiry for generating new knowledge, not as something that we are required to learn in school and often find no use for it in our life, but as something we want to take an initiative to learn more about in meaningful ways outside of school. While holding this belief in mind, I am aware that this belief might not be shared by many students, because most students acquire their image of science from their experiences of school science and school science, as practiced in many classrooms, tends to focus merely on content knowledge learning. Some students might be doing science outside of school (e.g., pursuing their

curiosity by reading or trying things out) without calling it science. Therefore, making these distinctions explicit in my study was meant to help reveal information about student interest in science which addresses the four areas of science, and to avoid the possibility that the participants might not automatically address all four areas because they are likely to use the word "science" in a narrower way.

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 has concentrated more on the characteristics of learning activities that capture the interest of many individuals (*situational interest*); the other body of research has emphasized variations in *individual interest* (people's relatively enduring preference for certain topics or activities) (for review, see Hidi, 1990). For the purpose of this study, I chose the development of individual interest in science as my central focus, because individual interest in science is what we want to foster in our students for their life-long science learning. However, while conducting the study, I didn't exclude the possibility that one's experiences of situational interest might contribute to the development of long-term individual interest. In fact, this possibility was explored in the interviews.

What is individual interest? When we say someone is interested in something, quite often we mean that he likes to pursue it and he enjoys it. One example would be someone being interested in playing the piano. This person is likely to spend his free hours playing the piano and enjoying the activity for its own sake. Individual interest in this example is what psychologists have called intrinsic motivation, the motivation to do certain things in the absence of any operationally separable reinforcement (i.e., in the absence of an extrinsic reward) (e.g., Lepper & Hodell, 1989; Csikszentmihalyi, 1990; Deci, 1992). But do we always enjoy the activities we are interested in for its own sake?

Probably not. One example here would be someone who is interested in studying the stock market. This person is likely to find time to study the stock market, but he is not doing it purely for the sake of studying. He is trying to earn money through it. Individual interest in this example is not intrinsic motivation, because the activity the person chooses to engage in is instrumental. However, it does lead to something that is of value to the person.

Deci's self-determination theory discusses the relation between interest, intrinsic motivation, and value in details (Deci, 1992). From the self-determination theory perspective, interest is closely linked to intrinsic motivation, but can become associated with extrinsically motivated activities to the extent that their regulation has been integrated with one's intrinsic self (Deci & Ryan, 1991). Integration occurs as a result of internalization, the process through which external regulation is actively transformed into internal regulation (Ryan & Connell, 1989; Ryan, Connell, & Deci, 1985). In other words, individual interest is a person's dispositional preference toward a particular domain of activities either for an intrinsic reason (i.e., enjoying the activity itself) or for a self-determined instrumental reason (i.e., the activity leads to something the person truly values, rather than being coerced to value).

This definition is highly related to the concept of continuing motivation discussed by Maehr. Maehr (1984) describes five behavioral patterns that can be used as indices of motivation related to learning. One of the five is "continuing motivation," which refers to "the return to a previously encountered task or task area on one's own, without apparent external constraint to do so." I think that Maehr's construct "continuing motivation" has captured the essence of what I call "interest." Both are related to the hypothetical psychological construct that motivates spontaneous return to tasks in a particular domain. However, Maehr emphasized the *behavior* of "returning to the previously encountered task area" as an index for "continuing motivation." While

agreeing with Maehr that the behavioral index serves well operationally, I also think that interest may exist without observable behavior. For example, one student might want to learn more science if he has the opportunity to do so. However, the school he attends does not allow electives, and his family responsibilities do not allow him to do science outside of school. For this student, we would not be able to assess his "continuing motivation" based on any behavior index, but we can assess his "interest" by interviewing him. Therefore, in this study, I have attempted to address interest in science by attending to both self-reported behavior and intention.

The above-described conceptualization of individual interest is consistent with what we see in related empirical studies. Most empirical studies which measured individual interest measured one or more of the following three components: (1) a positive affect toward certain topics or kinds of activities (e.g., liking, enjoying), (2) a positive value toward certain topics or kinds of activities (e.g., importance, significance), and (3) a preference or tendency to pursue certain topics or kinds of activities (e.g., wanting to find out more, voluntarily participating) (for review, see Schiefele, Krapp, & Winteler, 1992).

Putting together Deci and Maehr's theoretical thinking, the related empirical studies, and my own reflection on the way the word interest is used in our daily life, I believe that it was reasonable to assume that it was likely that the phrase "being interested" would be understood and be used by the participants to refer to the preference of pursuing certain topics or activities either for enjoying them or for leading to something else which was of true value to them. However, it is important to remember that an interview is a conversation between two people. It is a process through which two people are constantly trying to understand each other. The conceptualization of individual interest laid out here was the assumption that I brought into the study mostly implicitly. In other words, I assumed that the participants in the study more or less

shared my understanding of the meaning of interest when they heard me use the word interest and when they talked about their interest. Yet I also have to recognize that the participants in the study might not have shared my conceptualization of interest. Therefore, it was important that I make my assumption explicit here, so that we are aware of the assumption, and at the same time, try to keep our eyes open for evidence that either supports or disconfirms the assumption I held.

Rationale for This Study

Now that we have discussed what individual interest is, let me say a word about why the development of individual interest is important. Individual interest has been shown to result in higher attention, recognition, and recall in three-year olds (Renninger, 1987; Rinninger & Wozniak, 1985), better reading retention and inferencing in fourth graders (Estes & Vaughan, 1973), better mathematical problem solving in fifth and sixth graders (Renninger, 1988), higher reading comprehension in fifth and sixth graders and college students (Asher, 1979, 1980; Asher, Hymel & Wigfield, 1978; Asher & Markell, 1974; Fransson, 1977), and a higher degree of cognitive organization in college students' knowledge structures (Schiefele & Krapp, 1988). In summary, empirical evidence suggests that individual interest facilitates learning in various domains.

How is individual interest developed in a particular domain? Based on the conceptualization of individual interest as containing the component of intrinsic motivation and/or the component of integrated value, I will first review relevant literature on intrinsic motivation. The review will reveal a critical issue that has not been addressed well by research on intrinsic motivation. This, then, will lead to the discussion of integrated value and the relation between individual interest and interpersonal relationships.

Intrinsic motivation is discussed and studied most often in the cognitive/rationalist research tradition. In this tradition, children are seen as naturally motivated to learn when their experience is inconsistent with their current understanding or when they experience regularities in information that are not yet represented by their schemata (Greeno, Collins & Resnick, 1996). Therefore, motivating students to learn involves figuring out ways to present inconsistencies to foster students' natural tendencies to learn and understand. Yet we know that this view has not successfully explained the individual difference of interest in science based on our experience with conceptual change teaching. Conceptual change teaching in science education was developed based on the above mentioned assumption (Posner, Strike, Hewson, & Gertzog, 1982; Strike & Posner, 1992). In a lesson designed with a conceptual change model, groups of students are presented with a set of scientific phenomena and asked to talk about their ideas about those phenomena. The inconsistencies between their ideas and the observations are made salient. Then the students are asked to test out their ideas by making more observations and/or conducting more experiments. Through the whole process of discussing, observing and experimenting, the educators help the students to coordinate their ideas and the evidence they have gathered and to modify their ideas. Research indicates that conceptual change teaching has achieved some success but has not helped all students (e.g., Smith, 1990).

My personal experience with conceptual change teaching is consistent with this research finding. The typical pattern I see in a conceptual change classroom is that there are always some students who are actively engaged in this learning activity. They might not always have the right ideas, but they are "into the game." At the same time, there are always some students who are simply "not into the game." They do not seem to care whether a particular idea is consistent with the observation or not. This pattern suggests that the assumption commonly held by the cognitive/rationalist view about intrinsic motivation does not hold for all students all the time.

If I examine my own beliefs about various topics carefully, I can find that I hold many ideas that are mutually contradictory. I often do not examine my own beliefs seriously and try to figure out why I believe them and which belief among the mutually contradictory ones might be more accurate. I believe many others, if not all, also hold contradictory ideas in their mind. They might sometimes choose to strive for a deeper understanding of some of their ideas, but they leave many other contradictory ideas untouched.

Based on research findings and my personal observations described above, it seems that when someone has chosen to focus his attention on a topic, a cognitive disequilibrium in that topic becomes a motivator to push him to strive for a deeper understanding. However, a cognitive disequilibrium would not function in this way when that person does not choose to focus his attention on that topic. In other words, cognitive disequilibrium per se is not enough to explain the ultimate origin of intrinsic motivation. Its explanatory power is particularly weak when we consider domain-specific interest, because it does not explain how one chooses the domain he wants to focus on. As Brophy (1998) pointed out,

> We know a lot about motivation in achievement situations in which one is striving to accomplish clear goals and one's relative success or failure in doing so is assessed with reference to standards of excellence. However, we know much less about motivation in exploratory learning or appreciation development situations that do not involve seeking to achieve explicitly delineated goals...We also know that preexisting interest in a topic can lead to deeper processing and better retention of new information about the topic, although we know much less about how to induce and nurture such interest if it is not already present.

Most of the recent empirical work on the development of individual interests deals with young children in play situations (e.g., Krapp & Fink, 1986; Renninger, 1989, 1990; Renninger & Wozniak, 1985). It has been found that young children have relatively strong, stable, and focused interests that vary widely among individuals. However, we do not know whether these early individual interests lead to long-term

domain-specific interest, nor do we know how to encourage them. Csikszentmihalyi (1988) raised questions in regard to why a person becomes interested in information in a particular domain and in regard to how strong interest originates. He suggested that perhaps precocious interest in some aspect of the environment might be based on a peculiar sensitivity to those stimuli, a sensitivity that is either inborn or developed early as a result of interaction with others who are also interested in the same range of phenomena. Csikszentmihalyi's idea about "interaction with others" is consistent with Vygotsky's theory of human development and learning. In Vygotsky's discussion of internalization of higher psychological functions, he stated that

> every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (interpsychological), and then inside the child (intrapsychological). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. (Vygotsky, 1978).

Science certainly has its cultural value, and being interested in science certainly involves paying attention to science and forming concepts about science. Bandura's social cognitive theory also states that virtually all learning phenomena, resulting from direct experience, can occur vicariously by observing other people's behavior and its consequences for them (Bandura, 1986). Therefore, it might be possible that the child could observe how others do science and experience excitement in science and hence learn to like science. In other words, Csikszentmihalyi, Vygotsky, and Bandura all seem to suggest that it is reasonable to hypothesize that through interaction with others who are interested in science, the child might internalize that interest and make it his own.

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

Deci's self-determination theory carries the potential to help us further understand 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 & Powelson, 1991; Ryan & Stiller, 1991). Since we form different relationships with different people, it is possible that the quality of these relationships mediate the extent to which we develop 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., Boggiano & Ruble, 1979; Deci, 1971; Harackiewicz, 1979; Ryan, 1982; Deci & Cascio, 1972; Vallerand& Reid, 1984; 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., Amabile, DeJong, & Lepper, 1976; Deci & Cascio, 1972; Deci, Driver, Hotchkiss, & Robbins, 1993; Deci & Ryan, 1985; Deci, Schwartz, Sheinman, & Ryan, 1981; Zuckerman, Porac, Lathin, Smith, & Deci, 1978; Koestner, Ryan, Bernieri, & Holt, 1984). Some other studies (e.g., Avery & Ryan, 1988; Birch & Ladd, 1997; Roeser, Midgley, Urdan, 1996; Ryan, Stiller, & Lynch, 1994; Wentzel, 1997) have explored how various qualities of relatedness experienced with respect to parents, teachers, and/or friends by students were associated with their school-related functioning and affect. However, these studies mainly assessed general school-related constructs (e.g., school adjustment, perceived control over academic outcome, perceived competence, self-esteem, academic effort, school-related affect, etc.). Little research has directly addressed the relationship between "relatedness" and the development of domain-specific interest (with the exception of Midgley,

Feldlaufer, & Eccles, 1989). Empirical effort is needed to clarify the role of "relatedness" in mediating the development of domain-specific interest. This study is an empirical effort which contributes to this issue.

Conceptualization of Interpersonal Relationships

Most research on personal relationships is directed at one of three levels of analysis: individual, dyadic and systemic (Sarason, Sarason, and Pierce, 1995). At an individual level of analysis, a personal relationship can be defined in terms of a participant's perception of his/her relationship with another person. At a dyadic level of analysis, relationships are conceptualized primarily in terms of the social bond shared by both 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. I view the three levels 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/her interest in the context of that relationship (Maehr, 1991).

Taking an individual level of analysis, I was primarily interested in the way a participant perceived his or her relationship with the other person. The conceptualization of this perception of interpersonal relationship was mainly developed from Bowlby's attachment theory (1973; 1980) and Baldwin's idea of relational schemas (1992). In Bowlby's attachment theory and Baldwin's idea of relational schemas, it is assumed that people actively organize and internalize their interactions with significant others. The mental representations of the organized and internalized interactions with the significant others become the individual's perceived relationships with the significant others. The

formed relationships shape the individual's sense of self and the individual's experience of subsequent interactions with the same significant others as well as with other people. It was assumed 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. I assumed that students form relational schemas with these people. Since relational schemas can shape one's sense of self (possibly including how one sees himself/herself in relation to science) and subsequent interactions with other people (possibly including other people in science), it is worth examining whether the student's relational schemas affected his/her development of interest in science, and if they did, how.

In attachment theory, Bowlby proposed that on the basis of regular interaction with its attachment figure(s), the infant develops a mental representation of this (these) relationship(s). Bowlby (1973, 1980) termed these mental representations "internal working models." Once formed, the internal working models shape not only the person's subsequent orientations to human relationships but also the person's cognitive development. This theory has recently been extended to the study of adult relationships and development (e.g., Lopez, 1995). Numerous empirical studies have shown evidence consistent with the notion that early attachment qualities are related to the individual's social-emotional development (for review, see Grossmann & Grossmann, 1993) and cognitive development (for review, see de Ruiter & van Ijzendoorn, 1993; Moss, Parent, Gosselin, & Dumont, 1993), e.g., qualities of romantic relationships (Hazan & Shaver, 1987), exploratory competence (e.g., Tracy, Farish, & Bretherton, 1980; Hazen & Durett, 1982), and persistence in problem solving tasks (e.g., Matas, Arend & Sroufe, 1978; Frankel & Bates, 1990), etc. However, the exact mechanisms for the attachment quality to influence the person's subsequent development is not yet clear.

I found Baldwin's idea of relational schemas (Baldwin, 1992) promising in regard to helping us further understand how people's interpersonal relationships influence their subsequent social-emotional and/or cognitive development. Similar to attachment theory, Baldwin's conceptualization of interpersonal relationships assumes that people develop working models of their relationships that function as cognitive maps to help them navigate their social world. 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.* Ogilvie and Ashmore's definition of the "self-with-other" construct (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 when that other person is with this individual. It seems reasonable to hypothesize that through interactions with another person who bears a certain relationship with science, a student would develop a relational understanding of himself/herself and that other person. Since this understanding includes specified personal qualities that the individual believes characterizes his or her self, it might affect the student's development of his/her sense of self in relation to science, likely including his interest in science.

Building on the ideas discussed above, a conceptualization of science as including learning about the canon of science knowledge and the process of constructing scientific knowledge both in and outside of school, and a conceptualization of interest as a person's dispositional preference toward a particular domain of activities either for an intrinsic

reason or for a self-determined instrumental reason were used to form the design of this interview study, which sought to forward our understanding of the nature, origin, and development of student interest or lack of interest in science with the focus on how students perceive interpersonal relationships related to the development of their interest in science.

CHAPTER 3

RESEARCH METHODOLOGY AND PROCEDURES

Introduction

Based on the conceptual framework described in Chapter 2, I hypothesized that a learner's perception of the quality of his/her relationship with a person mediates the extent to which the learner will develop an interest similar to that other person's interest. In other words, people tend to develop shared interests with people with whom they perceive that they have had good relationships. If this hypothesis is true, we should see that students who are interested in science had earlier interactions with influential figures who were also interested in science and with whom the students had a good relationship. We should also see students who are uninterested in science lacked earlier interactions with influential figures who were interested in science and with whom they had a good relationship. To examine these predictions of the hypothesis empirically, I interviewed 24 college students about their development of interest or lack of interest in science in order to explore what experiences, from their own point of view, made them become interested or uninterested in science, and whether their experiences were consistent with the above-mentioned hypothesis. During the analysis, particular attention was paid to whether interactions with influential figures who were interested in science were important and whether good relationships with the influential figures were important for the development of student interest in science. From the students' descriptions of their interpersonal experiences related to the development of their interest in science, I explored the qualities of the interpersonal relationships that facilitated or hindered the development of their interest in science as reflected from their own point of view.

Research Design

I investigated the role that interpersonal relationships play in the development of interest in science by conducting clinical interviews with 24 college students at Michigan State University to examine how they described the nature, origin and development of their interest or lack of interest in science, and what factors they attributed their interest or lack of interest to. When any interpersonal relationship was mentioned, probing questions were used to explore the characteristics of that relationship that facilitated or hindered the development of interest in science. Six participants were males interested in science, six were males uninterested in science, six were females interested in science, and six were females uninterested in science.

Participants

Participants in the study were recruited from a few undergraduate psychology courses at Michigan State University during the fall semester of 1997 through the subject pool established by the Department of Psychology at MSU. All the research projects which were recruiting participants from the subject pool were posted to the students. Students in the subject pool were encouraged to sign up for the research projects they would like to participate in based on the project's title, restrictions for certain characteristics of the participants, the amount of time required, and the schedule. 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 was one and a half hours. Various time slats were offered for potential participants to sign up. I also offered the opportunity for each potential participant to set a time with me that will work for both of us. Students were given some extra credits in their psychology courses for their participation in these research projects. The policy for extra credits varied from instructor

to instructor. It generally contributed to about 5% of the final grade for 2 to 5 hours of participation in research projects.

Several factors should be taken into account when one considers the generalizability of this study. Here I will first discuss two factors that contributed to the limitation of the generalizability, and then I will discuss why the extent of the limitation should be within reasonable range. First, students who chose to take a particular course might share certain common interests. Therefore the group I recruited my participants from would not have been a completely unbiased subgroup of the MSU college student population. Second, the sign-up procedure could also have biased the sample because certain students might have chosen to or not chosen to participate in this particular project because of their feeling and considerations about the title, characteristics asked, schedule posted, and amount of time required. However, since all undergraduate students are required to take certain credits from a limited number of introductory courses, these courses often attract a wide variety of students. The posted amount of time required for the interview was one and a half hours, which would give them 3 extra credits when the number of extra credits encouraged by their instructor ranged from 4 to 10. This made my project not unreasonably time-consuming or unrewarding. I also tried to make the schedule as flexible as possible by providing opportunities for each participant to discuss with me the best time to do the study. Taking into consideration the limitations for generalizability and the features of participant recruiting process that helped to address the limitations, I believe the participants of this study reasonably captured some diversity of MSU student population.

Data Collection Procedures

In order to understand how college students describe the nature, origin, and development of their interest or lack of interest in science and what factors they attribute

their interest or lack of interest to, a semi-structured interview protocol was developed for the present study (see Appendix). The protocol contained several features to facilitate examination of the issues addressed in the study. First, in order to understand the student's development of interest in science, we need to understand what science means to the student. The protocol started with several opening questions concerning the student's understanding of the nature of science (e.g., "When you think about science, what comes to your mind?" and "What kind of things do you think people do when they are doing science?").

Second, after the student talked about his/her understanding of the nature of science, the protocol provided opportunities for the student to talk about his/her interest in science in his/her own way (e.g., " Are you interested in science?" and "Can you give me a few examples of the kinds of things you would do because of your interest in science?")

Third, after providing the student with opportunities to talk about the nature of science and his/her interest in science in his/her own way, the protocol specified four areas of science (learning the canon of science knowledge in school, learning the canon of science knowledge outside of school, figuring out scientific knowledge in school, figuring out scientific knowledge outside of school) in order to address the student's interest in each one of them.

Fourth, regarding the factors that might have affected the development of the student's interest in science, the protocol first provided opportunities for the student to mention factors that were important to the student (e.g., "Why are you interested in science?" "Is there anything in your life that has affected your interest in science?"), and later asked about the possible existence of influential interpersonal relationships (e.g., "Is there any person in your life who has affected your interest in science?"). This was done

to examine what factors were important to the student, and where interpersonal relationships stood among them.

Fifth, the protocol consisted of questions that probed the qualities of the influential interpersonal relationships in depth (e.g., "What did that person do to make you interested in science?" "How would you describe your interaction with this person?" "Can you come up with some adjectives to describe this person?" "What was your interest in science like before interacting with this person?" "What was your interest in science like after interacting with this person?").

During the interviews, probing questions were used to clarify the points the interviewees attempted to make. When any interpersonal relationship was mentioned, probing questions were used to explore the characteristics of that relationship, particularly those which facilitated or hindered the development of interest in science. All the interviews were conducted in a quiet room, and were audio-recorded with the permission of the interviewees. The complete interview protocol is in the Appendix.

Data Analysis Procedures

The data analysis procedures combined both the conventional hypothesis testing approach and the constant comparative method of qualitative analysis (Glaser & Strauss, 1967). This combination allowed me to examine evidence related to the guiding hypothesis in order to evaluate its accuracy, as well as to find patterns that emerged from the data. Research question #2 (Do college students who are interested in science attribute their interest to interest-raising interactions with influential figures who were also interested in science and with whom they had a good relationship?) and research question #3 (Do college students who are uninterested in science perceive a lack of interest-raising interactions with influential figures who were interested in science and with whom they had a good relationship?) were generated from the hypothesis that

guided this study. Therefore, the data relevant to these two research questions were first organized and interpreted for the purpose of testing the guiding hypothesis. Numbers of participants in the interested group who attributed their interest to interest-raising interactions with influential figures who were also interested in science and with whom they had a good relationship and numbers of participants in the uninterested group who perceived a lack of interest-raising interactions with influential figures who were interested in science and with whom they had a good relationship were obtained to examine the extent the findings supported the predictions from the hypothesis. Then, the constant comparative method was used to find patterns from the data. Research question #1 (What do college students mean when they say they are interested in science or uninterested in science?) and research question #4 (What perceived characteristics are associated with relationships that facilitated the development of interest in science? What perceived characteristics are associated with relationships that hindered the development of interest in science?) are more open ended by their nature. Therefore, the data relevant to research questions #1 and #4 were analyzed only by the constant comparative method.

Based on Glaser and Strauss' constant comparative method, I went through three stages of qualitative analysis.

(1) Formulating categories and comparing incidents applicable to each category: At this stage, I read and re-read the entire transcript thoroughly for each student, trying to see as much as possible anything that was potentially pertinent to my topic. 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 I constructed. After all tentative categories I could possibly form were already recorded in the matrix, I went through each transcript once more to code evidence in this matrix. While coding an

incident for a category, I compared it with the previous incidents in the same and different category.

(2) Integrating categories and their properties: As coding proceeded, this constant comparison of the incidents very soon started to generate 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 that resulted from initial comparisons of incidents. In addition, the diverse properties themselves started to become integrated. Revisions of categories were made when I could combine two or more tentative categories into one integrated category which was conceptually more meaningful in terms of making contrasts among participants.

(3) Development of claims with relevant evidence organized around the claims: At the third stage, comparisons were first made between the interested group and the uninterested group, and between male and female to examine whether any differential pattern existed between groups. Patterns that emerged during the process of analysis will be presented and discussed in Chapter 4.

CHAPTER 4

RESULTS

This chapter presents research findings for each of the four research questions addressed in the study. The descriptions involve comparing and contrasting patterns among students with different interest levels in science.

Meaning of Interest in Science (R.Q.#1)

Research Question #1 examines what college students mean when they say they are interested in science or uninterested in science. The findings with regard to this research question will be discussed in two parts. The first part addresses what science meant to the participants; the second part addresses what interest in science meant to the participants.

R.Q.#1-1. What did Science Mean to the Participants?

In order to understand the nature of students' interest or disinterest in science, I first strove to understand what science meant to the participants. Throughout the interview, the participant had many opportunities to talk about his/her experiences, understanding, beliefs, and feelings about science. The analysis revealed that the most frequently mentioned aspects of science included the following three: A, the epistemological nature of science, B, life relevance of science, and C, science in relation to the student's ability. Findings with regard to each of the three aspects will be discussed.

R.Q.#1-1.A. *Epistemological Nature of Science*

The ways the participants described epistemology of science fell into two categories: (1) doing science involved acquiring facts/concepts from a source (e.g., a more knowledgeable person, a book, or a TV program, etc.), (2) doing science involved a process of figuring out. Category (1) was further divided into two smaller categories: (a) the student mentioned science as acquiring facts/concepts from a source without describing it as memorization, and (b) the student mentioned science as acquiring facts/concepts from a source with an emphasis on memorization. Category (2) was also further divided into two smaller categories: (a) the student mentioned doing science as figuring out through making observations, manipulating/exploring, and/or trial and error, without specifying the role of coordinating theories and evidence in this process, (b) the student explicitly mentioned doing science as a process of coordinating theories and evidence to forward understanding. It should be noted that it was possible for the same student to mention more than one category in the interview. For example, a student could have described science as reading books and listening to lectures in school, and as trial and error outside of school, and also could have mentioned how people had coordinated theories and evidence in the history of science. In other words, the four categories were not mutually exclusive in the process of coding. Table 1 presents the results of all participants' responses regarding the four epistemological aspects of science.

Table 1

Student Understanding of the Epistemological Nature of Science

Name	Gender/ Interest	Doing science involves acquiring facts/ concepts from a source	Doing science involves memorization	Doing science involves a process of forwarding understanding through observation/ exploring/ trial and error	Doing science involves a process of forwarding understanding through coordinating theories and evidence
Adam	MI	x		x	
Charles	MI	x		x	x
Mark	MI	x		x	
Richard	MI	x		x	x
Simon	MI	x		x	
Tom	MI	x		x	x
Brice	MU	x	x	x	x
Bert	MU	x		x	
Derek	MU	x	x	x	x
David	MU	x		x	x
John	MU	x		x	x
Martin	MU	x	x	x	x
Amelia	FI	x		x	
Andrea	FI	x		x	x
Linda	FI	x		x	x
Melissa	FI	x		x	x
Rebecca	FI			x	x
Sarah	FI	x		x	
Anna	FU			x	
Angela	FU	x		x	x
Edna	FU	x	x	x	
Elza	FU	x		x	
Julie	FU	x		x	x
Theresa	FU			x	x

MI: male interested, MU: male uninterested, FI: female interested, FU: female uninterested

Table 1 revealed that no differential pattern was found regarding the understanding of the epistemological nature of science between the participants who were interested in science and the participants who were uninterested in science except that only uninterested participants mentioned science as memorization. Neither was there a differential pattern between male and female participants regarding their understanding of the epistemological nature of science. Twenty-one out of the 24 students either mentioned or strongly implied that doing science involved acquiring knowledge from a more knowledgeable person, a book, or a TV program. All twenty-four mentioned episodes in which science was described as a process to forward understanding by observing, manipulating, and/or trial and error without explicitly addressing the role of coordinating theories and evidence. Fifteen students (i.e., 3 male interested, 5 male uninterested, 4 female interested, 3 female uninterested) described the figuring-out process as a process of coordinating theories and evidence. Following are some examples of the four ways the participants described the epistemological nature of science.

Adam (male, interested), John (male, uninterested), Amelia (female, interested), Elza (female, uninterested) all had comments regarding science as acquiring knowledge from a source (e.g., a more knowledgeable person, a book, or a video program).

Interviewer:	What do you do when you do science?
Adam:	I am doing that for school. Study and homework, a lot of vocabulary, studying notes, getting ready for tests, reading books.

From Adam's comments, one can see that when Adam did science, he was acquiring knowledge from notes and books. In the following examples, we will see that when John and Amelia did science, they were acquiring knowledge from instructors and books. Elza mentioned acquiring knowledge from a video tape.

Interviewer:	Can you tell me some of your major experiences with science?
John:	...I want to fly (an airplane). The whole reason I am able to fly, I wasn't understanding, so I decided to do research to figure it out...

Interviewer: How did you go with the research?
John: I have to find the right resources. I had a flight instructor. I asked him, then I looked to books that have been written...

* * *

Interviewer: What do you think people do when they do science?
Amelia: ...If you are researching something, you are trying to learn as much stuff about that particular topic. You go to a library to look at people's reports on the specific topic you are researching ...

* * *

Interviewer: What kind of things do you do because of your interest in science?
Elza: I remember that the doctor gave me a prescription of medication...we looked it up in our book...
Later on in the interview...
Interviewer: Is there anything in your life that has affected your interest in science?
Elza: ...I had a really good physics teacher in high school...We would have homework assignments. Once my friend and I did it together. It was understanding motion. It was to play pool...First we watched a video on how to play pool. There was this billiard player who was teaching us. He said that there are diamonds on the side of the table. By hitting a certain diamond a certain way with a certain speed, he would hit this ball, then certain one would go in...

As far as looking at science as acquiring facts/concepts from a source (e.g., a more knowledgeable person, a book, a TV program, etc.), a differential pattern was found between the interested group and the uninterested group. Almost all the participants (21 out of 24) mentioned this aspect of science during the interview. However, there was not a single student in the interested group who described this process as memorization. Yet four students (3 male, 1 female) in the uninterested group emphasized memorization in their experience of science. Following are two examples (Brice: male, uninterested; Edna: female, uninterested).

Interviewer: Can you tell me your interest level in each of the four areas?
Brice: Area one, relatively low, one, because a lot of basic science courses involve memorization. I have never liked picking

up a science book and memorizing facts and names and different things...

Later on in the interview...

Interviewer: Why did you never develop a strong interest in science?

Brice: The reason I am not greatly interested in it is because I have never had any great interest in memorization, and the basic things you need to do in order to become a scientist. The basic things never seem that important to me. I never was real interested in the parts of a flower that I had to memorize and things like that. I never saw how that would impact my life real greatly...

* * *

Interviewer: What do you do when you do science?

Edna: I read a lot. I just memorize a lot, but I don't remember. I memorize for an exam. The next day it's all gone.

Later on in the interview...

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

Edna: ...I would study. I would make flash cards. Then I would remember and take the test. When I am taking the test, I would always think that they were trying to trick me with some terms. I would read the questions differently than they really were. I would never do good on that.

Regarding science as a figuring-out process, many students mentioned making observations, exploring, and/or using trial and error as being involved in this process, without explicitly addressing the role of coordinating theories and evidence. Charles' (male, interested) and Angela's (female, uninterested) comments illustrate how participants described making observations as being involved in doing science.

Interviewer: What was it that made your interest grow between age 5 or 6 to age 15?

Charles: Being around it, being exposed to it...For example, when I was six or seven, there was a pond across the street. We caught tadpoles and watched them grow into frogs.

* * *

Interviewer: What do you think people do when they do science?

Angela: ...Trying to find out...Like chemistry in high school, we mixed a couple of chemicals and found out what happened, what they created together, what effect you got, things like that, to find out results...

Both Simon's (male, interested) and Derek's (male, uninterested) comments demonstrate how students described science as a trial-and-error process to figure out new things without explicitly addressing the role of coordinating theories and evidence.

Interviewer:	What kind of things do you think people do when they are doing science?
Simon:	A lot of research, looking for new ways to solve problems, alternative ways that things are explained.
Interviewer:	Can you say a little bit more about what research is?
Simon:	People work in the lab to find a new vaccine. Play around. Try different things. Record what happened. Trial and error.

* * *

Interviewer:	What do you think people do when they are doing science?
Derek:	Science is a lot of research, experimentation.
Interviewer:	Can you tell me a little bit more what research is?
Derek:	Researching what has worked, what hasn't worked.
Interviewer:	Can you give me some examples?
Derek:	I think kind of like a try and fail method. When I think about testing drugs, they will try it on some sort of group, then see if it works. That hasn't worked, maybe use it again...

Consistent with the belief of certain scholars (Kuhn, 1989; Carey & Smith, 1993), fifteen participants described science as a figuring-out process that involved coordinating theories and evidence. The following four students' comments, one from each of the four groups (Richard: male interested, Brice: male uninterested, Andrea: female interested, Julie: female uninterested), provide examples that show understanding regarding this aspect of the epistemological nature of science.

Interviewer:	What kind of things do you think people do when they are doing science?
Richard:	...They are trying to come up with explanations why things are a certain way. One thing about science is that you can't prove something is true. You can only prove things false. One example would be Darwin's theory of evolution. A lot of scientists are working to see if his theory is really working...
Interviewer:	If a student from another country became your classmate, and s/he told you that s/he never had science before in his/her country, and s/he asked you, "What is science?" how would you respond to him/her?

Richard: ...For science you have to have proofs to continue on with science.
Interviewer: What constitutes a proof?
Richard: A proof to me would be something empirical, something you can see is happening...

Here one can see that Richard pointed out that doing science involved both "coming up with explanations" (theory) and "finding empirical proofs" (evidence). Similarly, Brice described science as involving the development of ideas, hypotheses, theories, and laws, as well as the importance of empirical data (evidence) in the process of supporting or discrediting the hypotheses.

Interviewer: When you think about science, what comes to your mind?
Brice: A field dedicated to the understanding of the world in which we live.
Interviewer: Anything else?
Brice: I would think experimentation, research, the attempts to understand things that previously were misunderstood or not understood at all.
Interviewer: Can you tell me a little bit more: What is experimentation?
Brice: When I talk about experimenting, I am thinking about the development of a hypothesis, testing that hypothesis, developing theories, possibly laws in time, supporting or defending or attacking one or another's hypotheses about a certain situation...
Interviewer: How do you do that? What constitutes a hypothesis?
Brice: A hypothesis is a belief, or an idea about the way, the reason something is, that is based upon empirical data that may have been collected by yourself or others. All hypotheses, in my opinion, must be either defended or credited by using empirical data, because that is the only thing that can prove hypotheses.
Interviewer: Can you give me an example as to what a hypothesis would be like, and how empirical data helps you to prove a hypothesis?
Brice: A hypothesis might be that college students with black hair do better on exams. And a way to test that would be to take a random sample of college students, look at their hair color and look at how they did on those tests, and use that data to support or discredit the hypothesis.

Similar to Richard and Brice, Andrea described science as a process of developing ideas (theory) and testing ideas (evidence); Julie phrased it as formulating a question and a hypothesis (theory) and proving it with the research and the data (evidence).

Interviewer: What kind of things do you think people do when they are doing science?

Andrea: ...Maybe growing different plants, doing experiments, working in labs.

Interviewer: Can you say a little bit more about what an experiment is?

Andrea: Coming up with the ways to try to test theories and hypotheses. People have questions about many aspects of science...It's just ways to find out what things are true and not true, and how things work.

Interviewer: How do experiments help to find that out?

Andrea: If you have an idea about how something works, why it is the way it is, you can come up with a way to test and prove it. You can prove it over and over, again and again. Then it becomes accepted...

* * *

Interviewer: What kind of things do you think people do when they are doing science?

Julie: I think they are constantly reworking the theories that are already there, working out problems, trying things, trying to perfect everything that's already out there. We have to expand our knowledge that's already there.

Interviewer: What is a theory? How do they make it better or perfect it?

Julie: A theory is something like a hypothesis that was proven and proven, again and again. I think it means that to be a theory, it has to be able to be repeated like the experiment, the whole thought, for people to understand it and agree with it. I think a lot of people aren't just going to accept it, especially people in the field of science. They are going to work on it, and make sure that's what it is.

Interviewer: What is a hypothesis?

Julie: It's like the question that needs to be answered in the first place. It's someone saying "I wonder why it's this way," then they make a hypothesis to try to answer that question, an educated guess, and they go about proving it with the research and the data.

The examples given above have illustrated four ways the participants described the epistemological nature of science: science as acquiring facts/concepts from a source, science as memorization, science as forwarding understanding through observation/exploring/trial and error, and science as forwarding understanding through coordinating theories and evidence. Beyond the above-mentioned four epistemological aspects of science, one pattern worth noting emerged from the data regarding the learning/epistemology of science as experienced by the students. Five out of the total 24

students mentioned that science was often experienced in ways that were different from authentic science. Four (3 male, 1 female) of the five students were in the uninterested group. It seemed to suggest that either uninterested participants experienced unauthentic science more, or they were more aware of this issue compared with interested participants. Following are three interview vignettes that addressed the issue of unauthentic science.

Brice (male, uninterested) described how experiments were not true experiments when he commented on his interest in area three of the four areas of science: figuring out scientific knowledge in school.

> Interviewer: ...Would you please think about each of the four areas of science and tell me whether you are interested in each one of them and why?
> Brice: ...For area three it would be a 2 or 3, because again in my experience with science, the experimentation has really not truly been experimentation, because the outcome is already known.

Derek (male, uninterested), similar to Brice, pointed out how school science often included experiments which were not experiments that would lead you to new discoveries.

> Interviewer: Why did you have different interest levels for in school and outside of school science?
> Derek: When we try to figure out things in school, it's different than outside of school...One experiment, you can pretty much tell what the outcome is going to be. At least I can. Nothing was really amazing about it. I didn't really learn anything from the experiment. I can learn more just from the introduction of the experiment. You can tell what's going to happen.

Julie (female, uninterested) started talking about how school science was different from real world science when she was asked about what science is. Julie described school science as book science, as learning about stuff that is already known to the scientists. In contrast to that, a scientist is actually dealing with the stuff and doing something with it.

> Interviewer: If a student from another country became your classmate, and s/he told you that s/he never had science before and

asked you, "What is science?" how would you respond to him/her?

Julie: I think science in the classroom is different than science in the real world...

Interviewer: You noticed the difference between school science and the real world science, can you say a little bit more about the difference?

Julie: I think school science is following the book, like learning about people you have to learn about for science, learning about the theories, and how the theories apply to the world, and learning all the numbers like I said before, like that Avogadro I learned for chemistry, learning about the protons and the neutrons. That's book science. Someone that's a scientist already knows that stuff. That stuff is known to them. They have to work with that stuff, and do something with all that stuff. In school you have to learn what's in the liquid and how you balance the equation. For a scientist, they are probably dealing with the actual liquids or the actual solids. They have to do something with that. We just learn in school like if this is heated, this is what happens. The scientist in the real world is doing that. They are doing.

From these three examples, one can see how Brice and Derek were aware that school science was often unauthentic because the "experiments" did not help one to truly "find out" what would happen. The outcome was simply already known. Julie also pointed out school science tried to teach students what was already known to scientists through knowledge transmission. In contrast to that, scientists in the real world were not told in this way. They were "doing."

R.Q.#1-1.B. *Life Relevance of Science*

Two kinds of information were mentioned by the participants with regard to life relevance of science: (1) whether science was related to the student's own life or not, and (2) whether science was helpful or harmful to people in general. The findings about each of the two aspects is summarized in Table 2, followed by a discussion of this table.

A differential pattern between the interested group and the uninterested group was the extent to which students in each group viewed science as related to everyday life. For the interested group, the majority of students (9 out of 12 students) described science as

highly related to life. For the uninterested group, only two students described science as highly related to life. Only one student in the interested group described science as something that can be related to life sometimes, but often is not. Yet this is the way nine students in the uninterested group described science. No student in the interested group described science as completely not related to life, while one student in the uninterested group did so. Two students (1 male, 1 female) in the interested group did not mention the issue of relevance during the interview.

Table 2

Life Relevance of Science

Name	Gender/ Inrerest	Science is highly related to life	Science is moderately related to life	Science is hardly related to life	Science helps people, solves problems, and improves life	Science can be harmful
Adam	MI	x			x	
Charles	MI	x			x	
Mark	MI		x			
Richard	MI	x			x	x
Simon	MI	x			x	
Tom	MI				x	
Brice	MU		x			x
Bert	MU		x		x	
Derek	MU	x				
David	MU		x			
John	MU	x				
Martin	MU		x			
Amelia	FI	x			x	
Andrea	FI	x			x	
Linda	FI	x			x	
Melissa	FI				x	
Rebecca	FI	x				
Sarah	FI	x			x	
Anna	FU		x		x	
Angela	FU			x		
Edna	FU		x		x	
Elza	FU		x		x	
Julie	FU		x		x	
Theresa	FU		x			

MI: male interested, MU: male uninterested, FI: female interested, FU: female uninterested

Charles' (male, interested) and Sarah's (Female, interested) comments will help us see how students in the interested group described science as highly related to life.

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 the things to your life. For instance, how sound waves travel in the air so we hear things the way we do.

Later on in the interview...

Interviewer: In general, are you interested in science?

Charles: Yes...I want to major in nutritional science, to understand chemistry, why certain foods are composed the way they are, how they affect the body, why some things are good or bad for us. The way I look at things, for instance, biological reasons as to why things are happening outside, why trees are certain colors, as opposed to being ignorant about the way why it happens. The more information you accumulate, the more you can relate to things you see in the world. A lot of it has scientific roots why it's a certain way.

* * *

Interviewer: Why are you interested in science?

Sarah: Probably just like a cell can grow into a person. That's just a "wow." That's amazing. And like all these different chemical reactions that keep your body alive...Even the air we breathe has something to do with science. That has to do with chemistry. You have to have oxygen in the air to be able to breathe and to live. Science is all around us, but I don't think people think about that.

From the above examples, one can see that Charles emphasized the importance of "applying science to your life" and "accumulating information in order to relate to the world;" Sarah illustrated how science was all around us through things we do everyday (e.g., breathing). In contrast to Charles and Sarah, Brice's (male, uninterested) and Julie's (female, uninterested) comments will illustrate how students in the uninterested group described science as something that could be related to life sometimes, but often was not.

Interviewer: Can you say a little bit more about what characteristics of those programs or magazine articles make them more interesting?

Brice: The programs and magazine articles show practical things in everyday happenings. Reading a textbook and learning the anatomy of a frog is not a very practical thing for someone unless it's the field of your study...I have not seen the importance of dissecting a frog or a worm for myself, because it's not knowledge I will ever need...

Here Brice pointed out how certain programs and magazines made science "practical," while school science was often about knowledge that he did not think he would need.

Later on in the interview when Brice talked about his interest development curve, he mentioned how he could not see the importance of certain aspects of science.

Brice: ...Science, certain aspects are very important, others are almost, I don't want to say trivial, but certain parts are almost trivial. Botanist research, plants. There have been plants on this planet since beginning, and there's never any research done, but farming still went on. You know, and I mean it attempts to better that. I am not saying that it's completely not important, but there are other more important things. A lot of scientific fields are almost trivial...

When Julie was asked to learn something, she wanted to know how it can be applied to life, but she often found that this desire was not satisfied when she was asked to learn science. Hence, the "book part of science' became irrelevant to her life.

Interviewer: Did you take science classes constantly through middle school and high school?
Julie: Yes, we had to.
Interviewer: What number (interest level) might you give to those classes?
Julie: ...There are some parts of physics that make sense to me. Some parts I was like, "Why are we learning this?"...Some teachers are able to say, "You are not just learning this because I am telling you to learn it. You are learning it because you can apply this to the world." ...Tell me why I am learning this. Tell me what I am going to do with it after I leave your classroom everyday... Everything may be applied. Like the chemistry I have taken. That might be applied to the real world. I don't know. But she didn't show me. She just said, "Here is the number. Plug it in the equation." Well, why do you want me to plug it in the equation? Tell me why.
Interviewer: Can you tell me how your interest or lack of interest in science plays out in your life?
Julie: I guess if I look at science as a hands-on kind of way to learn things, it's a big part of my life with the kids, learning why they do the things they do, how they play the way they do...If I apply the book part of science, then I'd say it wouldn't be a part of my life. The numbers and all the names. All of that, no.

One student in the uninterested group described how hard it was for her to see science as being related to everyday life.

Interviewer: What do you do when you do science?
Angela: Do you mean in class or do you mean in life?

Interviewer: Both.
Angela: As far as class, I always had science up to this year. I can't think of anything that I do in everyday life. It's very hard for me to relate.

From the above-mentioned examples, one might notice an interesting phenomenon. Both Charles and Brice mentioned the study of plants as a topic in science. Yet Charles perceived it as a way to help him "relate to things he sees in the world," while Brice perceived it as almost trivial. Both Sarah and Julie mentioned something related to chemical reactions as a topic in science. Yet Sarah perceived it as highly related to life because "these chemical reactions keep our bodies alive," while Julie found it hard to see how the chemistry she learned can be applied to the real world. From these comments, one can see that the extent to which science was perceived as being relevant to everyday life was not determined by what the science topic was about (e.g., plants or chemical reactions), rather it was more influenced by how the participants perceived the topic's connection to the world.

Now that we have examined how the participants perceived science as related to their own life, let us address how they perceived science as helpful or harmful to people in general. Ten out of the twelve students who were interested in science described science as something that would help people to solve problems and improve life. In contrast to that, only five students in the uninterested group mentioned or implied that science could help people. Following are two examples from the interested group. The helpful aspect mentioned by the students in the uninterested group was similar in nature, as illustrated by the third example.

Interviewer: What do you think people do when they do science?
Simon: A lot of research, looking for new ways to solve problems...
later on in the interview...
Interviewer: Would you please talk about each of the four areas of science and give me some examples of your interest in each area?
Simon: ...I am interested in the genetics and the medical field...
Interviewer: Why genetics?

Simon: I think a lot of problems can be solved by genetics. Certain genes cause problems. We can fix that.

* * *

Interviewer: Why are you interested in science?
Amelia: I don't know if you would call it science. I am interested in medicine and helping people.
Interviewer: So you are interested in helping people by medicine. In order to do that, science is related?
Amelia: Right.

* * *

Interviewer: What do you think people do when they do science?
Anna: Trying to think of cures or treatments for diseases or sickness...

More uninterested female students than uninterested male students mentioned science as helpful to people. Only one male student in the uninterested group mentioned science as helpful to people. In contrast to that, four female students in the uninterested group mentioned or implied science as helpful to people. This is consistent with the notion that females are traditionally more concerned with the social and caring aspects in their lives (e.g., Gilligan, 1988; Noddings, 1992). The finding also seems to suggest that the reason why these girls become uninterested in science does not lie on the issue of helpfulness or usefulness of science.

R.Q.#1-1.C. *Science in Relation to Student Ability*

During the interview process, I did not explicitly ask the student to talk about how good s/he was in science until the very end of the interview. However, some students spontaneously mentioned information related to how good they were in science when they talked about their development of interest in science. This seems to suggest that the issue of competence was important to these students when they thought of their development of interest in science. One might think that a student's perception of his/her ability in science is something about the student, not something about science. However,

this information does reveal how a student perceives science in relation to himself/herself. Imagine one student who perceives science as a subject which s/he is very good at, and another student who perceives science as a subject which s/he finds hard to understand. Science would mean quite different things to these two students. It would be important to understand this difference because it is likely to be related to the development of student interest in science.

Interestingly, a distinction could be made between two kinds of information mentioned by the participants that were relevant to the issue of competence: (1) the grades or scores they received in science classes or tests, and (2) how good they thought they were in science. The findings of this study indicate that grades did not always correspond to self perception of competence. Students who reported that they always received good grades in science did not necessarily think of themselves as "good at science." In fact, three out of the four students who mentioned that they always received good grades in science mentioned or implied that they also felt science was often hard to understand.

Four things can be noticed in the findings as summarized in Table 3. First, the three students who reported that they always did well in science classes and/or tests but found science hard to understand were all in the uninterested group. Second, the one student who reported that she always did well in science tests and believed she was good at science was in the interested group. Third, all three students who reported they always received bad grades in science also reported that they felt science was hard to understand, and they were all in the uninterested group. Fourth, all three students who felt they were good at science were all in the interested group; while eight out of the ten students who mentioned that science was hard to understand were in the uninterested group. The following examples will further illustrate the four patterns.

Table 3

Science in Relation to Student Ability

	Gender/ Interest	Science was an area in which the student often received good grades.	Science was an area in which the student often received bad grades.	Science was something the student felt s/he was good at.	Science was something the student felt hard to understand.
Adam	MI			x	
Charles	MI			x	
Mark	MI				x
Richard	MI				
Simon	MI				
Tom	MI				
Brice	MU				
Bert	MU		x		x
Derek	MU	x			x
David	MU		x		x
John	MU				
Martin	MU	x			x
Amelia	FI				
Andrea	FI				
Linda	FI				x
Melissa	FI	x		x	
Rebecca	FI				
Sarah	FI				
Anna	FU				
Angela	FU	x			x
Edna	FU		x		x
Elza	FU				x
Julie	FU				x
Theresa	FU				

MI: male interested, MU: male uninterested, FI: female interested, FU: female uninterested

Pattern (1): Derek (male, uninterested) reported that he always did well on science tests, but found science hard to understand. He talked about how this affected his interest in science. When I asked Derek to draw a curve to represent his development of interest in science, Derek automatically mentioned that he had a different interest outside of

school than in school, so he drew two curves. After Derek talked about both curves, he gave this comment:

> Derek: I have always done very well in science. In fact, on my ACT test, that was my highest score.

Here Derek pointed out that he always did well on science tests. However, he seemed to often feel frustrated because he was not able to understand science well.

> Derek: I feel science - in my experience I wanted to learn more about science, but it's kind of like just beyond my grasp. I tried to understand the things, but I feel that I didn't have maybe the help to help me understand. I can't understand things on my own, which is very frustrating. I have to be taught, but a lot of times I am not taught. It's not that I am not willing to put the work into it. I am, but I just can't find the teacher or the mentor to help me learn more about it.

When Derek was asked about the reasons for being interested or uninterested in science, he pointed out how the fact that he found it hard to understand science lowered his interest in science.

> Interviewer: It seems that you are pretty interested in science, but also in general, are you interested in every area of knowledge?
> Derek: Yes. There are things I am more interested in than science, mostly because I don't understand science in the way it's presented to me.
> Interviewer: Does that increase your interest or lower your interest?
> Derek: That definitely lowers my interest inside the classroom. I didn't feel I was involved. When I leave the classroom, it's just frustration! Period! It's like "Gee, I don't understand that. How am I going to get this knowledge? How am I going to learn this somewhere else?"

One can see that in Derek's experience, doing well on science classes and tests was not enough to make him feel interested in science. What was more important to him was whether he felt he could truly understand science well.

Pattern (2): Melissa (female, interested) was similar to Derek in the aspect of always doing well in science. Yet they differed in the way they felt about how good they were at science. Melissa felt that she was good at science. She talked about how this raised her interest in science.

Interviewer: Can you tell me some of your major experiences with science?
Melissa: I have always done well with science testing and classes...
Later in the interview...
Interviewer: How did your interest in science start?
Melissa: I think it comes from doing well on tests and things like that when you were younger, with achievement or aptitude tests, because I gained confidence in it. Once I gained confidence in it, I chose to take classes regarding that over other ones. Once I started knowing more about it, it became more and more interesting to me...
Interviewer: How come more knowledge makes you more interested?
Melissa: I guess it all stems from confidence again. I have felt secure with it, and I would like to learn more about it...

Pattern (3): Interestingly, both Derek and Melissa did well on science tests. Melissa mentioned it as the main reason that made her gain confidence in science. Yet for Derek it was not enough to make him feel that he was good at science. In contrast to Derek and Melissa, Bert's (male, uninterested) comments illustrate how bad grades and the experience that science was hard to understand lowered his interest in science.

Interviewer: Why aren't you interested in science?
Bert: I don't know if it's exactly one experience, or the whole experience. I think it started in junior high school when we had to take science courses, especially chemistry. I could never fully understand everything that was needed or was what the teacher wanted us to understand. I could never get it out in my head straight. It's too frustrating, so it's like that "I don't like this."...
Later during the interview, as Bert talked about his curve of development of interest in science...
Bert: I think junior high really had an impact on my science, because one year I had a teacher I didn't like at all...besides that, I would say the grades I would get back for what I was doing in science also discouraged me from science, because I have always liked my grades to be high. Science was always a struggle for me. I wasn't getting the grades I wanted, so I wasn't interested after...

Pattern (4): Adam's (male, interested) comments and Charles' (male, interested) comments illustrate how interested students felt they were good at science, and how that perceived competence increased their interest in science. Both of them mentioned that they were good at science, without explicitly mentioning anything related to grades.

Interviewer: How did your interest in science start?

Adam: It started with math. Science became another subject I was good at...

* * *

Interviewer: Can you tell me some of your major experience with science?
Charles: Mostly the reason I like doing it is because I have always been good at it. It comes easy to me. I can read it over and understand what they are talking about, instead of reading it five or six times and trying to figure out what's going on...

David's (male, uninterested) and Edna's (female, uninterested) comments illustrate how the feeling that science was hard for them lowered their interest in science.

Interviewer: Would you please tell me some of your major experiences with science?
David: ...Last year I took a class Physics 184. I just hated it...I realized that I was really not a science person.
Interviewer: How did you make that judgment?
David: Just the fact of lack of interest. As the weeks went on, the interest level decreased.
Interviewer: How did you tell your interest level?
David: Success wise. If I was doing well enough....Some people can understand right away. Other people have to either visualize it or draw it out certain ways, but both ways weren't for me either, so I learned that way that wasn't for me.

* * *

Interviewer: Would you please tell me how you feel about science?
Edna: It's just not interesting because I can't understand it. I can't put it into the context that it was probably meant to be. I just can't understand it at all. I can't understand anything that deals with it. It's just real complicated.

From the above mentioned patterns, one can see that receiving good grades or test scores did not always make someone interested in science. What seemed more important was to truly feel good at science. The opposite of that feeling (the feeling that science was hard to understand) was highly associated with lowered interest in science.

In summary, students in the interested group and the uninterested group did not differ with regard to their understanding of the epistemological nature of science except that only students in the uninterested group described science as memorization.

Nevertheless, more students in the uninterested group mentioned that science was often experienced in ways that were different from authentic science. In general, students in the interested group saw science as more related to everyday life and more helpful to people compared to students in the uninterested group. Only students in the interested group described science as something they were good at, while more students in the uninterested group described science as something hard to understand.

R.Q.#1-2. What did Interest in Science Mean to the Participants?

Having described what science meant to the participants in this study, I will now address what interest in science meant to them. As discussed in Chapter 2, I conceptualized individual interest as a person's dispositional preference toward a particular domain of activities either for an intrinsic reason (i.e., enjoying the activity itself) or for a self-determined instrumental reason (i.e., the activity leads to something else that is of true value to the individual). One issue I must examine is whether this conceptualization of interest was consistent with the participants' experiences and ideas of interest as they described them. In other words, when they talked about interest in science, did they mean enjoying doing science, and/or tending to pursue science because it would help them to acquire something else they valued. The findings indicate that this conceptualization was consistent with the participants' talk of interest. As presented in Table 4, the component of "enjoying" science was identified in all the participants' comments when they talked about interest in science; the component of science "leading to something else of value" was identified in eighteen participants' comments when they talked about interest in science (2 male interested, 5 male uninterested, 5 female interested, 6 female uninterested). One example from each of the four groups will be given to illustrate how the participants talked about "enjoying science" and "choosing to

pursue science in order to acquire something of value to them" when they commented on interest in science.

Table 4

Components in Students' Talk of Interest

Name	Gender/ Interest	Interest as enjoying	Interest as choosing to do in order to acquire something of value
Adam	MI	x	
Charles	MI	x	x
Mark	MI	x	
Richard	MI	x	
Simon	MI	x	x
Tom	MI	x	
Brice	MU	x	x
Bert	MU	x	x
Derek	MU	x	x
David	MU	x	x
John	MU	x	x
Martin	MU	x	
Amelia	FI	x	x
Andrea	FI	x	x
Linda	FI	x	x
Melissa	FI	x	x
Rebecca	FI	x	
Sarah	FI	x	x
Anna	FU	x	x
Angela	FU	x	x
Edna	FU	x	x
Elza	FU	x	x
Julie	FU	x	x
Theresa	FU	x	x

MI: male interested, MU: male uninterested,
FI: female interested, FU: female uninterested

In the first example, Simon (male, interested) talked about how he enjoyed various science activities.

Interviewer: Would you please think about each of the four areas and tell me whether you are interested in them?

Simon: I enjoy learning facts and concepts in school, but much more I enjoy taking the information and doing the experiments, and working with the knowledge, doing the figuring out stuff. I do that both in and out of school.

Later on in the interview, Simon also talked about how his interest in science was affected by a friend's illness and death. That experience raised his interest in a certain area of science because he wanted to find cures for that illness.

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

Simon: There is one that made me start thinking about medicine. My best friend had muscular dystrophy. He became weaker and weaker and eventually passed away. He was fourteen. I wish there is something that can be done, because that is a disease that's terminal. I thought about physical therapy. I watched him do physical therapy. It does slow the process down, but it doesn't stop it. Then I thought about medicine. I started reading about genetics. There is a lot of things that can be corrected by genetics. That's probably why I started to think about genetics...

David (male, uninterested) did not have too much interest in science. Yet from the way he talked about his limited amount of interest in science, we can see that what he meant by interest contained the component of enjoying science and the component of science leading to something else of value to him.

Interviewer: In general, are you interested in science?

David: ...school science I don't really enjoy, but I think it's a necessity that I know what's going on in daily life. If you don't know what the weather is, you don't know what to wear.

Interviewer: Do you avoid doing something because of your lack of interest in science?

David: I avoid taking classes. If I don't have to take a class, I won't take it...For leisure time, if something involves science, that seems to be interesting and fun, I am going to go ahead and do it and see. Maybe I will learn something.

Later on in the interview...

Interviewer: Why are you not interested in science?

David: As I said, science is hard for me. If it is basically unnecessary, I don't go into it. If it's a necessity, I need science to live my life, I will do it.

When Linda (female, interested) talked about how her interest in science played out in her life, she used the word "like." She also mentioned the instrumental aspect of her interest in science when she pointed out how science could help her get a good job.

Interviewer: Would you please tell me how your interest in science plays out in your daily life?
Linda: ...I like doing things like going to the zoo, seeing animals.
Interviewer: Why are you interested in science?
Linda: ...I think it's a pretty relevant field. Not everybody thinks that, but it is...
Interviewer: Are there other reasons why you are interested in science?
Linda: I know there are a lot of jobs in the field. I am going to want to get a good job after school.

When Theresa (female, uninterested) talked about her interest in science, she used the words "love, fulfillment, excite," which implied the component of enjoying. She also talked about "important" and "fix the problem," which implied the component of "science leading to something else of value."

Interviewer: In general, are you interested in science?
Theresa: Yes. It's not something I would really love to go into, because I just don't think I would be that successful in it, but I think it's definitely important to study it...
Interviewer: Can you give me a few examples of the kinds of things you would do because of your interest in science, or would avoid doing because of your lack of interest in science?
Theresa: Chemistry. I just don't like. It doesn't give me any fulfillment. I guess it's important to study how atoms work, but it just doesn't excite me at all. But like biology and environmental studies, those are cool, because they are pertinent to my life, because we have to live in it.
Later on in the interview...
Interviewer: How does your interest in science play out in your daily life?
Theresa: I don't really have an active role in it. I do a lot of thinking about it...I just think about it. I think about my kids. If I am going to bring them to this world, it's going to be polluted. There is got to be a way to fix it. That's why I am interested in science, like the future.

The findings presented in Table 4 and the examples presented above confirmed that the conceptualization of interest discussed in Chapter 2 was consistent with the participants' ideas and experiences of interest.

After unpacking what the participants meant by interest, let's examine what their interest in science looked like. During the interview, I asked the student: "To what extent would you say you are interested in science?" I asked each participant to choose a number between 1 and 5 to indicate his/her level of general interest in science, as well as his/her interest level for each of the four areas (learning science facts/concepts in school, learning science facts/concepts outside of school, figuring out scientific knowledge in school, figuring out scientific knowledge outside of school). The number 5 represented strongly interested, the number 4 represented pretty interested, the number 3 represented neutral, the number 2 represented not interested, the number 1 represented not interested at all. Table 5 presents the numbers given by the students.

Three things are worth noting in Table 5. First, most students had different levels of interest in different areas of science. This finding indicates that interest in science is not a unified construct. Someone can be interested in one aspect of science but not in another. Second, students in the interested group had smaller variations among the interest levels across the four areas compared with students in the uninterested group. As one can see, the students who reported that they were generally interested in science were pretty much interested in the four different areas of science. Their interest levels in different areas tended to vary a little, but not too much. Third, in contrast to students in the interested group, students in the uninterested group almost all showed a low interest in learning facts and concepts in school, yet they often were interested in some other areas of science. Their interest levels in the four different areas varied a great deal. All students in the uninterested group except one gave a number equal to or lower than 2 for their interest in learning facts and concepts in school. However, all of them except that

one gave a number equal to or higher than 4 for at least one area of science when they considered the other three areas of science.

Table 5

Student Interest in Science in General and in the Four Areas

Name	Gender/ Interest	Interest in general	Facts & concepts in school	Facts and concepts outside of school	Figuring out in school	Figuring out outside of school	Variation of interest among the four areas
Adam	MI	4.5	3.5	3	4.5	3.5	0.40
Charles	MI	4.5	3	3*	5	4	0.92
Mark	MI	3.5	3	4	3	2	0.67
Richard	MI	4	4.5	5	3.5	5	0.50
Simon	MI	5	3.75	5	5	5	0.39
Tom	MI	3.5	3	4	4	3	0.33
Brice	MU	3.5	1	3.5	2.5	4	1.75
Bert	MU	2.3	2.5	3.5	4	4.5	0.73
Derek	MU	4	2	4	2	5	2.25
David	MU	1.75	1	5	2.5	4	3.06
John	MU	4	2	4	3	4	0.92
Martin	MU	3	2.5	5	4	1.5	2.42
Amelia	FI	4	3.5	4.5	4	3.25	0.31
Andrea	FI	4.5	3	4	3	5	0.92
Linda	FI	4.5	3	4	4	4	0.25
Melissa	FI	4	4	3	4	3.5	0.23
Rebecca	FI	3.5	4	4	3.5	3	0.23
Sarah	FI	4.5	5	3.5	5	3	1.06
Anna	FU	2*	2	4	2	4	1.33
Angela	FU	1	1	3	3	5	2.67
Edna	FU	1	2	4	1	5	3.33
Elza	FU	3.5	2	4	3.5	1.5	1.42
Julie	FU	3	2	3	4	5	1.67
Theresa	FU	3	3	3	3	3	0

MI: male interested, MU: male uninterested, FI: female interested, FU: female uninterested

*: Charles insisted that he did not have enough experience to comment on his interest level in this area. A number was assigned to him in order to facilitate the statistical process. The number 3 was chosen because it seemed most appropriate to describe someone who neither had a strong interest nor a strong disinterest in a particular area.

*: Anna explicitly expressed that her interest in natural sciences is very different from her interest in social sciences. Anna gave the number 2 for her interest in natural sciences, and the number 5 for her interest in social sciences. Since this distinction was not anticipated before the study, and my original conceptualization of science put more emphasis on natural sciences, the number 2 was used here for the purpose of statistics.

A statistical process was used to further describe these phenomena. First, each individual variance among the individual's interest levels in the four areas of science was calculated (Table 5). This number represents one individual's variation of interest among the four areas. Then group means of these variances were compared between the male interested group and the female interested group, between the male uninterested group and the female uninterested group, between the male interested group and the male uninterested group, between the female interested group and the female uninterested group, and between the combined interested group (containing both the male and the female interested participants) and the combined uninterested group (containing both the male and the female uninterested participants), using a series of t tests. These comparisons would help us see the differences of extents to which individual interests vary among the four areas of science between various groups. No significant difference was found between the male interested group and the female interested group. Neither was there a significant difference between the male uninterested group and the female uninterested group. All three comparisons involving a contrast between the interested group and the uninterested group yielded significant results, with an alpha value of 0.01 for the comparison between the male interested group (group mean = 0.53, SD = 0.22) and the male uninterested group (group mean = 1.85, SD = 0.90), 0.05 for the comparison between the female interested group (group mean = 0.50, SD = 0.38) and the female uninterested group (group mean = 1.74, SD = 1.16), and 0.001 for the comparison between the combined interested group (group mean = 0.52, SD = 0.30) and the combined uninterested group (group mean = 1.80, SD = 0.99). These statistics further confirm the patterns discussed in the previous paragraph.

Since many students' interest levels in various areas of science were different, I wanted to further understand the reasons for these differences. During the interviews, the students were asked to talk about the reasons for the different interest levels they gave for

different areas of science. The analysis of Table 5 and the reasons given by the students revealed that the most meaningful interest difference among these areas lies in the difference between in-school science and outside-of-school science. The reasons given by the participants to account for this difference could be categorized into three categories: (1) reasons that had very little to do with science per se (e.g., I often have other things to do outside of school); (2) reasons related to the learning process and/or understanding of science (e.g., memorization vs. meaningful understanding), and (3) reasons related to the student's motivational and/or emotional preferences (e.g., feeling pressured to learn science or not). Table 6 summarizes the reasons offered by the participants to account for the different interest levels between science in school and science outside of school.

Table 6

Reasons for Differences between Interest in School and Interest Outside of School

Name	Gender/ Interest	Reasons that had little to do with science		Reasons related to learning process/ understanding of science		Reasons related to the student's motivational /emotional preferences	
		lack of material outside of school	have other things to do outside of school	memori-zation vs. meaning-ful under-standing	experience what happens vs. being told	feel being forced to learn vs. being free to choose what to learn	pressure of failing vs. learning in a relaxed atmosphere
Adam	MI	x	x				
Charles	MI						
Mark	MI		x	x			x
Richard	MI			x			
Simon	MI	x			x	x	
Tom	MI		x		x		
Brice	MU			x			
Bert	MU			x	x		
Derek	MU			x	x	x	x
David	MU			x	x	x	
John	MU					x	
Martin	MU				x	x	
Amelia	FI					x	
Andrea	FI			x		x	
Linda	FI				x	x	
Melissa	FI		x				
Rebecca	FI						
Sarah	FI		x				
Anna	FU					x	x
Angela	FU			x			
Edna	FU			x	x	x	
Elza	FU			x	x	x	x
Julie	FU				x	x	
Theresa	FU						

MI: male interested, MU: male uninterested, FI: female interested, FU: female uninterested

From Table 6 one can see that only students in the interested group offered reasons that had nothing to do with science itself. This, taken together with the finding that students in the interested group had a smaller variance among their interest levels across the four areas, seems to suggest that for students who were generally interested in science, the slight difference of interest levels in different contexts had less to do with science itself, but more to do with temporary situational factors. Mark's (male, interested) and Sarah's (female, interested) comments were examples of this kind.

> After Mark chose a number between 1 and 5 to indicate his interest level for each of the four areas of science (area one: 3, area two: 4, area three: 3, area four: 2)...
> Interviewer: Can you talk about the different interest levels for area three and area four?
> Mark: When I am outside of school, I don't think about science that much because I do other things.
>
> * * *
>
> After Sarah chose a number between 1 and 5 to indicate her interest level for each of the four areas of science (area one: 5, area two: 3 or 4, area three: 5, area four: 3)...
> Interviewer: Can you talk about the difference of interest level between In-school and outside-of-school?
> Sarah: Because outside of school I like to do things that have nothing to do with school. I don't have to think about school.

In contrast to the students in the interested group, students in the uninterested group often had reasons to account for their different interest levels for different areas that were related to the very core of the process of learning and/or understanding of science. Ten students attributed their interest difference to whether the context required memorization or supported meaningful understanding. Seven out of these ten students were in the uninterested group. Brice's (male, uninterested) and Angela's (female, uninterested) comments illustrate the contrast between memorization and meaningful understanding.

> Brice chose the number 1 to indicate his interest level in learning science facts and concepts in school, the number 3 or 4 to indicate his interest level in learning science facts and concepts outside of school.

Brice: My interest for area one is relatively low, because a lot of basic science courses involve memorization. I have never liked picking up a science book and memorizing facts and names and different things...The interest for area two is 3 or 4, because it presents the facts. There is no memorization involved. The type of programs makes it interesting. Science textbooks tend not to be quite interesting and as entertaining as the programs might be or magazine articles.

Interviewer: Can you say a little bit more about what characteristics of those programs or magazine articles make them more interesting?

Brice: The programs and magazine articles show practical things in everyday happenings. Reading a textbook and learning the anatomy of a frog is not a very practical thing for someone unless it's the field of your study. Programs and things like that present it in a way that is very colorful, very engaging, a lot more practical. It's a lot easier to follow. You don't have to force yourself to follow it. It's more entertaining.

Angela had a higher interest in learning science outside of school (area one: 1, area two: 3, area three: 3, area four: 5). When she explained why, Angela pointed out that the stuff you learned in the classroom was hard to connect to real life, while figuring out scientific knowledge outside of school was "necessary" in everyday life.

Interviewer: Can you talk about the difference between inside and outside of school?

Angela: ...Sometimes when we think of science, we tend to think of school science. It's the stuff you learn in the classroom. You don't really use it. You don't realize it actually does go on in real life. It's very hard to put the two together.

Interviewer: Why is area four interesting to you?

Angela: It's necessary...If your car breaks down, you have to figure out what's going on with that. It's always helpful to know exactly what's in the car. What such and such might not be working. It's necessary.

Another contrast that emerged from the participants' comments related to the learning process/understanding of science was the difference between experiencing what happens and being told about it. Ten students mentioned that they had a higher interest when they were able to experience what happened in science instead of merely being told about it. Again, seven out of these ten students were in the uninterested group.

When Derek (male, uninterested) was asked to draw a curve to represent his development of interest in science, he drew two curves because he had a different interest outside of school than in school. Derek (male, uninterested) then pointed out how certain contexts which did not allow hands-on experiences lowered his interest in science.

Derek:	I have a different interest outside of school than in school. ...When I was in elementary school and middle school I was more interested in science. When I got into high school, I became less interested, especially when we started getting into biology. Maybe I was less interested in that because there was less hands-on in biology. They didn't let us get into dissecting, because of certain government things in the public schools. It was more lectures and book work, just busy work.
Interviewer:	Busy work?
Derek:	Busy work is work sheets, tests, memorization of facts the whole year long. I suppose it's part of science, but it wasn't the part I was interested in...
Interviewer:	How did your early experience differ from your high school experience to make you interested?
Derek:	I guess as kids you can't have so many work sheets, quizzes, tests. We had the astronomy type thing. They bring animals to us every year. Things you do as a kid. Going to the zoo, going to the science museums...

Later on during the interview, Derek mentioned how certain contexts which allowed experiencing and exploring increased his interest in science.

Interviewer:	Is there anything in your life that has affected the development of your interest in science?
Derek:	Going to a science museum, exploring on my own...My interest definitely increased when I began to understand things...When I go to a museum, I started to understand things. Then I can apply that to things in my life. I say "You know what? I understand that." That's the knowledge I gained from doing that. That's why my interest would go up.

Julie (female, uninterested) was more interested in figuring out scientific knowledge than learning science facts and concepts. She also tended to be more interested in science outside of school than in school. Being able to experience what happens through hands-on experiences was an important factor to account for her different interest levels in different contexts.

Interviewer: Why do you have higher levels of interest for area three and four compared to area one and two?

Julie: Because this is the hands-on stuff. To me, someone would learn something more by fixing the car than reading about how to fix their car. It's just the way our brain works. That's just me.

As far as students' personal motivational/emotional preferences, twelve students mentioned that they felt a stronger interest outside of school because they could choose what they felt interested in learning rather than being forced to learn something within the confined curriculum. Similar to the pattern of reasons about learning/understanding, eight out of these twelve students were in the uninterested group. In the following example, John (male, uninterested, area one: 2, area two: 4, area three: 3, area four: 4) indicated higher interest levels outside of school than in school. The main reason to account for this interest difference was that he felt he was an active free learner outside of school, whereas in school, he was constrained to learning certain things.

Interviewer: Can you talk about the difference between in school and outside of school?

John: ...I go to school. I do well in school, but the whole school concept seems confined. You are going to learn this. That's it. There is no time for you to say, "What about this?" You want to go over it, but you have to follow the curriculum. It's just very confining. I don't enjoy the school atmosphere very much. Outside of school, I am the teacher. I am the one who pushes myself to learn, so I am following a track here. If I find something really interesting, I can split off, then come back to the original idea. It's almost relaxing. One I look at as doing work, doing a job to figure this out. You have to do it. Otherwise you don't get a grade, you don't pass a class, you get hurt later on in your life. One is enjoyment. You can do it without thinking of it as a job. You can do it on a vacation, and it wouldn't matter. I always think you get more out of the one you do for fun, the one outside of school.

Edna (female, uninterested, area one: 2, area two: 4, area three: 1, area four: 5) also talked about how she felt pressured to learn in school, and free to learn outside of school.

Interviewer: Why do you have a higher interest outside of school?

Edna: Maybe because when I am out of school, nobody is really pressuring me to do it. It's not about a grade. It's just about me learning to understand and to figure out why

things happen. It's like not a professor saying "Remember this. It's so important. Know these graphs. Know these charts. Know this formula." I think it's just easier for me if I am learning about it on my own, rather than somebody telling me exactly what I should study, because some classes don't cover everything you want to know about.

Four students mentioned how pressure of failing in school lowered their interest in school. Again, three out of the four were in the uninterested group. In the following example, Derek (male, uninterested, area one: 2, area two: 4, area three; 2, area four: 5) definitely had higher interest levels outside of school. The pressure of failing played a role.

Interviewer: Why is area four more interesting?
Derek: It's more interesting because I know I can do it. I don't feel that I failed if I don't figure something out. I also accomplish more this way, trying to learn how things work and trying to fix things.

Anna (female, uninterested, area one: 2, area two: 4, area three: 2, area four: 4), similar to John and Edna, also pointed out that she had more freedom to choose what to learn outside of school. In addition to that, Anna also mentioned the pressure of "feeling dumb" in school.

Interviewer: Can you talk about the difference between inside school and outside of school?
Anna: Inside school, you have to do a certain thing. You have to watch a film strip when everyone else is watching. When you have to question about things, that makes you kind of dumb...Outside of school, you can learn. If you see a TV show about something you are interested in, you can watch a whole hour on just that.

In summary, the findings revealed that most students had different levels of interest in different areas of science. Students in the interested group had smaller variations among the interest levels across the four areas compared with students in the uninterested group. Reasons to account for the different interest levels fell into three categories: (1) reasons that had little to do with science, (2) reasons related to the learning process/understanding of science, and (3) reasons related to the student's

motivational/emotional preferences. Only students in the interested group offered reasons that had nothing to do with science itself. Students in the uninterested group often had reasons that were related to the very core of the process of learning and/or understanding of science as well as their motivational/emotional preferences. Contexts that facilitate meaningful understanding (rather than memorization), hands-on experiences (rather than merely being told), free choice (rather than being forced to learn certain topics), and relief from evaluation pressure tend to raise student interest.

Interpersonal Relationships and Interest in Science (R.Q.#2)

The second research question examines whether college students who are interested in science attribute their interest to interest-raising interactions with influential figures who were also interested in science and with whom they had a good relationship. My hypothesized answer was yes. The answer to this research question was also yes, at least for the majority of the participants. All 12 participants who were interested in science mentioned interest-raising influential figures. The influential figures mentioned were science teachers (by 10 students), parents or grandparents (by 4 students), and siblings (by 2 students). Nine out of the 12 students (4 males, 5 females) mentioned interest-raising influential figures as portrayed in the research question. The other three students mentioned interest-raising relationships or interactions which were different from what was portrayed in the research question. One male student mentioned interest-lowing experiences which involved some influential figures. Table 7 summarizes the characteristics of the interest-raising influential relationships mentioned by the participants in the interested group.

Table 7

Characteristics of Interest-raising Relationships Mentioned by Participants in the Interested Group

Name	Gender/ Interest	Influential figure	Inter-ested/ curious /excited about science	Practiced in a science related field	had a scien-tist's habit of mind	Demon-strated science can be useful/ related to life	had a good relation-ship with student	did not have too much relation-ship with student
Adam	MI	Father		x			x	
		Grandfather		x			x	
		Sci T		x			x	
Charles	MI	HS Physics T		x		x		
		Sister	x	x			x	
Mark	MI	College Prof	x	x		x		x
Richard	MI	Father			x			
Simon	MI	HS biology T		x			x	
Tom	MI	Father		x			x	
		MS & HS T		x			x	
Amelia	FI	HS biology T		x			x	
		Mother		x			x	
Andrea	FI	HS genetics T	x	x			x	
Linda	FI	HS biology T		x		x	x	
Melissa	FI	Surgeon		x		x		x
Rebecca	FI	ES Sci T		x				
		Brother					x	
Sarah	FI	MS Sci T		x			x	
		HS Sci T		x			x	

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

The interest-raising experiences the nine participants had with their influential figures often contained two components. First, the influential figures were often described by the students as "being interested in science" or as "a practitioner in a science-related field." Second, the influential figures and the students often had a good relationship with each other. The following examples illustrate the two common

components that characterized the experiences described by the participants who were interested in science.

R.Q.#2-1. Interest-raising Experiences with Influential Figures Who Were Interested in Science and/or Practiced in a Science-related Field

Charles (male, interested) described how his interest in science was raised because of his sister, who always liked science and talked to him about science. That made Charles want to go into a similar field. Charles perceived his relationship with his sister as supportive and caring, and thought that the relationship changed science from "something other people do" to "something someone close to me can do."

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

Charles: My sister. She always likes science. She's got a major in biology from the University of Michigan. She's three and a half years older than me...It influenced me. Because she's always interested in it, I became exposed to it, and became interested in it. When she went to college...she took a couple of classes about trees and learned to identify them without leaves, and to understand what happens to them during the winter. She talked to me about it. I thought it was interesting.

Interviewer: Can you tell me a little more about the change of your interest in science as a result of interacting with your sister? What did your interest in science look like before that experience? What did your interest in science look like after that experience?

Charles: I was probably interested in science before, but not to that extent. I didn't know whether I wanted to go into science or into business until I saw the stuff she was doing and how I was interested in the same thing. I wanted to go into a similar field.

Later on in the interview...

Interviewer: How would you describe your relationship with your sister?

Charles: Good. When we were young we fought all the time. When she went to college, we started to get along. She's supportive of me. She cares about me. She gets down on me if I am not doing what I am supposed to do.

Interviewer: Do you think that your relationship with your sister has anything to do with your interest in science?

Charles: Probably, because before science was always something other people did. When I saw her doing, she's someone close to me.

When Adam (male, interested) talked about the teachers who increased his interest in science, he stressed how well they helped students to understand science. He also emphasized the personal aspect of his relationships with teachers, which were characterized by mutual understanding and caring.

Interviewer:	Is there any person in your life who has affected your interest in science?
Adam:	Definitely my dad, also my mom's father...and my teachers. I had a pretty good teacher in the 6th, 7th, and 8th grades. A science teacher. He's real good with the kids, real helpful as far as getting the understanding between the science and the students. In high school I had a couple of good science teachers.
Interviewer:	What did they do?
Adam:	What interested me the most was hands-on kind of things. Not just doing it to get it done, but they helped you to understand what was going on, what the experiment was about. That's mostly what they did.
Interviewer:	Can you tell me a little bit more about your interactions and relationships with your teachers?
Adam:	In middle school, it was a private and small school. They could be real personal to students. They could be a friend as well as a teacher.
Interviewer:	Personal?
Adam:	You knew about each other. You knew how each person felt, what their true feelings were about. They were not just teaching for their paychecks.
Interviewer:	It seemed that they cared about students?
Adam:	Exactly.
Interviewer:	Can you come up with some adjectives to describe your relationships with your teachers?
Adam:	Friendly, helpful, personal.

Similar to Adam, Linda (female, interested) also mentioned a science teacher who raised her interest. Parallel to Adam's comment about how well his teachers helped students to understand science, Linda mentioned how this teacher made science "relevant to her everyday life." Parallel to Adam's emphasis on the personal aspect of relationship, Linda stressed that the teacher was nice, patient, personal, and went out of his way to help students understand everything, and how her experience with this teacher made her "like biology a lot."

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

Linda: My freshman year in high school, I had biology, and that was such a great class. I had a great teacher. That's probably why I am so interested in that now. We had dissections. I had never done it before.

Interviewer: What is it about that class that made it so special for you?

Linda: Probably because it seemed so relevant to my everyday life - more than I find in physics and chemistry. Those could be pretty confusing. I had a great teacher. He was really nice, really patient. He actually went here for graduate school. We had a lot of opportunities to have our questions answered if we were confused.

Interviewer: What was it about the teacher that made him a great teacher?

Linda: He was just a really nice guy. He was really easy to talk to. If you had any questions, you could always ask him. He never yelled at us once. He held review sessions. He went out of his way to make sure we understood everything.

Interviewer: Went out of his way?

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

...

Interviewer: Can you tell me a little more about the change of your interest in science as a result of interacting with that person?

Linda: I think I was interested in learning about biology before I got into that class...After that class, I liked biology a lot. I wanted to take another class.

Interviewer: Am I understanding it right that you had some interest in biology before you took that course, and you became more interested after the course?

Linda: Yeah.

Later on in the interview...

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

Linda: My teacher from that biology class.

Interviewer: What did he do?

Linda: He took time with the students. I think with some people, I know at least with me, it was a more personal level. I still see him now. He was like, "Come back and visit me. Tell me how you like State." Just like a really nice easy-going guy, he definitely knew what he was talking about.

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

Linda: When he lectured, usually he kept our interest. He always asked if we had questions. If we were working in a lab, we could just call him over for him to help.

Interviewer: How did he keep you interested?

Linda: He didn't have a monotone voice which puts me right to sleep. I don't know what it was. I wish he could teach other people how to do it. He had different overheads. We did watch some movies sometimes. I can't think of anything else right now.

Interviewer: Can you come up with some adjectives to describe your relationship with this teacher?
Linda: Supportive, helpful, easy-going.

Andrea (female, interested) described how her science teacher helped her experience science through various hands-on experiences, and how that got her to "think a lot more" about issues related to science.

Interviewer: Would you please tell me some of your major experiences with science?
Andrea: My genetics class. We bred those fruit flies. We counted them all, made all those diagrams...
Later on in the interview...
Interviewer: Is there anything in your life that has affected your interest in science?
Andrea: Probably that one genetics class I took. It got me to think a lot about how genetics affects people, animals, and plants... We also talked about extinction. That one class got me thinking a lot more about how things actually work. That was in junior high school.
Interviewer: Can you tell me a little bit more about the characteristics of that class that made you interested?
Andrea: I really liked the teacher. I had him for another class that was environment. I took that class the same time, the same year. In that class we took a wilderness trip. We took a five-day trip. I really liked that teacher. Just doing the fruit fly experiment. They were like my babies. I had them for the whole semester. I was so sad when they died. I guess it was just having my own experiment and learning about it, seeing it actually happen. They reproduced so fast. You could actually see the babies and what they looked like. I had one experiment that failed. They all died the first time I tried it. It was good though. I just liked the whole process.

With regard to her relationship with the teacher, Andrea stressed the personal aspect of it. She also mentioned various ways the teacher showed his care toward her learning through actions such as asking her about the experiments, reassuring her when she was frustrated, and being open to her suggestions.

Interviewer: Can you tell me more about this teacher?
Andrea: He was younger. He was enthusiastic. He was really interested in what we were doing, in our success and failure with fruit flies...
Interviewer: How did you sense that he was interested in your experiment?

Andrea: He just always asked us about them. He helped us with them. If we were frustrated, he reassured us. He would listen to you, respond to you. He was interested in everyone's project.

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

Andrea: Good. A lot of interactions in the classroom with everybody. He would walk around the room, stop at our tables, and look at our experiments and help us, point out things. He was always walking around. He wasn't just sitting at one spot. He was always coming to us. He had an office where we could go.

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, twenty students with him and another teacher for five days. We brought all the food for five days. We didn't see any other civilization. We ran canoes. That got to be pretty personal. We were addressing him on a first name basis. We were like friends. We were all out in nature. After that trip it was more casual, because we had spent a lot of time together...

Andrea also explained that one reason for her to become more interested in science through this relationship was that this teacher was excited about science and that was contagious and made her want to learn more too.

Interviewer: Can you come up with some adjectives to describe your relationship with the teacher?

Andrea: Exciting. He always has some crazy stories to tell you...He knew how to relate to kids really well. He would talk to us just like we talk to one another,...He was also really open to new ideas and suggestions, like one day it's really nice outside, "Can we go outside?" "Sure," he was open to kids' suggestions.

Interviewer: Were those crazy stories related to science?

Andrea: Yes.

Interviewer: Do you think your relationship with this teacher has anything to do with your interest in science?

Andrea: Yes. He made the genetics class interesting. It could have been really boring, just reading a book. He was so excited about science and learning stuff. It was contagious. It made you want to learn stuff too.

R.Q.#2-2. Interest-raising Experiences with Influential Figures Who Had a Scientist's Habit of Mind

Although the pattern revealed in the findings about students in the interested group was consistent with the prediction from the guiding hypothesis, not every single student's experience fit this pattern. Three students in the interested group had their own developmental profile which was different from the hypothesis. One male student reported an influential figure who might not have been particularly interested in science, but had a habit of mind which was similar to that of a scientist. After Richard (male, interested) and I had finished all the questions on the interview protocol, he somehow started talking about his father. He 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.

Richard then described how the experience with his father affected his interest in science. Although his father's questioning attitude had frustrated him for several years, it seemed to also have helped him to mature in his scientific thinking, which I know constitutes an important part of his current life from his other comments such as "My girl friend 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."

Interviewer: Do you think that has anything to do with your interest in science?

Richard: I definitely think that it does. My father telling me that you don't know it's necessarily true, as a kid it burned me up inside. I wanted to pull the string and say, "See? Daddy, it's just here." He would give me the same answer. Then I

went through a period that I didn't share anything with my father. I got tired of him saying that to me. Then I came to a point that I got some evidence to back up and support what I was telling him, claiming. It seemed that he would believe me a little bit more. It was when I was 15 or 16. From 6 to 12 was more like I was telling him things, and him saying "It's not true."

Interviewer: Is your father interested in science?

Richard: I know him, but I don't know his interests that well. But when we watch a nature documentary, the man in the nature documentary would say, "The female lion felt guilty for leaving her cubs there." My father would say, "The lion cubs' mother doesn't feel guilty. She doesn't have feelings." My father is a very reasonable man. He looks into a lot of things. I think my father's life is very oriented to the way science is. He really doesn't believe anything until he sees it in front of him. He can grasp the idea that is actually happening, but as for his interest in science, I am not sure whether he has any.

Interviewer: How would you describe your relationship with your father?

Richard: Very informal. The conversation, when we have one is very one-sided now when I am older. There are very few things we talk about. It is either about my financial situation, how I am doing in school, and hockey.

Interviewer: How about when you were growing up?

Richard: I have two brothers and one sister. My father seems to be closer to my sister and my brothers than to me. I think it's because I have a lot of disconcerting points of view my father doesn't necessarily share. We have ideals and beliefs that differ. We argue about them. My father and I are close but it is a strange closeness. I stay close to him just because he's my father.

Here one can see that although Richard was not sure whether his father was particularly interested in science, he believed that his father had an impact on his interest in science. Richard's father asked him questions that pushed him to re-examine the evidence he had and the thinking process he went through for his claims. This seems to have installed the scientist's habit of mind into his way of thinking, and thus he became "highly believing in science."

R.Q.#2-3. Interest-raising Experience with Influential Figures with Whom the Student Did Not Have Too Much Personal Relationship

A male student said that a professor was influential in promoting his interest in science. However, it was mainly because his lectures helped the student to see how science could be applied to daily life. There was not too much interpersonal relationship involved.

Interviewer:	Is there any person in your life who has affected your interest in science?
Mark:	The college professors I have right now.
Interviewer:	A particular one?
Mark:	My psychology professor right now. He makes everything easier to learn. He uses a lot of examples that apply to my daily life.
Interviewer:	Can you give me an example?
Mark:	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. He was talking about the scientific effects of alcohol on motor skills.
Interviewer:	How would you describe your interaction with your psychology professor?
Mark:	I don't know him that well. I only talked to him once or twice.

A female student mentioned someone influential in her development of interest in science. This person demonstrated how science could help people in ways that were amazing to the student. Although there was not too much interaction and relationship between that influential figure and this student, the experience raised her interest in science with a very strong and long-lasting effect.

Interviewer:	Is there anything in your life that has affected your interest in science?
Melissa:	When I was younger, around seventh grade...I was playing the soccer game, and broke my arm. I had to go to a surgeon. I thought it was just so amazing that he made a little cut in my arm, put on something, and ... I just thought that was so amazing... Before I broke my arm, I always wanted to be a teacher. It's like every child wants to be a teacher, since it's a big role model. After I was in so much pain for my arm and he fixed it, it wasn't even as bad as it was supposed to be, I was like, "Wow! This is pretty amazing stuff." Then I just wanted to learn about that.

Interviewer: Before that would you say that you were interested in science, but in a different way, or you were not that interested in science?
Melissa: I was only interested in ...like the nature. It's just like a child's thing.
Later on in the interview,
Interviewer: Is there any person in your life who has affected your interest in science?
Melissa: That surgeon.
Interviewer: How would you describe your interaction with him?
Melissa: He was really successful. It was like the American dream, get tons of money and stuff like that, but it wasn't totally that. The other thing was that he was totally outgoing, really nice, comforting even when I was in so much pain. I just thought it was amazing how I just went in surgery four hours after breaking my arm, and it was completely fixed when I woke up.
Interviewer: Did you have opportunities to interact with him a little more?
Melissa: Yes. Afterwards, I had to go to therapy for about a month. Coming to the office, I saw other things he had done, like repairing hips and stuff like that.
Interviewer: Interaction?
Melissa: No. It's very limited.
Interviewer: And there is no real relationship?
Melissa: No. It's not like that at all.
Interviewer: In terms of affecting your interest in science, how important is this event?
Melissa: Probably very. After that, it was all I wanted to be when I was older.
Interviewer: Does it have a pretty long-lasting effect?
Melissa: Yes, I will have to say.

In summary, all twelve participants in the interested group mentioned interest-raising experiences in which one can easily identify at least one heavily involved influential figure. Nine participants' experiences with their influential figures were consistent with the prediction from the guiding hypothesis. The other three had relationships or interactions with the influential figures which were different from the hypothesis' prediction.

Interpersonal Relationships and Lack of Interest in Science (R.Q.#3)

Research question #3 examines whether college students who are uninterested in science perceive a lack of interest-raising interactions with influential figures who were

interested in science and with whom they had a good relationship. My hypothesized answer was yes. However, the findings were not so straightforward. Five (3 male, 2 female) out of the 12 students who were uninterested in science fit this prediction of the hypothesis perfectly. These five students did not mention any interest-raising interactions with others who were interested in science. Yet the whole picture revealed by the students' experiences in the uninterested group was more complicated than what was suggested in the hypothesis. The other seven students (3 male, 4 female) in the uninterested group all reported interest-raising experiences that were very similar to the experiences reported by the students in the interested group. Four students (1 male and 3 female) described interest-raising experiences with influential figures who were interested in science and with whom the student had a good relationship. Three students (2 male and 1 female) described interest-raising experiences with one influential figure who was not particularly interested in science, but had a habit of mind which was similar to that of a scientist. Three students (1 male, 2 female) mentioned interest-lowering experiences accompanied by a negative relationship with influential figures who practiced in a science-related field. The results suggest that it was not that the students in the uninterested group completely lacked interest-raising experience in their life; it was rather possible that their interest-lowering experiences outweighed their interest-raising experiences. Table 8 summarizes characteristics of the interest-raising relationships mentioned by the participants in the uninterested group.

Table 8

Characteristics of Interest-raising Relationships Mentioned by Participants in the Uninterested Group

Name	Gender/ Interest	Influential figure	Interested/ curious/ excited about science	Practiced in a science related field	Had a scientist's habit of mind	Demon-strated science can be useful/ related to life	Had a good relation-ship with student
Brice	MU						
Bert	MU						
Derek	MU	Mother	x		x		x
David	MU						
John	MU	Father			x		x
Martin	MU	Sci T		x			x
Anna	FU	Brother	x	x		x	x
Angela	FU						
Edna	FU	Cousin	x	x		x	x
		HS astronomy T	x	x			x
Elza	FU	HS physics T		x		x	
Julie	FU	Mother					x
Theresa	FU						

MI: male interested, MU: male uninterested, FI: female interested, FU: female uninterested
HS: High School, Sci: Science, T: Teacher(s)

In the following sections, I will first give examples of interest-raising experiences with influential figures who were interested in science and/or practice in a science-related field. Then I will give examples of interest-raising experiences with influential figures who were not particularly interested in science, but had a scientist's habit of mind. Then I will give examples of interest-lowering experiences accompanied by a negative relationship with influential figures who practiced in a science-related field.

R.Q.#3-1. Interest-raising Experiences with Influential Figures Who Were Interested in Science and/or Practiced in a Science-related Field

Before discussing the interest-raising experiences with influential figures mentioned by the participants in the uninterested group, it is important to note that the participants in this group often appeared quite interested in science or in a certain area of science when they talked about their interest-raising experiences. They were coded in the uninterested group because that it was the way they identified themselves when they signed up for the study. From Table 5, we have already seen that although they belonged to the uninterested group and tended to have a low interest for learning science facts/concepts in school, their interest in science was not non-existent. In their comments about the interest-raising experiences with influential figures, we will see how these experiences were related to their existing interest in science.

Martin (male, uninterested) talked about how his "upbeat" science teachers made him more interested in science by "bringing life to the class and putting energy into it."

Interviewer:	Is there anything in your life that has affected your interest in science?
Martin:	My religion...
Interviewer:	Anything else?
Martin:	Maybe the teachers I had.
Interviewer:	Particular ones that you think are influential?
Martin:	Yes, the teachers who had a more upbeat atmosphere.
Interviewer:	Upbeat?
Martin:	They wouldn't just get up and drag. They were like, "Bring a bottle tomorrow." Then "Today we are going to mix ..." You know people who actually brought life to their class, put energy into it.
Interviewer:	What exactly did they do to bring life or to put energy?
Martin:	They made more class participation things that weren't graded, so you could get a feel for the subject, instead of getting tense like, "I have to do this. I have to do that right. My grades depend on this."

Later on, Martin explained how these teachers let him participate in science without feeling the pressure, and how that helped him understand science was not a "set thing," and there could be "variations" in science. This seemed to have piqued his interest in science.

Interviewer: Can you tell me a little more about the change of your interest in science as a result of experiencing those teachers? What did your interest in science look like before that experience? What did your interest in science look like after that experience?

Martin: Before I had those teachers, science seemed to deal with a set thing, almost like a math problem. There are certain procedures you follow. Those teachers showed that there are variations. They kind of simplified some of the concepts, and showed that it's not just one set thing. It's a broad spectrum of things you can do.

Interviewer: What does it mean to be set? What are the variations?

Martin: For example, some people might discuss electrons, protons, and neutrons, the nucleus in atoms, etc. They never do anything for you to see the protons and neutrons in action. For the better teachers, they actually showed you something or let you participate in something, and they didn't grade it. It was just to pique your interest. They relieved pressure.

Interviewer: When did you have the three good teachers?

Martin: Mainly in high school, I had two of them in high school.

Interviewer: How would you describe your interaction with your teachers?

Martin: It was a good interaction. They were very humorous, which I like. They had a light-hearted atmosphere, so it didn't feel like that you were just sitting there for them to lecture you. They let more of their personality shine through, but not too much to overshadow what they were doing.

Interviewer: Letting personality to shine through?

Martin: Like they let a girl touch the ball. They were like, "Okay, now her hair is about ..." They took a big ruler just so you could see how high it went up. I mean it's just something that they brought their own aspects to the experiment. They didn't just do it. Or like, "He has a good one," and showed kids that.

About his relationships with his teachers, Martin emphasized how the teachers were "open" to the students, interested in what the students were interested in, and responded to the students' desire of wanting to know in helpful ways even if what they wanted to know was not in the planed curriculum. These relationships, Martin thought, definitely made a difference to his interest in science.

Interviewer: How would you describe your relationships with these teachers?

Martin: It was a good relationship.

Interviewer: Can you come up with some adjectives to describe your relationships with your teachers?

Martin: It wasn't totally like I was a teacher's pet, or it was just me. They were open to the whole class. They were open for sometimes even a discussion, something they didn't plan on discussing in class. They liked to hear our points of interest, like what we wanted to know about. Like he mentioned electrons. Somebody wanted to know why is it that when I walked on the carpet...they would discuss it even though it's not part of the actual class.

Interviewer: Do you think your relationships with these teachers made a difference to your interest in science?

Martin: Definitely. If I hadn't had those kinds of teachers, and if the things that I remembered really stood out as something that made me enjoy science class hadn't been there, I would have probably just took it as just another science class, just another set of things and materials to memorize.

For Edna (female, uninterested), her interest in science was highly influenced by her cousin, who was always interested in science and was studying in a science-related field. The cousin often shared his enthusiasm and knowledge about science with Edna in an atmosphere that made Edna "just want to know."

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

Edna: My cousin. He goes to U of M. He is studying to be a psychologist and he wants to be a psychiatrist too. He had a telescope. We were just looking at the moon. He pointed out the stars. This was the first time I ever knew that there were volcanoes on the moon. There was something he was telling me. It was really fascinating to find out about the twin two moons, and it had ice chunks in it, the temperature and stuff. He was really smart when he came down to that. He was telling me about it when we were looking. It was just interesting, because it wasn't going to be on a test. It was just something that I just wanted to know. He was like, "This is why this is like this." When my grandmother passed away, my first grandmother, he was telling me what had happened...and how cancer just eats through your body, until none was left, how your fighters inside your body just couldn't fight any more. That stuff was really interesting. He just broke it down to dummy terms. It was easy for me to understand, because when he talks to his friends about it, I don't understand what they are saying, but when he broke it down for me term after term, I knew exactly what he was talking about. I can understand it a lot better than I did when I was in school. He's constantly watching all kinds of television - talking about plants and animals, what they do. He watches all that. When I have science class, I ask him to tutor me.

Edna further contrasted how she used to hate science in class, and how her cousin's enthusiasm and style of sharing, questioning, and showing raised her interest in scientific issues that he was talking about.

Interviewer:	Can you tell me a little more about the change of your interest in science as a result of interacting with your cousin? What did your interest in science look like before that experience? What did your interest in science look like after that experience?
Edna:	Before he told me, I just hated it. Every time he would come over, it would be something new that had happened. He would read the paper, and say, "Can you believe it?" I would be like, "What are you talking about?" He was like, "Don't you know such and such? This does this, and that's why this happened." When it started getting warm, he called me to tell me something's happening, why we are receiving warmer weather. He said, "The temperature of the water is rising. It can cause floods." Since he told me, I now know that. I am still interested when he tells me about it. I want to know more opposed to when I am in class. I am sitting there for hours trying to keep my eyes open.
Interviewer:	How would you describe your interaction with your cousin?
Edna:	He influenced me.
Interviewer:	How?
Edna:	Just showing me. It was more just we would read. He's like, "We will read, then I will let you see exactly what I am talking about." Instead of saying like teachers do, "Just read this chapter, and we will talk about it tomorrow," he would be like, "We can read this, and then when we go out, I will show you exactly what they are talking about." He gets National Geographic. He would be like, "Read this article. Read this article. I am going outside. I will show you." Like he had done some experiments about some water, or something...He was like, "Okay, you see this water." We went down to the Detroit River. He was like, "Put your hand in here. Now feel this." You know, just crazy stuff. He was like, "Right now there are so many little things in your hand. You just don't know." We took some water home. He put it under his microscope. He took samples. We looked at it. It was just like interaction. You can touch. You can feel. You can read. You can understand it better.

Edna described her cousin as helpful, sweet, caring, and understanding. She then talked about how he had always helped her in science as well as in other issues in her life, and

how much she would like to be of help to him. Edna also made the assertion that the relationship with her cousin raised her interest in science.

Interviewer:	How would you describe your relationship with your cousin?
Edna:	He is my best friend. He helped me do science.
Interviewer:	Can you come up with some adjectives to describe your relationship with him?
Edna:	He's helpful, sweet, caring, understanding. He's smart, (Edna started crying) and I love him.
Interviewer:	Why are you so touched?
Edna:	Because he would help me when nobody else would help him... When I had nobody to talk to, I could talk to him. He helped me out. He showed me ...I don't know. We are like buddies. Like a lab, or anything he can help me out. He would set his time out to help me out.
Interviewer:	Do you see him often?
Edna:	I try to see him as often as I can. Because he is at U of M, he's always studying. I try to talk to him. He's like having problems now. It really hurts me that I can't be there to help him, because he helped me so much.
Interviewer:	Were you always close when you were little?
Edna:	Since he was born.
Interviewer:	Do you think your relationship with your cousin affects your interest in science?
Edna:	Yes, because he just makes it interesting. He would just show me step by step. He would show me this is how. He would explain it and explain it until I understood. Other people just don't have time for it.

R.Q.#3-2. <u>Interest-raising Experiences with Influential Figures Who Were Not Particularly Interested in Science, But Had a Scientist's Habit of Mind</u>

With the same reason mentioned in the previous section (R.Q.#3-1), the examples given by the participants in the uninterested group discussed in this section are also indistinguishable from those given by the participants in the interested group. They are about interest-raising experiences with a certain kind of influential figures related to their existing interest in science.

Similar to Richard's (male, interested) father, John's (male, uninterested) father did not seem to be particularly interested in science. Yet he pushed John to question everything he believed, and to strive for deeper understanding by asking "why."

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

John: My father. I used to be kind of like...someone told me something. It's a fact. It's true. This table, is the most solid thing in the world, as solid as a rock. Nothing can get through it. I guess he took Socrates...He taught me to question everything, like the table is not as hard as everyone thinks it is. There is a lot of space in it. He brings out little facts and information. If you take out all the space between protons and all that, and bring that all together, all the marker can fit into the head of a pin. It's just amazing there is that much space in things that seem to be so hard.

Interviewer: It seems that your father tends to ...

John: He pushed me like, "Why?" Like this paper ...(John was bending the paper in a certain way.) why doesn't it break when you do that?

John talked about how his father's attitude became his attitude, and how this "questioning" attitude related to his interest in science.

Interviewer: So he was doing that throughout your life?

John: It rubbed off. He does it quite a bit, and I have picked up on the trait by watching him.

Interviewer: Why is that making you more interested in science?

John: Because it doesn't let me slide. I have to always figure out for myself. It's kind of hard once in a while.

Interviewer: Anything else?

John: He has always taught me not to accept things as you see them on the surface...If you want to understand them, you have to look at them extremely close. You get to the point where it's almost a part of you to really understand it, then you get by.

Interviewer: Can you give me an example?

John: You see things the way they are, like this is a pen. What makes this pen? How does it work? Basically it's a simple thing. Ink in the ball. Ink can spread out when you turn the ball. But human behavior, that's one of the main things I want to study. That's part of psychology. I have a class in psychology also. In reactions of people you can see them. You see them sad, and in order to understand why they are sad, you really need to know what happened. You have to be able to relate to them. If you cannot relate to them, you can't understand what's going on in their life. There is no way you are going to be able to help them.

Interviewer: What do you mean by relate to them?

John: Understand their problems.

With regard to his relationship with his father, John described how his father focused on kids and family, how he took him to places that enriched his experiences with nature, and how he shaped his character as a person.

Interviewer: How would you describe your interaction with your father?
John: High. There is a lot, always doing stuff. He's got a very busy job. It's been stress, stress, stress, but when he comes home, everything gets left behind. He focuses on kids and family. He's really good at that.
Interviewer: Can you tell me some examples of things you do with him?
John: We used to go on the ocean, to the volcano. He showed us all these cool things. We were taken to the middle of the forest to these pools of warm water. I was shocked. That's the way I learned about hot springs. He took us to this cave underground. It was completely dark. It's amazing. It's just cool like that.
Interviewer: Can you come up with some adjectives for your father or your relationship with him?
John: He is my teacher. Over my lifetime, he has taught me more about what is actually important than any teacher ever can.
Interviewer: What kind of things does he think is important?
John: You have to be honest with yourself, be true to people. He's taught me a lot about leadership. You can't lie. You have to do what's right even it's the hardest thing in the world for you to do. Be responsible for your actions, how to be honorable, be brave. He's the first to introduce me to "chivalry." It's a phrase that was used during medieval era. You protect those weaker than you. You always treat people like people. You never make yourself look or act like you are better than someone. People are always equal, no matter what has happened to them. You always help people who need it...A lot of people say chivalry is dead, because it just isn't happening. People step on people to get to the top. When the world was created, it was hoped that people could live this way. Instead of people stepping on people, it would be people helping other people out, and the strong would pull up the weak. That stuff seems very important to me. I don't see how people can hurt other people and go on thinking that life is perfect.

One can see that the influence John's father had on him went way beyond science. It was this most influential figure in his life that John was telling me about who had a scientist's habit of mind and that habit of mind had been adopted by John.

Interviewer: Do you think that your relationship with your father has anything to do with your interest in science?
John: Yes. Science to me is basically the study and research of things. If my father hadn't been the type of person he was,

I probably would have been just like a lot of people who just say, "That's that because of that. I don't need to learn any more. What I need to learn will come to me eventually." But he did teach the way he did. I go out. I am interested in jets and planes. I figure out everything I can. Just any interest I have, I just go and get it, and figure it all out.

Interviewer: In terms of affecting your interest in science, how important is your relationship with your father?

John: Very influential. Probably if he wasn't around, and I just went to class, I would be very similar to a lot of people, who just go and leave the classroom, go on to party.

Similar to Richard's father and John's father, Derek's (male, uninterested) mother was not particularly interested in science. Although she did not "push" Derek to think like a scientist like Richard's and John's fathers did, she had this "curiosity" toward knowledge, which was picked up by Derek.

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

Derek: I think indirectly my parents, probably my mom. Curiosity, I think I acquired from her, just being curious about different things, wanting to acquire different knowledge...

Interviewer: How did you acquire curiosity from your mom?

Derek: I don't know. It's probably genetic. She's more interested in things, wanting to acquire knowledge. I have always been that way about every subject, every aspect in my life. I have been curious about things.

Derek's mother was not only a model of curiosity, but also a supportive figure for what Derek was curious to know more about. She helped him collect materials he needed, acquire information he was interested in learning about, and get his questions answered. Her support, Derek claimed, was very important for his interest in science.

Interviewer: So it was more that you are like her, but not so much about her teaching you, or interacting with you?

Derek: 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."

Interviewer: It seems that you had a lot of questions and your mom responded in a helpful way. Can you say more about how she supported you?

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.

Interviewer: Do you think your interaction with your mother affected your interest in science?

Derek: Yes, because she's patient enough to answer questions. She would let me pursue my interest. She's open to whatever I want to do. Things that I need in classroom, she would help me with.

Interviewer: Is she herself interested in science?

Derek: No, not as much as I am.

Interviewer: So she's more supportive of your interest?

Derek: Yes.

Interviewer: How would you describe your interaction with your mother?

Derek: She's helpful. She's always open to any question. She let me explore, bought me a chemistry set, took me to the science places and book stores.

Interviewer: Can you come up with some adjectives to describe your mother?

Derek: Supportive and helpful in my learning. I think a lot of people's curiosity comes from an early age, being able to interact with parents in that way, especially science, if they don't get it in the classroom. I think curiosity is built up in little kids in a lot of things.

Interviewer: Do you think that your relationship with your mother has anything to do with your interest in science?

Derek: Yes, she was probably the one who kept me the most interested during certain points in my life... She was always open to anything I had to ask.

Interviewer: In terms of affecting your interest in science, how important is your relationship and interaction with your mother?

Derek: I think it's very important to have someone to go to, like a resource, somebody who will help me alone, just being supportive.

R.Q.#3-3. Interest-lowering Experiences Accompanied by Negative Relationships with Influential Figures

The data revealed that some participants who were uninterested in science not only perceived a lack of interest-raising relationships, but also attributed their lack of interest to interest-lowering relationships with influential figures connected to science. In other words, the findings pointed out that influential relationships can work in the

interest-lowering direction as well as the interest-raising direction. Following are some examples of interest-lowering relationships.

When Bert (male, uninterested) talked about his developmental curve of interest in science, he mentioned one negative experience with a junior high school science teacher. Bert was not getting the help he needed from the teacher, and he was not receiving the grades he wanted.

> Bert: ...I think junior high really had an impact on my science, because one year I had a teacher I didn't like at all. It was very hard for me in that class. I didn't feel that I got a lot of help from him. He wasn't willing to offer a lot of help to any of the students. That was probably the only negative thing. But besides that, I would say the grades I would get back for what I was doing in science also discouraged me from science, because I have always liked my grades to be high. Science was always a struggle for me. I wasn't getting the grades I wanted, so I wasn't interested after that.

Bert further explained that the problem was not inherent in the materials to be learned. It was more due to the fact that the teacher did not provide help when it was needed, and that discouraged him from even asking for help any more.

> Interviewer: When you said the class was hard, do you mean the materials or the atmosphere?
> Bert: I think it was more the atmosphere. I don't think the material was necessarily something I would never be able to understand. I think just the way he had us go about doing it. He would lecture one day. We would have to take notes, but we were in the seventh or eighth grade, we didn't even know what a lecture was when you were just put into a junior high school. I remember for maybe a month, we had a series of experiments to do. Maybe they were not experiments, just projects. I think we had twenty. You had to get the one completely right before you go on to the next. When you asked him questions...he would throw the questions back on you. It's like I didn't even understand in the first place, how am I going to ...He wouldn't give a direct answer, so it was discouraging to even ask him any questions. I didn't enjoy that.

Although Edna (female, uninterested) had a cousin who increased her interest in science, most of her school experiences lowered her interest. Here she talked about how

hard it became for her to understand and care about science in school, even though she started out with the curiosity to know more about the world.

Interviewer:	Is there anything in your life that has affected your interest in science?
Edna:	I lost interest in science in high school, because it was getting so hard. I just couldn't understand it. Some kids can understand it. They really enjoyed it... I didn't want to be there. It just made it even harder for me.
Interviewer:	What did your interest look like before that?
Edna:	Before I was really interested. Basically they always tried to find cures and stuff like that. I was like, "If I can find a cure, I can be famous." It was just a lot easier. I wanted to know how we evolved, and about the environment that we were in, what's going on in the air. Like our teacher told us there are so many micro-organisms in the air. It just amazed me.
Interviewer:	What did your interest look like after the hard courses?
Edna:	I was like, "Wow, this is a lot to know. This doesn't interest me any more." It was so many facts thrown at me. Maybe it was like every year I went to a different high school. Some professors didn't care if you understood it or not. It was just like, "Here. This is what it does. Remember it for the test." It wasn't interesting for you to just know, just like you know other things like basketball or football. It was just not interesting for me to even know anymore. It was just like I don't understand it. Okay. I know there is stuff in the air. I was taught all this. They get more technical, trying to tell you what is in the air is this, and they get this from this. If you know that, that's all it is. There is nothing else behind it. That's just all it is.

Edna explained that school science had been hard for her, because there were too many facts thrown at her with no time for discussion and questions. Passing the tests seemed to become the only reason for learning. After a while, she just did not care about it any more.

Interviewer:	Am I understanding you right that it seems that in earlier years, you thought it was fascinating that there are so many organisms in the air, and you wanted to learn more about that. Someone might say that your high school courses were helping you to learn more about that, but you felt that they threw too many facts at you just for the purpose of tests. It seems that that's all. There is nothing beyond that. It's not leading to anything more interesting...
Edna:	Right. They were just like no discussion, no why they are there. It was basically the way the teacher taught it, like "It's here because of this." There wasn't time for

questions. It was just like, "This is why it's here. Remember it. This is important for the test." So you would just write down notes why it's important. Soon it became such a habit, you just write down notes and... you don't even know what you were writing, so when it's time to remember for test, you just look at your notes, and say "Okay, this is what he's talking about. Remember it. That's all." You know, you had interest in other things, like, are you going to make the cheering team, or the boy behind you is cute. You just don't care about it any more.

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

Edna: Just teachers. The way they teach it...You have to understand it to really be interested in it, or it has to be something that you already are interested in and you want to know more about. 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." There is no motivation for the students to like it. I don't understand how people do it. I guess if you already know, you don't have to be motivated, you just find this ...interesting.

Edna also expressed how the "not caring" attitude of teachers made her lose interest in science.

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

Edna: Bitter, very bitter.

Interviewer: Why?

Edna: Because I can't tell them how they can teach their classes, or how they should write up their syllabus or what they want to concentrate on. They know they know. They have been doing the same thing for six years, doing the same boring... 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.

Interviewer: Can you come up with some adjectives for those teachers?

Edna: They are very educated, but they are bored teachers.

Interviewer: Can you come up with some adjectives to describe your relationships with the teachers?

Edna: It would be like non-existing. I would go up and say, "I don't understand this." They would be like, "Read chapter three. Just read it again. Just take notes." It wouldn't be an in-depth thing, because another class is coming in. They want to clear the room.

Interviewer: So your interaction with them was basically that they lectured, not too much face-to-face interaction?

Edna: Right.

Interviewer: Do you think that your relationship with your teacher has anything to do with your interest in science?

Edna: I think so, because I think they could have made it a lot more interesting - broke it down into terms so we can understand. Before putting it back in that term, they can use really really complex words, and they can just tell you exactly what it means, then they would start using that word, then they would just change, and you would know, because the repetition of them like, "This is a hemisphere. This is a hemisphere. This is something else. This is a hemisphere." I think it would be easier for me to understand. I think the reason that I do not like science is because all science teachers that I had were very boring, no relationship with the class. They just wanted to do their job. They just wanted to do what they were paid for, and they would leave. They didn't stay and try to motivate us more.

Then Edna described her vision of a good teacher-student relationship, which would be characterized by paying attention to the student, understanding the student, providing support for the student's learning when it was needed.

Interviewer: What would a good relationship look like?

Edna: Just interaction with the class, like know my name, know that I am trying. I am trying to understand. I am coming to you everyday after class. I want to talk about it. Take five minutes out. Tell me to meet you in the hall, like five minutes when you are taking a break, so I can just understand exactly what you are talking about. I guess it's just like you have to pay attention to all your students. I know it's hard. The ones who come to you with questions, you should not just brush them away. You should let them know exactly what they need to know. I don't think they should just like brush you away. You are just another student. They wanted to go home. They really didn't want to talk about it. They are tired. I can understand that, but when it's going to affect somebody, like me... I hate science just because of my teachers. When it's going to affect somebody, you should take some time out, because a lot of students don't even approach teachers like that...

Research question #2 and research question #3 each addressed one prediction from the hypothesis under examination. The results, as described above, indicate that although the prediction stated in research question #2 was consistent with the findings,

the prediction stated in research question #3 did not hold true for many students (7 out of 12). The findings related to research questions #2 and #3, on one hand, suggest that the hypothesis that guided this study only constitutes one possible mechanism for the development of student interest in science. There are certainly other mechanisms for students to develop an interest in science. On the other hand, the results do indicate that interpersonal relationships can play a role in many students' development of interest in science. Positive influential interpersonal relationships can start the interest (e.g., Edna's relationship with her cousin, pp. 81-83; Tom's relationship with his father, p 112-113), sustain the interest (e.g., Derek's relationship with his mother, pp. 86-87), and/or intensify/focus the interest (e.g., Linda's relationship with her high school biology teacher, p. 69-71; Melissa's relationship with the surgeon, pp. 75-76; Simon's relationship with his high school biology teacher, p. 106,115). Negative interpersonal relationships can kill the existing interest (e.g., Edna's relationship with her high school science teachers, pp. 88-91). In other words, the mechanism suggested in the hypothesis is a valid mechanism that has accounted for a significant number of students' development of interest in science. Therefore, it is worth exploring in more depth what qualities of interpersonal relationships have what effects on the development of student interest in science.

Qualities of Interest-raising Relationships and Interest-lowering Relationships (R.Q.#4)

Research question #4 examines the characteristics associated with relationships that facilitated the development of interest in science, and the characteristics associated with relationships that hindered the development of interest in science. During the interviews, nineteen students (6 male interested, 3 male uninterested, 6 female interested, 4 female uninterested) out of a total of 24 mentioned one or a few interest-raising experience(s) in which I could easily identify at least one heavily involved person(s). Four students (1

male interested, 1 male uninterested, 2 female uninterested) mentioned interest-lowering experiences which involved (an) influential figure(s). The total number of interest-raising relationships mentioned was twenty-seven. The total number of interest-lowering relationships mentioned was four. Using each piece of interest-raising or interest-lowering experience as a unit of analysis, I tried to understand the characteristics of the interpersonal relationships associated with the interest-raising experiences as well as the characteristics of the interpersonal relationships associated with the interest-lowering experiences. It was found that as the students described their interest-affecting experiences associated with an influential figure, they mentioned four kinds of information about the relationship: (1) how they perceived the relation between this influential figure and science, (2) how they perceived the ways the influential figure mediated the relation between science and themselves, (3) what emotions/motivations were conveyed and/or created between the influential figure and the students, and (4) how they perceived the personal aspect of the relationship between the influential figure and themselves.

One might wonder why I treated the above-mentioned four kinds of information as information about a relationship, because at first glance they did not seem to be all about a relationship per se. For instance, the first kind of information seemed to be about something between the influential figure and science, rather than something between the influential figure and the student. Some clarification will be provided here. The reason I treated the four kinds of information as information about a relationship came from Baldwin's idea of relational schema (1992). As discussed in Chapter 2, according to Baldwin, a student's perception of his/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 proved to be important when I tried 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 I describe findings with regard to each category.

R.Q.#4-1. 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 (Table 9).

Table 9

Relation between the Influential Figure and Science

Name	Gender	Influential figure	Practice in a science-related field (behavioral engagement)	Knowledge able/ smart in science (cognitive engagement)	Interested/ curious/ excited about science (motivational engagement)
Adam	MI	Father	x		
		Grandfather	x		
		Sci. T	x		
Charles	MI	HS Physics T	x		
		Sister	x	x	x
Mark	MI	College Prof	x	x	x
Richard	MI	Father			
Simon	MI	HS biology	x		
Tom	MI	Father	x		
		MS & HS T	x		
Brice	MU				
Bert	MU				
Derek	MU	Mother			x
David	MU				
John	MU	Father			x
Martin	MU	Sci. T	x		
Amelia	FI	HS biology T	x		
		Mother	x		
Andrea	FI	HS genetics T	x		
Linda	FI	HS biology T	x	x	
Melissa	FI	Surgeon	x	x	
Rebecca	FI	ES Sci. T	x		
		Brother		x	
Sarah	FI	MS Sci. T	x	x	
		HS Sci. T	x	x	
Anna	FU	Brother	x		x
Angela	FU				
Edna	FU	Cousin	x	x	x
		HS astronomy T	x	x	x
Elza	FU	HS physics T	x		
Julie	FU	Mother			
Theresa	FU				

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

The most commonly mentioned behavioral engagement with science of the influential figure was practicing or learning in a science-related field. Twenty-two out of the 27 interest-raising figures were described as practicing in a science-related field. Tom's (male, interested) father is one example.

Interviewer:	Is there any person in you life who has affected your interest in science?
Tom:	My science teachers, Mr. Wizard, and my dad.
Interviewer:	How did your dad affect your interest in science?
Tom:	I saw him go out to work everyday. I wanted to know what he did at work. He tried to explain, but I still don't understand that well...He's some kind of an engineer, doing satellite photos, remote sensing. They can look at satellite photos and tell where there is vegetation growing.

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. Sarah's (female, interested) biology teacher is one example.

Interviewer:	Is there any person in your life who has affected your interest in science?
Sarah:	My biology teacher, my junior year in high school. Ms. Kuhn, my junior year biology teacher. She's so smart, like some teachers you can really learn from, really absorb everything they are saying to you...
Interviewer:	When you say she is smart, do you mean she knows science well or she is smart in teaching?
Sarah:	She's both. She's very intelligent. She used to be a genetic engineer, I think. She's just a very intelligent woman. She can teach you if you want to learn. Her teaching methods are good too...When I did talk to her about science, it was like, "Wow! She is so smart." If I had a question, she would not hesitate to help. She would always help.

Five interest-raising figures were described as interested in science, or curious about science. This description reflected the motivational engagement with science of this person. The following two examples demonstrate the influential figure being interested in science or curious about science.

Interviewer:	Is there any person in your life who has affected your interest in science?
Charles:	My sister. She always likes science. She's got a major in biology from the University of Michigan...It influenced

me. Because she's always interested in it, I became exposed to it, and became interested in it...

* * *

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."...I don't know. It's just so interesting. I had a really good astronomy teacher. I think that's what really made me get into it...It was just really interesting, because he was so exited about the topic...When people are excited about something, it makes you think "Why is he so excited? Maybe I am not getting this. Maybe I will understand it." It makes you want to understand it more, or try to understand it, so you understand why he's so excited about it.

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, there was a complete lack of mentioning of 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 (male, interested) talked about why he was not interested in science before he came to Michigan State University, he mentioned that his high school teachers were not knowledgeable about science, did not seem to care about science, and that lowered his interest in science.

Mark: In high school my teachers were not that great.
Interviewer: What made your teachers not great?
Mark: Some of the teachers didn't major in any science course in my high school. They were basically reading from the teacher's edition book. They really didn't know that much about what they were talking about. It was hard for them to tell me what they were trying to say...
Later on in the interview...
Interviewer: Is there anything in your life that has affected your interest in science?
Mark: My teachers in high school were at least part of the reason that I didn't have an interest in science.
Interviewer: How did that affect you?

Mark: Like the teachers here, you can tell that they know what they are talking about. They are interested in it. They want you to learn what they know, so it's easier to learn. The teachers in high school, when they didn't really care about what they were talking about, it's hard for you to understand.

Interviewer: You mentioned that they didn't have enough knowledge, and they didn't seem to care. Can you talk a little bit more about each?

Mark: I felt that in my science classes, they really didn't have a high interest in science. They just seemed to read straight out of the teachers' edition book. They wrote the problems down on the board. They wouldn't discuss anything further than that. They didn't seem to be excited about it.

R.Q.#4-2. How the Influential Figure Mediated a Relation between the Student and Science

Twenty-one out of the twenty-seven 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 to experience science through first-hand experiences, and C, helpfully responding to the student's desire of wanting to know (Table 10). The meaning of each category will be further revealed by the examples given after Table 10.

Table 10

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 Pro	x		
Richard	MI	Father			
Simon	MI	HS biology T.		x	x
Tom	MI	Father	x	x	x
		MS& HS T		x	x
Brice	MU				
Bert	MU				
Derek	MU	Mother		x	x
David	MU				
John	MU	Father			
Martin	MU	Sci 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
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				

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

R.Q.#4-2.A. *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.

Interviewer: Is there any person who has affected your interest in science?
Mark: The college professors I have right now.
Interviewer: Do you have a particular one in mind?
Mark: My psychology professor right now...He makes everything easier to learn. He uses a lot of examples that apply to my daily life.
Interviewer: Can you give me an example?
Mark: 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. He was talking about the scientific effects of alcohol on motor skills.

* * *

Interviewer: Is there anything in your life that has affected your interest in science?
Elza: ...I had a really good physics teacher in high school...We were always doing different types of experiments, like bumping cars together. We would have homework assignments. Once my friend and I did it together. It was understanding motion. It was to play pull. I thought it was really fun, because it was something that applies to real life more to me. It would be more like something that goes on everyday...

R.Q.#4-2.B. *Helping the Student to Experience Science Through First-hand Experiences*

Sixteen interest-raising influential figures were described by the students as having done something to help the student obtain first-hand experiences in science by seeing, touching, and so forth.

Interviewer: Is there any person in you life who has affected your interest in science?
Simon: ...my high school freshman biology teacher....
Interviewer: How would you describe your interaction with this teacher?
Simon: We did dissections. She helped us to work with frogs and lab hearts. She would bring things and walked around to

let us see them. We measured openings of skulls. She gets you involved...

* * *

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

Andrea: Probably that one genetics class I took. It got me to think a lot about how genetics affects people, animals, and plants...

Interviewer: Can you tell me what characteristics of that class made you interested?

Andrea: I really liked the teacher...just doing the fruit-fly experiment. They were like my babies. I had them for the whole semester. I was so sad when they died. I guess it was just having my own experiment and learning about it, seeing it actually happen...

R.Q.#4-2.C. *Helpfully Responding to the Student's Desire of Wanting to Know*

Thirteen interest-raising influential figures were mentioned as responding helpfully to the student's desire of wanting to know.

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

Adam: Definitely my dad...

Interviewer: Can you describe your interaction with your father?

Adam: We were always real close. He helped me out. I have always asked questions. If there is anything out there I am interested in, he would at least try to answer my questions.

* * *

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

Derek: I think indirectly my parents, 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."

Interviewer: It seems that you had a lot of questions and your mom responded in a helpful way. Can you say more about how she supported you?

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.

* * *

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

Linda: My freshman year in high school I had biology, and that was a great class. I had a great teacher. That's probably why I am so interested in that now...

Interviewer: What about that class made it so special for you?

Linda: Probably because it seemed so relevant to my everyday life...I had a great teacher...We had a lot of opportunities to have our questions answered. If we were confused, he gave us reviews...He went out of his way to make sure we understood everything...

Again, a different pattern existed in the four interest-lowering relationships with regard to how the influential figures mediated the relation between the student and science. There was a complete lack of mentioning any of the three positive aspects in these four relationships. Opposite to interest-raising relationships, one interest-lowering figure was complained about for not providing hands-on experience to help students learn, another two figures were described as "not providing help when the students needed it." Edna's (female, uninterested) comments reflected a lack of hands-on experience; Bert's (male, uninterested) comments reflected a lack of help received from the influential figure.

Edna: When I got in high school, all my science teachers were just boring, boring, boring. We didn't go out of the classroom. If he said anything about organisms in the dirt, he wouldn't bring in anything. You have to motivate yourself to walk to the dirt to see exactly what he was talking about, but you wouldn't understand it.

* * *

Bert: When you asked him (junior high science teacher) questions, he would throw the questions back to you. It's like I didn't even understand in the first place, how am I going to...He wouldn't give a direct answer, so it was discouraging to even ask him any questions.

R.Q.#4-3. 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 is 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 (Table 11).

Table 11

Emotions/Motivations Conveyed/Created between the Influential Figure and the Student

Name	Gender	Influential figure	Showed enthusiasm in helping me learn science	Helped me experience wonder/ amazement in science	Challenged me with a high expectation
Adam	MI	Father			
		Grandfather		x	
		Sci T			
Charles	MI	HS Physics T	x		x
		Sister			
Mark	MI	College Prof	x		
Richard	MI	Father			x
Simon	MI	HS biology T	x	x	x
Tom	MI	Father			
		M.S & HS T	x		
Brice	MU				
Bert	MU				
Derek	MU	Mother			
David	MU				
John	MU	Father		x	
Martin	MU	Sci. T			
Amelia	FI	H.S biology T	x		
		Mother			
Andrea	FI	HSgenetics T	x		
Linda	FI	HS biology T	x		x
Melissa	FI	Surgeon		x	
Rebecca	FI	ES Sci T			
		Brother	x		
Sarah	FI	MS Sci T			
		HS Sci. T			
Anna	FU	Brother			
Angela	FU				
Edna	FU	Cousin	x	x	
		HS astronomy T	x	x	
Elza	FU	HS physics T			
Julie	FU	Mother			
Theresa	FU				

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

Ten out of the twenty seven interest-raising influential figures were felt by the students as "wanting the student to learn" due to the various ways they helped the students.

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.

Here 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 life. Andrea emphasized how her teacher would help her patiently until she understood better.

Interviewer:	How did your interest in science start?
Andrea:	Probably in high school, biology class.
Interviewer:	Why?
Andrea:	Probably because of the teacher...
Interviewer:	What did the teacher do to make you more interested in science?
Andrea:	I don't really know. I just thought, "He's a really good teacher."...I felt that he interacted with students more...
Interviewer:	Can you come up with some adjectives to describe your teacher?
Andrea:	Helpful, understanding, respectful.
Interviewer:	Can you tell me more what you mean by understanding?
Andrea:	Because most teachers, if you don't understand something, they don't even care. They would just be like, "I will go over it again," then "Go back to your seat." He was like, if you have a question, you don't understand it, he would explain it, do it over and over until you understood the concept a little better.

When Edna described the astronomy teacher who made her really interested in astronomy, she emphasized how he actively took the initiative to understand the difficulties of learning that students were experiencing, and to offer help.

Edna:	...He was just really interactive. He knew everybody. He knew what you were having trouble with. He would ask you, "Are you still having trouble with that? Let me try to explain that to you." He really liked teaching...

The sense of amazement or wonder was mentioned in episodes with five interest-raising influential figures. Following are two examples.

Interviewer: Is there any person in your life who has affected your interest in science?
Simon: ...my high school freshman biology teacher. She was hard. She challenged you, but she made it interesting. I got straight Cs in her class, but I never learned as much as I learned there in any other class...
Interviewer: Did you become more interested in science?
Simon: At first I felt overwhelmed. For a little while I thought this was a mistake. Then I started working toward what she wanted. Once I got it going, I realized that this can be interesting and fun, even when there's so much work. Freshman biology goes inside. It's just amazing all this is happening inside people. Yeah, I became more interested...

* * *

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 ...of 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/her to reach a higher standard, to figure out and to know more. John's father and Richard's father would be good examples to illustrate how they did it.

Interviewer: Is there any person in your life who has affected your interest in science?
John: My father. I used to be kind of like...someone told me something. It's a fact. It's true. This table, is the most solid thing in the world, as solid as a rock. Nothing can get through it. I guess he took Socrates...He taught me to question everything...
Interviewer: It seems that your father tends to ...
John: He pushed me like "why," like this paper...why doesn't it break when you do that.
Later on in the interview,
Interviewer: Why does that make you more interested in science?

John: Because it doesn't let me slide. I have to always figure out for myself. It's kind of hard once in a while.

Interviewer: Anything else?

John: He has always taught me not to accept things as you see them on the surface, but if you want to understand them, you have to look at them extremely close. You get to the point where it's almost a part of you to really understand it, then you get by.

* * *

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 hear or see." Hearing that so many times as a child when I didn't have the reasoning to actually understand what he was saying, it frustrated me so to have my father tell me that it's not true. I thought I was sharing something important, something he would like to hear. 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.

Interviewer: Do you think that has anything to do with your interest in science?

Richard: I definitely think that it does. My father telling me that you don't know it's necessarily true, as a kid it burned me up inside. I wanted to pull the string and say, "See? Daddy, it's just here." He would give me the same answer. Then I went through a period that I didn't share anything with my father. I got tired of him saying that to me. Then I came to a point that I got some evidence to back up and support what I was telling him, claiming. It seemed that he would believe me a little bit more. It was when I was 15 or 16. From 6 to 12 was more like I was telling him things, and him saying, "It's not true."

Once again, there was a complete lack of mentioning any of the three 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. Edna's comments offer an example of it.

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

Edna:	Just teachers. The way they teach it...It's just like, "We are here. We are going to do our job, and we are going home." There is no motivation for the students to like it...
Interviewer:	How would you describe your interactions with those teachers?
Edna:	Bitter. Very bitter.
Interviewer:	Why?
Edna:	...They have been doing the same thing for six years, doing the same boring...They knew it's boring because half of the class was asleep, talking, or distracted, but they just kept 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.

R.Q.#4-4. Personal Aspect of the Relationship between the Influential Figure and the Student

Before I report the findings in regard to this aspect of interpersonal relationships, I would like to first describe a challenge found in the process of data analysis of this part. When the participants talked about their experiences with the influential figure(s), they mentioned many things that happened between the influential figure(s) and themselves. The participants used various ways to describe these experiences. Finding patterns among these personal stories proved to be particularly challenging for me as a researcher, because every person seemed to be describing his/her experience in his/her unique way. Many words were used by the participants, yet it was hard to categorize them. For example, one participant might have described his teacher as "always patient;" another participant might have said her teacher was "warm and helpful," while the third person might have said his mother was "supportive." It was hard to decide whether these characteristics should be treated as similar or as different during the analysis. A decision was made when I recognized this challenge. I decided to avoid becoming lost in the large number of adjectives and other descriptions used by the participants, and try to step back and look for a few somewhat higher-level and more meaningful concepts to categorize what I saw in these students' stories with their influential figures. As a result of this effort, I realized one thing. The students mentioned many things that happened between

them and the influential figure(s). These things vary a great deal regarding the extent to which they were directly related to science learning. Yet many of them shared a commonality: They seemed to convey a message to the student about how the influential figure saw the student. For example, when a teacher took a student aside to explain to him individually about the importance of doing homework, studying hard, and meeting a challenge, it was quite possible that the student recognized that the teacher saw him as someone important and someone carrying the potential to meet the challenge. When a teacher shared his own feelings about things with the student, it was quite possible that the student took it as a message that the teacher saw the student as someone worth making friends with, and the teacher was trying to promote their mutual understanding. I am aware that the "possible messages" that I saw were not 100% self-evident in the data. However, I believe that they are very plausible possibilities of messages that were conveyed by the influential figure to the student. In other words, the "possible messages" that I saw and used in my analysis were high inferences that I drew from the data. Yet I believe they were meaningful and legitimately-supported high inferences.

Based on the analytical method described above, three characteristics were identified with regard to the personal aspect of interpersonal relationships. I found that many relationships between the interest-raising influential figure and the student carried all or part of the following three qualities: A, caring, B, sharing, and C, launching (Table 12). A caring relationship is a relationship in which the influential figure made the student receive the message "He cares about me. Therefore, I am important in his eyes." A sharing relationship is a relationship in which the influential figure and the student liked to do things together, to reveal themselves to each other. In other words, they were sharing their lives with each other. A launching relationship is a relationship in which the student received a message "He sees my potential. Therefore, I can do better than I am doing."

Table 12

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		
Brice	MU				
Bert	MU				
Derek	MU	Mother	x	x	
David	MU				
John	MU	Father	x	x	x
Martin	MU	Sci. 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	
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				

MI: male interested, MU: male uninterested, FI: female interested, FU: female uninterested
HS: High School, M.: Middle School, ES: Elementary school
Sci: Science, T: Teacher(s), Prof: Professor

R.Q.#4-4.A. *The Quality of Caring*

Twenty out of the total twenty seven episodes with interest-raising influential figures were identified as containing the quality of a caring relationship. The ways the influential figure interacted with the student seemed to show the student that s/he and/or his/her learning was important, and the influential figure cared about him/her. 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 were all characterized by a lack of a caring attitude. The findings here support Noddings' idea that "if we want every individual child to become immersed in centers of care, to care about things we can endorse as significant, we must first care for each child." (1992). One example will be given from each of the four groups of participants to illustrate the characteristic of caring in the interest-raising relationships.

When Simon (male, interested) talked about his relationship with his high school biology teacher, he emphasized how much she cared, and how her behavior conveyed the caring message.

> Simon: ...She cared. She wanted everyone to do well...She went out of her way. She would come before school, stay during lunch, or stay after school to explain things to you. She gave us her home phone number. A lot of teachers wouldn't do that. She was accessible.

Derek (male, uninterested) talked about how her mother cared for him and his learning by responding to his desires for certain things, certain kinds of knowledge, or certain activities.

> Derek: ...Whatever book I wanted, she would be willing to get for me. She would be willing to answer questions. She would be patient with me. She stayed up late to watch whatever was on NOVA, Mr. Wizard...She was open to whatever I want to do, things that I need in classroom, she would help me with...

Similar to Simon, Linda (female, interested) described how her high school biology teacher cared, and "went out of his way" to help students learn.

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.

Edna (female, uninterested) talked about how her cousin cared about her and was always willing to "set his time out" to help her.

Interviewer: Can you come up with some adjectives to describe your cousin?

Edna: He's helpful, sweet, caring, understanding. He's smart.

Edna started crying here.

Interviewer: Why are you so touched?

Edna: Because he would help me when nobody else will help him. When I had nobody to talk to, I could talk to him. He helped me out...We are like buddies. Like a lab, or anything he can help me out, he would set his time out to help me out...

R.Q.#4-4.B. *The Quality of Sharing*

Sixteen out of the total twenty-seven episodes with interest-raising influential figures could be identified as containing an element of sharing. None of the interest-lowering relationships contained this component. The sharing implied that the two of them liked to share their lives with each other. Some of the shared experiences were about science, while many others were about various things in their lives. One example will be given from each of the four groups to illustrate the quality of sharing in these relationships.

Tom (male, interested) talked about how he and his father always did science experiments and other things together in a loving relationship, and how that started his interest in science.

Tom: When I was three, four, or five, I always wanted to do science experiments with my dad. We mixed the whole

bunch of stuff together. I was having a great time. He gave me a book with science experiments you could do at home. We put the baking soda on the little thing, put them in water and watched them go around. I think that's how my initial science interest started...

Interviewer: How would you describe your relationship with your father when you were growing up?

Tom: Loving. He's my dad. We always did stuff together. We always built these model rockets. We launched them together. It was really cool....

Although John (male, uninterested) singed up for the uninterested group and reported a low interest for learning science facts and concepts at school, he appeared very interested in learning about certain science topics outside of school. John attributed this interest to his relationship with his father. From his description of this relationship, one can see how the two of them shared various learning experiences together. John learned a great deal in this sharing relationship. His father also picked up one of John's interests and made it his own.

Interviewer: How would you describe your interaction with your father?

John: High. There is a lot, always doing stuff. He's got a very busy job, but when he comes home...everything gets left behind. He focuses on kids and family. He's really good at that.

Interviewer: Can you give me some examples of the things you did with him?

John: We used to go on the ocean, to the volcano. He showed us all these cool things. We were taken to the middle of the forest to these pools of warm water. I was shocked. That's the way I learned about hot springs. He took us to this cave underground. It was completely dark. It's amazing. It's just cool like that.

Later on in the interview...

Interviewer: Does your father have other personal interests that you don't have or you have?

John: He picked up flying. He always knew I loved it. He wasn't quite sure. Then he said, "Well. I will see if I can do it too." He's now a good pilot...

Sarah (female, interested) 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. She liked to provide fun things for her students. She was in the RC club with me. I know she wanted to do fun things with us.

Anna (female, uninterested) talked about how she and her brother shared each other's life on a daily basis, how much fun they had doing that, and how their relationship affected her interest in social sciences.

Interviewer: Can you tell me more about your interaction and relationship with your brother?

Anna: He's basically my best friend. It's more like I am interested in some things, he's interested in these other things. When we go together, we just talk, talk, and talk about everything. We used to have a daily routine. Everyday I went to school and came back at night time. We went to the store together and got the same thing.

Interviewer: How old were you when you were doing this?

Anna: We have done this all our life.

Later on in the interview...

Anna: ...We can relate to each other. When we were together, we laughed. Everything is so funny. If I have a question I might be interested in, he can answer it. It's more like I know the math, he knows the science. It's fun to figure things out when you can put the two together...

Interviewer: Do you think your relationship with your brother affects your interest in science?

Anna: ...Yes in the social sciences, because he's a gay. I was the one who had to tell the family. I was the first person he told. That's what brought us closer together. It made me talk more about science, about things he is interested in.

R.Q.#4-4.C. *The Quality of Launching*

In seven out of the total twenty-seven interest-raising relationships, the influential figure was described by the student as someone who did things that seemed to convey a message to the student about the potential of the student - a potential that pointed to a higher or better 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. Following are two examples.

Simon (male, interested) talked about how his high school biology teacher helped him see how he could be a better student, and out of that experience, he did become a better student.

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, in addition to all the stuff I learned about biology.
Interviewer:	Did she help you individually or as a whole class?
Simon:	Both. She explained to the whole class, also to me individually. I am glad she did that. It really helped me. She cared. She wanted everyone to do well...
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 home work to be able to be accomplished in any field, and that class definitely helped me be interested in science...

Andrea (female, interested) talked about how her high school science teacher helped her see that she could achieve even though she felt unsure.

Interviewer:	Is there anything that has affected the development of your interest in science?
Andrea:	Probably that one genetics class I took. It got me thinking a lot about how genetics affects people, animals, and plants...
Interviewer:	What characteristics of that class made you interested?
Andrea:	I really liked the teacher...Just doing the fruit-fly experiment. They were like my babies. I had them for the whole semester. I was so sad when they died. I guess it was just having my own experiment and learning about it, seeing it actually happen...I had one experiment that failed. They all died the first time I tried it. It was good though. I just liked the whole process.

Here Andrea mentioned a failing experience with her fruit-fly experiment, yet she viewed it as a positive experience. This made one wonder why she viewed a failure as a positive experience. What Andrea said later on in the interview seemed to give a clue to it. Later on in the interview, Andrea revealed how her teacher reassured the students in situations when they were not so sure about what could be achieved.

Interviewer:	Can you tell me more about this teacher?
Andrea:	He was younger. He was enthusiastic. He was really interested in what we were doing, in our successes and failures with fruit flies...
Interviewer:	How did you sense that he was interested in your experiment?
Andrea:	He just always asked us about them. He helped us with them. If we were frustrated, he reassured us...

Andrea pointed out that the teacher reassured the students when they experienced a failure. In other words, the teacher conveyed to the students that they had the potential to reach a higher goal even though they were not reaching it yet. This seemed to suggest a plausible explanation for Andrea's positive attitude toward the failure mentioned earlier in the interview.

In summary, four qualities were found to be associated with interest-raising relationships: (1) The influential figures were often perceived by the students as having a positive relation with science. They were perceived as being engaged in science at the behavioral level, the cognitive level, and/or the motivational level. (2) The influential figures were often perceived to actively mediate the relation between the students and science by pointing out how science can be meaningful/interesting, helping students experience science through first hand experience, and helpfully responding to the students' desire of wanting to know. (3) The influential figures conveyed enthusiasm and created in the students a sense of wonder/amazement while doing science. (4) The influential figures cared about the students and their learning, liked to share his/her life with the students, and helped the students to see their potential as being higher than their

current performance level. Interest-lowering relationships were characterized as lacking these qualities.

CHAPTER 5

SUMMARY, CONCLUSION, AND DISCUSSION

In this chapter, I will first present a summary of findings. Conclusions and practical implications drawn from the findings will then be provided. Limitations of this study and ideas for future research will be discussed.

Summary of Findings

The present study examined four research questions: (1) What do college students mean when they say they are interested in science or uninterested in science? (2) Do college students who are interested in science attribute their interest to interest-raising interactions with influential figures who were also interested in science and with whom they had a good relationship? (3) Do college students who are uninterested in science perceive a lack of interest-raising interactions with influential figures who were interested in science and with whom they had a good relationship? (4) What perceived characteristics are associated with relationships that facilitated the development of their interest in science? What perceived characteristics are associated with relationships that hindered the development of their interest in science?

The findings of the study revealed that three aspects of science were addressed by the participants when they talked about their experiences, feelings, and beliefs about science: (1) the epistemological nature of science, (2) life relevance of science, and (3) science in relation to the student's ability. No differential pattern was found between students in the interested group and students in the uninterested group with regard to their understanding of the epistemological nature of science except that only students in the uninterested group described science as memorization. Students in the interested group saw science as more related to everyday life and more helpful to people compared with

students in the uninterested group. Only students in the interested group described science as something they were good at, while more students in the uninterested group described science as something hard to understand.

The findings indicate that the conceptualization of interest as a person's dispositional preference toward a particular domain of activities either for an intrinsic reason or for a self-determined instrumental reason was consistent with the participants' ideas and experiences of interest. The findings also indicate that interest in science is a rich and complicated entity. Most students had different levels of interest in the four different areas of science: (1) learning science facts/concepts in school, (2) learning science facts/concepts outside of school, (3) figuring out scientific knowledge in school, and (4) figuring out scientific knowledge outside of school. In general, the participants in the interested group were pretty much interested in the four areas of science, although their interest levels in different areas tended to vary a little. In contrast to that, the uninterested participants' interest levels for the four areas varied a great deal.

Research question #2 and research question #3 each addressed one prediction from the hypothesis under examination. The prediction stated in research question #2 was consistent with the findings. All twelve interested students said their interest either started with, or was increased by, some positive experiences they had with one or a few influential figures. Nine out of twelve students mentioned influential figures as predicted and portrayed in the hypothesis - figures who were interested in science and/or practiced in a science-related field, and with whom the student had a good relationship. However, the prediction stated in research question #3 did not hold true for many students. Although five out of the twelve uninterested students did not mention any interest-raising relationship, seven of them mentioned interest-raising relationships which were very similar to those mentioned by the interested students. The findings related to research questions #2 and #3, on one hand, suggested that the hypothesis that guided this study

might only constitute one of many mechanisms for the development of student interest in science. Yet on the other hand, the results did indicate that interpersonal relationships played a role in many students' development of interest in science. Positive influential interpersonal relationships can start the interest, sustain the interest, and/or intensify/focus the interest. Negative interpersonal relationships can kill the existing interest.

Four qualities were found to be associated with interest-raising relationships: (1) The influential figure was perceived by the student as being positively engaged in science at the behavioral level, the cognitive level, and/or the motivational level. (2) The influential figure mediated the relation between the student and science by pointing out how science can be meaningful and/or interesting to the student, helping the student to experience science through first-hand experiences, and helpfully responding to the student's desire of wanting to know. (3) The influential figure conveyed his/her own positive emotions about engaging in science, as well as created positive emotions in the student while they were engaged in science. (4) Between the influential figure and the student there existed a personal relationship which was characterized by caring, sharing, and launching. Interest-lowering relationships were generally characterized as lacking these qualities.

Among all the possible aspects of comparison, differential patterns between two genders were only found in two places: (1) With regard to life relevance of science, more female uninterested students than male uninterested students mentioned science helps people to solve problems and improve life. (2) With regard to how influential figures mediated the relation between students and science, more female uninterested students than male uninterested students mentioned "pointing out how science can be meaningful/interesting."

Conclusions and Practical Implications

This study had three purposes: (1) to understand the nature of college students' interest in science, (2) to explore whether college students perceived their interpersonal relationships affected the development of their interest in science, and (3) to investigate what qualities of perceived interpersonal relationships had what effects in the development of student interest in science.

With regard to the nature of college students' interest in science, the results indicated that student interest in science is a rich entity. The student who is uninterested in one aspect of science can be quite interested in another. Instead of viewing a student as being either interested in science or uninterested in science, it would be wiser for parents and teachers to put effort into understanding the content and profile of the student's interest. The current existing interest would be a good starting point for guiding the student in learning science.

This study also revealed that many students who identified themselves as uninterested in science actually looked very interested in some areas of science in some contexts. Yet they all had a low interest in learning science facts/concepts in school. Literature tells us that many students are not interested in science. This study tells us that when students identify themselves in terms of interest in science, they tend to focus on their interest in school learning of science facts/concepts. As mentioned by several students in the uninterested group, in their experiences, school learning of science fact/concepts involves a lot of memorization; and figuring out scientific knowledge in school often is not an authentic process of figuring out. Putting all these together, we seem to see a bigger picture, which indicates that many students identify themselves as uninterested in science, while what they are uninterested in is mainly memorization of science facts/concepts and unauthentic scientific processes. In other words, these students probably appear uninterested in science at school, while the school science they have experienced is not authentic science. This picture poses a challenge which should be reflected on by science educators. While considering issues related to student interest

in science, we need to be careful about our assumptions. It is important that we do not misjudge a student's interest in science based only on his/her interest in school science.

The findings also indicate that from the students' perspective, interpersonal relationships do facilitate or hinder the development of student interest in science in many cases. Although direct causal inferences can not be drawn from the data, this study revealed characteristics associated with interest-raising relationships and characteristics associated with interest-lowering relationships. For parents and teachers who want to facilitate the development of their children's/students' interest in science, the principles best suggested by the study would be as follows.

(1) Let the student sense that you are positively engaged in science yourself.

(2) Share the meaningful and interesting aspects of science with the student, help him/her to experience them, and be supportive of his/her inquiry.

(3) Convey positive emotions when you do science with the student.

(4) Show the student you care about him/her, like to share your life with him/her, and see his/her potential at a higher level than s/he sees his/her current self.

Discussion

Limitations of the Study

As pointed out in the literature review chapter, 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/her interest in the context of that relationship. Based on this assumption, the design of the study allowed the participants to talk about how they perceived their interest-raising and/or interest-lowing relationships with others. While analyzing the data, I chose to treat each relationship as a unit of analysis. When one participant had more than one influential relationship, these relationships were treated separately as individual episodes. Common characteristics were sought among all these interest-raising relationships or interest-lowering

relationships. This way of analysis posed a constraint in what could be seen from the data. It helped me see the effect of each interest-affecting relationship, but it did not allow me to detect the possible accumulative effect through multiple relationships.

Another potential limitation to consider is whether students who were interested in science tended to report stories about positive experiences (including interest-raising relationships), and students who were uninterested in science tended to report stories about negative experiences (including interest-lowering relationships) due to the tendency of people to construct stories which are consistent with their current identify (e.g., Hopper, 1993; LaRossa, 1995; Orbuch, 1993, 1997; Sternberg, 1995). Although this possibility should be kept in mind, I believe that this concern was not serious in this study for two reasons. First, inaccuracy of self reporting is likely to occur in two situations: (1) when there is a strong social expectation which specifies the right thing to say, (2) when the researcher is asking people about something they really do not know much about, so they have to make up responses that sound sensible. With regard to social expectations, the very fact that I was soliciting people who were either interested or uninterested in science should have suggested to the participants that it was okay to be uninterested in science. I also assured each participant before the interview that there were not certain accurate responses that I was looking for. Since this study was about their own interest in science, an area of study which they should have had at least several years of experience of, the concern for lack of knowledge should not be serious here. Second, the data revealed that many students in the uninterested group actually reported interest-raising experiences and relationships that were not expected from the guiding hypothesis. This lowered the concern that students who were uninterested in science would only talk about negative experiences due to their intention to report experiences that were consistent with their current interest level.

Several factors besides influential relationships may constitute alternative explanations for the students' different levels of interest in science observed in this study: self selection for participating in the study, ability in learning science, prior achievement in science, and the ability to reflect on their experience. If this study had taken a quantitative approach, these factors could have been treated as potential confounding variables. Since a qualitative approach was taken, and these factors were not addressed directly in the study, we need to keep in mind that all these factors might have influenced the findings in ways that we do not know. Speculations about the possible influence of each of these factors will be discussed.

The fact that potential participants knew that I was soliciting students who were either interested or uninterested in science might have influenced who chose to participate in the study. Yet we do not know in what ways the influence worked. One might suspect that this project could have been more attractive to people who were interested in science, since the project was in fact about science. The strongly uninterested students might not be interested in participating because they were simply not interested in anything related to science. This might be the reason why the uninterested group in this study still contained students who actually were interested in science in various contexts. In other words, there might be another group of students out there who were completely uninterested in science. Since they did not choose to participate, they were not represented in this study. However, one might also suspect that the project could have been attractive to students who were either strongly interested or strongly uninterested in science more than to students who were neutral in their feeling about science, because it should have been easier for the former to identify themselves with the characteristics asked for the study. It was also possible for the strongly uninterested students to be interested in an opportunity which might allow them to express their frustrations and complaints about science.

It seems reasonable to speculate that the students who developed a higher interest in science might be the ones who had a better ability of learning science, and/or the ones who had a higher achievement in science. Since this study did not assess the participants' ability to learn science, nor their prior achievement in science, it is hard to untangle the contribution of influential interpersonal relationships to their development of interest in science from the contribution of their learning ability and prior achievement. Future studies can use a design which matches students with the same learning ability and/or prior achievement in order to examine the contribution of influential interpersonal relationships independent of the other two factors.

One distinction needs to be made here about the discussion of learning ability and prior achievement. That is the distinction between what really was the case versus what the students perceived to be the case. Suppose a factor has influenced a student's development of interest in science. It does not necessarily mean that the student would perceive it as important in his development of interest in science. The above discussion about the alternative explanations and the future design that tried to control these alternative factors tend to put more emphasis on what really was the case. This study, nevertheless, had its emphasis on what the students perceived to be the case.

Another uncontrolled factor in this study was people's ability to reflect on their experiences and to perceive causal links. Even though the focus of this study was on perceptions, some people might perceive things more accurately than others. It is also possible that people do not perceive the significance of a certain experience until later. Since these factors were not controlled or tested in this study, they become factors we have to be aware of while interpreting the results.

Interpersonal Relationships and the Development of Domain-specific Interest

This study provides support that positive interpersonal relationships do facilitate the development of interest in science. The approach used in this study allows the researcher to see the qualities and effects of interpersonal relationships that are of importance to students in their own thinking. Considering the findings from this approach in the light of other studies investigating the relation between interpersonal relationships and various motivational outcomes will help us better understand the affecting power of interpersonal relationships on the development of domain-specific interest. Midgley and her colleagues have 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) has reported that student-perceived teacher support explained over one third of students' assessment of the interest, importance, and value of the academic work of that class. These findings have pointed out an association between teacher-student relationship and student interest in a related domain within a relatively short period of time. The present study, taking a retrospective approach, further strengthens the assertion that from the students' perspective, interpersonal relationship is an influential factor for the development of relatively long-term domain-specific interests. As pointed out by Goodenow (1993) and Wentzel (1997)), most effort of motivation research focuses on variables that describe the psychological functioning of a student, such as goal orientations (e.g., Ames, 1992; Dweck & Leggett, 1988), beliefs about ability (e.g., Bandura, 1986, Schunk, 1989), and beliefs about control (e.g., Stipek & Weisz, 1981; Weiner, 1992), and relatively objective aspects of teaching and instruction, such as

reward structures (Ames & Ames, 1984), and classroom organization (e.g., Rosenholtz & Wilson, 1980). The results of the present study support Wentzel's and Goodenow's insight that models of motivation based on psychological or instructional variables should be extended to include the students' perceptions of relationships with others.

Some qualities of influential relationships identified in this study are similar to the qualities found to be associated with outstanding science teachers in previous studies. The positive relation between the influential figure and science, the ways the influential figure mediated the relation between the student and science, as well as the ways the influential figure conveyed and created positive emotions about science identified in this study are similar to the findings by Vargas-gomez and Yager (1987) when they studied student attitudes concerning their science teachers in exemplary programs, and to the findings by Van Sickle and Spector (1996) when they studied science teachers who were particularly caring. With regard to students' attitudes toward their science teachers, Vargas-gomez and Yager found significantly more positive attitudes of students from the exemplary programs compared with students from randomly selected teachers in the following ways: (1) pleasure with student questions; (2) desire for students to explore their own ideas; (3) liking of science, and (4) ability and knowledge of it to make science study exciting. Van Sickle and Spector described how science teachers who were perceived to be caring built three kinds of relationships in their classrooms (teacher-student, student-student, teacher-content), and how the interaction and integration of these three kinds of relationships result in teacher-student-content relationships. These similarities suggest that interest-raising influential figures studied in the present study probably correspond to teachers whom people identified as outstanding and caring. The contribution of this study lies in the careful examination of the relation between the perceived influential figure-student relationship and the development of student interest

in science, a relation which was not addressed by the previous studies when they investigated the outstanding and/or caring science teachers' characteristics.

Given the assertion that positive interpersonal relationships facilitate the development of student interest in science, one observation in this study remains puzzling: many students who had some interest-raising experiences/relationships in science ended up calling themselves "uninterested in science." This makes one ask whether these interest-raising experiences/relationships are really important for their development of interest in science or not. I think two issues need to be addressed when we consider this question. First, the dualistic conceptualization of people as being either interested or uninterested in science needs to be re-considered. This dissertation project started with such a dualistic conceptualization, which led to the design of four groups (male interested, male uninterested, female interested, 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. In other words, even though one person belongs to the uninterested group in general, it does not necessarily mean that his 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 are not important. Quite the opposite, I tend to believe that without them, these people's current interest would have been even lower than what was reported in the study. This being said, it would still be interesting to further understand the reasons why these people with interest-

raising experiences/relationships did not develop an interest in science which was stronger than their current one.

Two things were noticed from the data. First, some students said that they thought their particularly good interest-raising experience with a particular influential figure might be just an exceptional experience. 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 about science and people in science stayed 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 the interaction of science, people in science, and the student's perception of him/herself in regard to science. Second, the data revealed that there were actually three kinds of development of interest in science: (1) Some people developed a strong interest in science due to interest-raising experiences. (2) Some people developed a low interest in science accompanied by a negative feeling toward science due to interest-lowering experiences. (3) Some people were simply never "turned on" to science, but did not develop a particularly negative feeling toward science either. The third kind of people were usually "turned on" to something else, and thus directed their time and effort toward that. A future study can further understand the experiences of people who were simply never "turned on" to science. Do they have experiences similar to what other people think of as interest-raising experiences? If yes, why did those experiences not turn them on? If they were simply turned on toward other domains but not science, what are the mechanisms that accounted for the development of interest in those domains? Do these mechanisms share similarities to what we found in the development of interest in science with people who are interested in science?

Motivational Zone of Proximal Development (MZPD)

As pointed out by Brophy (1998), there have been remarkable developments in theory and research on motivation in education, but we currently know much more about motivation in its expectancy aspects than its value/interest/appreciation aspects. We know how a person's sense of efficacy or expectations for success connect with related causal attributions for success and failure, emphasis on learning vs. performance goals, selection of strategies for accomplishing the task and managing failure and frustration, and so on. However, we know much less about how one's value/interest/appreciation for a particular domain gets developed.

To promote research in this direction, Brophy outlined some principles that might emerge as components in a model that addresses the value aspects of motivation in education. One of the two major principles outlined by Brophy is the idea of a "motivational zone of proximal development (MZPD)." Sociocultural educational models state that mediation by a more capable other can make a task that lies within the zone of proximal development appropriate as a context for mentor-guided learning, when the task might have been too difficult as a context for self-guided learning (Vygotsky, 1978). Brophy argued that we also need a motivational analog of the "zone of proximal development" concept to incorporate the idea that classroom teachers or other mentors can help learners begin to see the value in potential learning opportunities that they have not yet come to appreciate (and might never come to appreciate) on their own. This concept is particularly important for the development of value/interest/appreciation for an academic domain because academic learning often involves abstract concepts which are away from basic skills and obvious connections to the student's daily life. Brophy argued that in many cases, intrinsically motivated learning may not become possible for most students unless teachers help these students begin to appreciate the potential value in the domain and begin to explore it in ways that enable them to experience its satisfactions.

Based on Brophy's idea of a motivational zone of proximate development, we can say that if a learner's interest in science increased because of his engagement in a certain activity with a certain person(s), something must have worked in the learner's motivational zone of proximal development to promote his interest. The question becomes: What is the nature of that something? It would be good to take a detailed look at what happened in that motivational zone of proximal development. This study, in a sense, constitutes an empirical effort to examine what happened between the more capable other and the learner as they were engaged in science-related activities within the learner's motivational zone of proximal development. The design of this study allowed the participants a large amount of freedom to describe in their own ways what happened between the influential figure and themselves. The patterns reported in the findings mainly emerged from the data, rather than from a previously existing theoretical framework. Therefore, the patterns in the findings indicate what was important in the students' mind when they thought about their relationships with the influential figures. Due to the particular nature of this study, it provides empirical evidence to help us examine whether certain components suggested in the MZPD are actually important in the students' thinking.

Now let us consider the components of MZPD proposed by Brophy. Eccles and Wigfield (1985) suggested that subjective task value has three major components: (1) attainment value (the importance of attaining success on the task in order to affirm our self-concept or fulfill our needs for achievement, power, or prestige); (2) intrinsic or interest value (the enjoyment that we get from engaging in the task); and (3) utility value (the role that engaging in the task may play in advancing our career or helping us reach other larger goals). Building on this conceptualization, Brophy proposed a broadened version which included experiencing the satisfaction of achieving understanding or mastering a skill under attainment value, developing aesthetic appreciation of the content

or skill under intrinsic value, and gaining awareness of the role of the learning in improving the quality of one's life or making one a better person under utility value. Based on this broadened version of conceptualizing values, Brophy made a theoretical argument that creating motivationally optimized learning situations requires optimally mediated learning experiences through modeling, coaching, and scaffolding to enable students to learn with understanding, appreciation, and life applications.

This study provides supportive evidence to some components in Brophy's model. Basically, all participants in the study understood the epistemological nature of science quite well. There was not a great deal of difference in the understanding between the interested group and the uninterested group. The data suggested that the students who were uninterested in science did not become uninterested because they did not understand what science is supposed to be about, but because they found it hard to learn science with *understanding* (as indicated in Tables 1, 3, and 6).

Some evidence about the emotions the influential figure conveyed to the student or created in the student can be viewed as indirect evidence that reflects the sense of appreciation. Ten out of the twenty-seven positive influential figures were felt by the students as "being enthusiastic about helping the students learn." The sense of amazement or wonder was mentioned in episodes with six interest-raising influential figures. In other words, quite a few participants mentioned how the influential figures helped them to experience an aesthetic *appreciation* of science.

The issue of life application was salient from the data. In summary, the majority of the students in the interested group viewed science as highly related to their life and people's lives in general; the majority of students in the uninterested group viewed science as something that can be related to life sometimes, but often is not. This forms strong supportive evidence for the *application* component in Brophy's model.

As for the idea about modeling, coaching, and scaffolding, unfortunately, this study did not provide enough evidence for these components. Due to the limitations of human memory, especially in regard to detail, I think a retrospective interview would not be the best way to acquire information about these three components. A detailed understanding of the existence and nature of these three components requires observational research, which conducts observations of an on-going interaction between a teacher and his/her student(s), in order to unfold *how* a teacher models, coaches, and scaffolds the ways to experience understanding, appreciation, and life application of science.

Future Directions

This study provides information to help us understand the ways in which students perceive interest-raising relationships. The findings indicate several components which are important in these relationships. Yet in a broader context, we know that many students are not interested in science. Therefore, I would like to propose the following questions 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) Are these interest-raising components present in science teachers' beliefs about the development of student interest in science?

(3) Are there other components in science teachers' beliefs about the development of student interest in science? If yes, what are they?

(4) Are these interest-raising components present in science teachers' practice when they interact with their students? When the answer is "yes" for certain teachers, do we see an increase in their students' interest in science? When the answer is "no" for certain

teachers, do we see a decrease in their students' interest in science? What are the reasons to account for the absence of these components?

(5) We seem to know 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?

Final Note

This study has deepened my understanding of the nature of student interest in science, and the relation between its development and various characteristics of interpersonal relationships between the student and the influential figures. The insights developed from the findings provide parents and teachers certain principles to follow, as well as a tentative theory to confirm and/or scrutinize, in their effort to understand and facilitate the development of student interest in science. Ideas for future research have also been generated from reflecting on the findings and related theoretical and empirical work. Thus, this piece of research not only adds to our present knowledge, but also will lead to a further line of meaningful inquiry.

APPENDIX

Interview Protocol

Opening: Thank you for coming to talk to me about your experience and interest in science. In our interview, I will be interested in understanding your experiences and your ideas. There is not a certain outcome that is the "right response." Some of the questions that I ask you might be easy, and some might need a little bit more thinking to respond to. Please do try and be patient with me. In order to understand your thinking better, I might be asking you questions such as "Can you tell me more about it?" or "Can you give me an example?" or "What do you mean by saying ...?" Please feel free to say anything or ask any questions when something is not clear. If it is okay with you, I will tape record our talk. The tape will help me to understand your ideas better because I can go back and listen to it. Our talk will be kept completely confidential.

Question: When you think about science, what comes to your mind?

Question: What kind of things do you think people do when they are doing science?

Question: What do you do when you do science?

Question: If a student from another country became your classmate, and s/he said to you, "I have never had science in my country. What is science?" how would you respond to him/her?

Question: Would you please tell me some of your major experiences with science?

Question: Would you please tell me how you feel about science?

Question: In general, are you interested in science?
Probe: To what extent would you say you are interested in science (e.g., strongly interested, pretty interested, neutral, not very interested, not interested at all)?
Probe: Can you give me a few examples of the kinds of things you would do (or avoid doing) because of your interest in science (or your lack of interest in science)?
Probe: Would you please tell me how your interest in science plays out in your daily life? For example, one person might spend 5% of his time pursuing his interest in science by watching science programs on TV; another person might spend 80% of his time pursuing his interest in science by studying as a science major.

Question: Why are you interested (or not interested) in science?

Question: When I think of science, I tend to think that there are four kinds of science activities that make me feel quite differently: (1) learning science facts and concepts in school (e.g., listening to lectures or reading textbooks about biological evolution, chemical equilibrium, force and motion, etc.), (2)

learning science facts and concepts outside of school (e.g., reading science magazines or watching TV programs for new knowledge about cancers, polymers, outer space, animals and plants, etc.), (3) trying to figure out scientific knowledge in school (e.g., doing experiments, having discussions in school about science topics, etc.), and (4) 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 device such as 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, etc.). Would you please think about each of these four areas and tell me your interest level for each of them?

Probe: Can you give me one or two examples?

Probe: Why are you interested in that area?

Probe: Why are the interest levels different?

Question: How did your interest in science start? (or Why did you never develop an interest in science? or How did your "uninterest" start?)

Question: 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?

Probe: Can you talk about the curve?

Probe: Why was your interest high (or low) at that time?

Probe: Why did it go up (or down) at that time?

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

Probe: How did that something affect you?

Probe: Can you tell me a little more about the change of your interest in science as a result of experiencing that something? What did your interest in science look like before that experience? What did your interest in science look like after that experience?

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

Probe: 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 your interest in science look like before that experience? What did your interest in science look like after that experience?

Probe: What did that person do to make you interested in science? or What did that person do to lower your interest in science? Can you give me an example?

Probe: How would you describe your interaction with your (father, mother, teacher, or ...)? Can you give me an example?

Probe: How would you describe your relationship with your (father, mother, teacher, or...)?

Probe: Can you come up with some adjectives to describe your relationship with your (father, mother, teacher, or...)?

Probe: Do you think that your relationship with your (father, mother, teacher, or...) has anything to do with your interest in science?

If yes...

Probe: How?

Probe: In terms of affecting your interest in science, how important is your relationship with your (father, mother, teacher, or...) compared with other factors that might also have an influence?

If the student is interested in science and has had (an) influential figure(s) who affected his/her interest in science...

Question: Does this person have interests other than science that you know about? Have you developed interests similar to his/her other interests?
Probe: How? or Why not?

If the student is uninterested in science...

Question: Would you please tell me about something that interests you a lot?

Question: How did your interest in _____ start?

Question: Why is it that _____ makes you interested but science doesn't?

Question: Is there anything or anyone in your life that has affected your interest in _____?
Probe: How did that affect your interest in _____?

Question: Do you know someone who is quite interested in science, e.g., a family member, a teacher, a friend, etc.?

Question: Why didn't that person's interest ever influence your interest in science?

Question: How good do you think you are in science? How good do you think you are in each of the four areas?

REFERENCES

Anderson, C. W. (1992). *Teaching for functional scientific literacy.* Unpublished manuscript, Michigan State University at East Lansing.

Amabile, T. M., DeJong, W., & Lepper, M. R. (1976). Effects of externally imposed deadlines on subsequent intrinsic motivation. *Journal of Personality and Social Psychology*, 34, 92-98.

Ames, C. (1992). Classrooms: Goal, structures, and student motivation. *Journal of Educational Psychology*, 84, 261-271.

Ames, D., & Ames, R. (1984). Systems of student and teacher motivation: Toward a qualitative definition. *Journal of Educational Psychology*, 76, 478-487.

Asher, S. R. (1979). Influence of topic interest on black children's and white children's reading comprehension. *Child Development*, 50, 686-690.

Asher, S. R. (1980). Topic interest and children's reading comprehension. In R. J. Spiro, B. C. Bruce, & W. F. Brewer (Eds.), *Theoretical issues in reading comprehension* (pp. 525-534). Hillsdale, NJ: Lawrence Erlbaum.

Asher, S. R., Hymel, S., & Wigfield, A. (1978). Influence of topic interest on children's reading comprehension. *Journal of Reading Behavior*, 10, 35-47.

Asher, S. R., & Markell, R. A. (1974). Sex differences in comprehension of high-and low-interest reading material. *Journal of Educational Psychology*, 66, 680-687.

Avery, R. R., & Ryan, R. M. (1988). Object relations and ego development: Comparison and correlates in middle childhood. *Journal of Personality*, 56, 547-569.

Baldwin, M. W. (1992). Relational schemas and the processing of social information. *Psychological Bulletin*, 112 (3), 461-484.

Bandura, A. (1986). *Social Foundations of Thought and Action: A Social Cognitive Theory.* Englewood Cliffs, NJ: Prentice Hall.

Birch, S. H., & Ladd, G. W. (1997). The teacher-child relationship and children's early school adjustment. *Journal of School Psychology*, 35(1), 61-79.

Boggiano, A. K., & Ruble, D. N. (1979). Competence and the overjustification effect: A developmental study. *Journal of Personality and Social Psychology*, 37, 1462-1468.

Bowlby, J. (1973). *Attachment and loss: Vol. 2. Separation: Anxiety and anger.* New York: Basic Books.

Bowlby, J. (1980). *Attachment and loss: Vol. 3. Sadness and depression.* New York: Basic Books.

Brophy, J. (1998, April). *Toward a model of the value aspects of motivation in education: Developing appreciation for particular learning domains and activities.* Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Carey, S., & Smith, C. (1993). On understanding the nature of scientific knowledge. *Educational Psychologist*, 28 (3), 235-252.

Csikszentmihalyi, M. (1988). Motivation and creativity: Toward a synthesis of structural and energistic approaches to cognition. *New ideas in Psychology*, 6, 159-176.

Csikszentmihalyi, M. (1990). Literacy and intrinsic motivation. *Daedalus*, 119(2), 115-140.

Deci, E. L. (1971). Effects of externally mediated rewards on intrinsic motivation. *Journal of Personality and Social Psychology*, 18, 105-115.

Deci, E. L. (1992). The relation of interest to the motivation of behavior: A self-determination theory perspective. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), *The role of interest in learning and development* (pp. 43-70). Hillsdale, NJ: Lawrence Erlbaum.

Deci, E. L., & Cascio, W. F. (1972, April). *Changes in intrinsic motivation as a function of negative feedback and threats.* Paper presented at the Eastern Psychological Association, Boston, MA.

Deci, E. L., Driver, R. E., Hotchkiss, L., & Robbins, R. J. (1993). The relation of mothers' controlling vocalizations to children's intrinsic motivation. *Journal of Experimental Child Psychology*, 55 (2), 151-162.

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior.* New York: Plenum Press.

Deci, E. L., & Ryan, R. M. (1991). A motivational approach to self: Integration in personality. In R. Dienstbier (Ed.), *Nebraska symposium on motivation: Vol. 38. Perspectives on motivation.* Lincoln: University of Nebraska Press.

Deci, E. L., Schwartz, A. J., Sheinman, L., & Ryan, R. M. (1981). An instrument to assess adults' orientations toward control versus autonomy with children: Reflections on intrinsic motivation and perceived competence. *Journal of Educational Psychology*, 73, 642-650.

Deci, E. L., Vallerand, R. J., Pelletier, L. G, & Ryan, R. M. (1991). Motivation and education: The self-determination perspective. *Educational Psychologist*, 26(3&4), 325-346.

de Ruiter, C., & van Ijzendoorn, M. H. (1993). Attachment and cognition: A review of the literature. *International Journal of Educational Reviews*, 19, 525-540.

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review*, 95, 256-273.

Eccles, J., & Wigfield, A. (1985). Teacher expectations and student motivation. In J. Dusek (Ed.), *Teacher Expectancies* (pp. 185-226). Hillsdale, NJ: Erlbaum.

Estes, T. H., & Vaughan, J. L., Jr. (1973). Reading interest comprehension: Implications. *Reading Teacher*, 27, 149-153.

Firestone, W. A. (1993). Alternative arguments for generalizing from data as applied to qualitative research. *Educational Research*, 22 (4), 16-23.

Frankel, K. A., & Bates, J. E. (1990). Mother-toddler problem solving: Antecedents in attachment, home behavior, and temperament. *Child Development*, 61, 810-819.

Fransson, A. (1977). On qualitative differences in learning: IV. Effects of motivation and test anxiety on process and outcome. *British Journal of Educational Psychology*, 47, 244-257.

Gilligan, C. (Ed.) (1988). *Mapping the moral domain.* Cambridge, MA: Center for the Study of Gender, Education and Human Development.

Glaser, B. G., & Strauss, A. L. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research.* Chicago, IL: Aldine.

Goodenow, C. (1993). Classroom belonging among early adolescent students: Relationships to motivation and achievement. *Journal of Early Adolescence*, 13(1), 21-43.

Greeno, J. G., Collins, A., & Resnick, L. B. (1996). Cognition and learning. In D.C. Berliner, & R. R. Calfee (Eds.), *Handbook of educational psychology* (pp.15-46). New York: MacMillan Library Reference USA.

Grossmann, K. E., & Grossmann, K. (1993). Emotional organization and concentration on reality from an attachment theory perspective. *International Journal of Educational Reviews*, 19, 541-554.

Harackiewicz, J. (1979). The effects of reward contingency and performance feedback on intrinsic motivation. *Journal of Personality and Social Psychology*, 37, 1352-1363.

Harackiewicz, J. M., Abrahams, S., & Wageman, R. (1987). Performance evaluation and intrinsic motivation: The effects of evaluative focus, rewards, and achievement orientation. *Journal of Personality and Social Psychology*, 53, 1015-1023.

Harms, N. S., &Yager, R. E. (1981). *What research says to the teacher (Vol. 3).* Washington, D. C.: National Science Teachers' Association.

Hazen, N. G., & Durett, M. E. (1982). Relationship of security of attachment to exploration and cognitive mapping abilities in 2-year olds. *Developmental Psychology*, 18, 751-759.

Hazen, C., & Shaver, P. (1987). Romantic love conceptualized as an attachment process. *Journal of Personality and Social Psychology*, 52, 511-524.

Hidi, S. (1990). Interest and its contribution as a mental resource for learning. *Review of Educational Research* , 60 (4), 549-571.

Hopper, J. (1993). The rhetoric of motives in divorce. *Journal of Marriage and the Family*, 55, 801-813.

Hueftle, S. J., Rakow, S.J., & Welch, W. W. (1983). *Images of science: A summary of results from the 1981-82 National Assessment of Science.* Minneapolis, MN: Minnesota Research and Evaluation Center, University of Minnesota.

Koestner, R., Ryan, R. M., Bernieri, F., & Holt, k. (1984). Setting limits in children's behavior: The differential effects of controlling versus informational styles on intrinsic motivation and creativity. *Journal of Personality*, 52, 233-248.

Krapp, A., & Fink, B. (1986, October). *The transition from family to kindergarten and its impact on person-object-relationships.* Paper presented at the meeting of the International Association for the Study of People and their Physical Surroundings, Haifa, Israel.

Kuhn, D. (1989). Children and adults as intuitive scientists. *Psychological Review*, 96, 674-689.

Lemke, J. L. (1990). *Talking Science: Language, learning, and values*. Norwood, NJ: Ablex.

Lepper, M., & Hodell, M. (1989). Intrinsic motivation in the classroom. In C. Ames, & R. Ames (Eds.), *Research on Motivation in Education: Vol. 3. Goals and Cognitions* (pp. 73-105). San Diego, CA: Academic Press.

Lopez, F. G. (1995). Contemporary attachment theory: An introduction with implications for counseling psychology. *The Counseling Psychologist*, 23, 395-415.

LaRossa, R. (1995). Stories and relationships. *Journal of Social and Personal Relationships*, 12(4), 553-558.

Maehr, M. L. (1984). Meaning and motivation: Toward a theory of personal investment. In C. Ames, & R. Ames (Eds.), *Research on Motivation in Education: Vol. 1. Student motivation (pp. 115-144).* Orlando, FL: Academic Press.

Maehr, M. L. (1991). The "psychological environment" of the school: A focus for school leadership. In P. Thurstone, & P. Zodhiates (Eds.), *Advances in Educational Administration (Vol. 2)* (pp. 51-81). Greenwich, CT: JAI Press.

Matas, L., Arend, R. A., & Sroufe, L. A. (1978). Continuity of adaptation in the second year: The relationship between quality of attachment and later competence. *Child Development,* 49, 547-556.

Midgley, C., Feldlaufer, H., & Eccles, J. S. (1989). Student/Teacher relations and attitudes toward mathematics before and after the transition to junior high school. *Child Development*, 60, 981-992.

Moss, E., Parent, S., Gosselin, C., & Dumont, M. (1993). Attachment and the development of metacognitive and collaborative strategies. *International Journal of Educational Reviews*, 19, 55-572.

Mullis, I., & Jenkins, L. (1988). *The science report card: Elements of risk and recovery. Trends and achievement based on the 1986 National Assessment.* Princeton, NJ: Education Testing Service.

Noddings, N. (1992). *The challenge to care in schools.* New York, NY: Teachers College Press.

Ogilvie, D. M., & Ashmore, R. D. (1991). Self-with-other representation as a unit of analysis in self-concept research. In R. C. Curtis (Ed.), *The Relational Self* (pp. 282-314). New York: Guilford Press.

Orbuch, T. L., Veroff, J., & Holmberg, D. (1993). Becoming a married couple: The emergence of meaning in the first years of marriage. *Journal of Marriage and the Family*, 55, 815-826.

Orbuch, T. L. (1997). People's accounts count: The sociology of accounts. *Annual Review of Sociology,* 23, 455-478.

Posner, J., Strike, K., Hewson, P., & Gertzog, W. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education*, 66, 211-227.

Prenzel, M. (1988, April). Task persistence and interest. In U. Schiefele (Chair), *Content and interest as motivated factors in learning.* Symposium conducted at the annual meeting of the American Educational Research Association, New Orleans.

Renninger, K. A. (1987). Do individual interests make a difference? In *Essays by the Spencer Fellows (Vol. IV)* (pp. 228-253). Cambridge, MA: National Academy of Education.

Renninger, K. A. (1988, April). Effects of interest and noninterest on student performance with tasks of mathematical word problems and reading comprehension. In A. Krapp (Chair), *Differences in student performance across subject areas as a function of interest.* Symposium conducted at the annual meeting of the American Educational Research Association, New Orleans.

Renninger, K. A. (1989). Individual patterns in children's play interests. In L. T. Winegar (Ed.), *Social interaction and the development of children's understanding* (pp. 147-172). Norwood, NJ: Ablex.

Renninger, K. A. (1990). Children's play interests, representation, and activity. In R. Fivush, & J. Hudson (Eds.), *Emory Cognition Series: Vol. III. Knowing and remembering in young children* (pp. 127-165). Cambridge, MA: Cambridge University Press.

Renninger, K. A., & Wozniak, R. H. (1985). Effect of interest on attentional shift, recognition, and recall in young children. *Developmental Psychology*, 21, 624-632.

Roeser, R. W., Midgley, C., & Urdan, T. C. (1996). Perceptions of the school psychological environment and early adolescent's psychological and behavioral

functioning in school: The mediating role of goals and belonging. *Journal of Educational Psychology*, 88(3), 408-422.

Rosenholtz, S. J., & Wilson, B. (1980). The effect of classroom structure on shared perceptions of ability. *American Educational Research Journal*, 17, 75-82.

Rutherford, F. J., & Ahlgren, A. (1989). *Science for all Americans*. Washington, DC: American Association for the Advancement of Science.

Ryan, R. M. (1982). Control and information in the intrapersonal sphere: An extension of cognitive evaluation theory. *Journal of Personality and Social Psychology*, 43, 450-461.

Ryan, R. M., & Connell, J. P. (1989). Perceived locus of causality and internalization: Examining reasons for acting in two domains. *Journal of Personality and Social Psychology*, 57, 749-761.

Ryan, R. M., Connell, J. P., & Deci, E. L. (1985). A motivational analysis of self-determination and self-regulation in education. In C. Ames, & R. E. Ames (Eds.), *Research on motivation in education: Vol. 2. The classroom milieu* (pp. 13-51). New York: Academic Press.

Ryan, R. M., & Powelson, C. L. (1991). Autonomy and relatedness as fundamental to motivation and education. *Journal of Experimental Education*, 60(1), 49-66.

Ryan, R. M., & Stiller, J. (1991). The social contexts of internalization: Parent and teacher influences on autonomy, motivation and learning. In P. R. Pintrich, & M. L. Maehr (Eds.), *Advances in motivation and achievement: Vol. 7. Goals and self-regulatory processes* (pp. 115-149). Greenwich, CT: JAI Press.

Ryan, R. M., Stiller, J. D., & Lynch, J. H. (1994). Representations of relationships to teachers, parents, and friends as predictors of academic motivation and self-esteem. *Journal of Early Adolescence*, 14(2), 226-249.

Sansone, C. (1986). A question of competence: The effects of competence and task feedback on intrinsic interest. *Journal of Personality and Social Psychology*, 51 (5), 918-931.

Sansone, C. (1989). Competence feedback, task feedback, and intrinsic interest: An examination of process and context. *Journal of Experimental Social Psychology*, 25 (4), 343-361.

Sarason, I. G., Sarason, B. R., & Pierce, G. R. (1995). Social and personal relationships: current issues, future directions. *Journal of Social and Personal Relationships*, 12(4): 613-619.

Schiefele, U., & Krapp, A. (1988, April). The impact of interest on qualitative and structural indicators of knowledge. In U. Schiefele (Chair), *Content and interest as motivational factors in learning.* Symposium conducted at the annual meeting of the American Educational Research Association, New Orleans.

Schiefele, U., Krapp, A., & Winteler, A. (1992). Interest as a predictor of academic achievement: A meta-analysis of research. In K. A. Renninger, S. Hidi, & A. Krapp

(Eds.), *The role of interest in learning and development* (pp. 183-212). Hillsdale, NJ: Lawrence Erlbaum.

Schunk, D. (1989). Self-efficacy and cognitive skill learning. In C. Ames, & R. Ames (Eds.), *Research on motivation in education: Vol. 3. Goals and cognitions* (pp. 13-44). New York: Academic Press.

Simpson, R. D., & Oliver, J. S. (1985). Attitude toward science and achievement motivation profiles of male and female science students in grades six through ten. *Science Education*, 69, 511-526.

Smith, E. L. (1990). A conceptual change model of learning science. In S. Glynn, R. Yeany, & B. Britton (Eds.), *Psychology of learning science*. Hillsdale, NJ: Lawrence Erlbaum.

Sternberg, R. J. (1995). Love as a story. *Journal of Social and Personal Relationships*, 12(4), 541-546.

Stipek, D. J., & Weisz, J. R. (1981). Perceived personal control and academic achievement. *Review of Educational Research*, 51: 101-137.

Strike, K. A., & Posner, G. J. (1992). A revisionist theory of conceptual change. In R. A. Duschl, & R. J. Hamilton (Eds.), *Philosophy of science, cognitive, psychology, and educational theory and practice*. Albany, NY: State University of New York Press.

Tracy, R. L., Farish, G. D., & Bretherton, I. (1980*). Exploration as related to infant-mother attachment in one-year olds*. Paper presented at the International Conference on Infant Studies, New Haven, CT.

Vallerand, R. J., & Reid, G. (1984). On the causal effects of perceived competence on intrinsic motivation: A test of cognitive evaluation theory. *Journal of Sport Psychology*, 6, 94-102.

Van Sickle, M., & Spector, B. (1996). Caring relationships in science classrooms: A symbolic interaction study. *Journal of Research in Science Teaching*, 33(4), 433-453.

Vargas-Gomez, R. G., & Yager, R. E. (1987). Attitude of students in exemplary programs toward their science teachers. *Journal of Research in Science Teaching*, 24(1), 87-91.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Weiner, B. (1992). *Human motivation: Metaphors, theories, and research.* Newbury Park, CA: Sage.

Wentzel, K. R. (1997). Student motivation in middle school: The role of perceived pedagogical caring. *Journal of Educational Psychology*, 89(3), 411-419.

Zuckerman, M., Porac, J., Lathin, D., Smith, R., & Deci, E. L. (1978). On the importance of self-determination for intrinsically motivated behavior. *Personality and Social Psychology Bulletin*, 4, 443-446.