

## CHAPTER ONE

# Introduction

### *Motivation to Learn Science*

**A**t a very basic level, motivation (the drive to pursue, work toward, and accomplish a goal) can be described as either *intrinsic* or *extrinsic*. *Intrinsic motivation* refers to the internal psychological impetus an individual has to pursue and fulfill a particular goal because it is enjoyable, interesting, fulfilling, or meaningful to the person. *Extrinsic motivation*, on the other hand, refers to impetus that comes from outside an individual in the form of giving or withholding tangible rewards (grades, points, approval, praise, special privileges, or goods) or meting out punishments (demerits, detentions, chastisement). From these definitions, it can be seen that motivation is situational—it varies depending on the goal and characteristics of the environment. Motivation is a state, not a trait.

We focus on intrinsic motivation to learn in this book for several reasons. The first reason is practical: In reality, both extrinsic and intrinsic motivations play a role in sparking learning, but most schools already capitalize heavily on extrinsic motivation. As a result, teachers have been exposed to and have access to many techniques that attempt to promote learning through the use of external means, such as reinforcements or punishments. Most teachers have far less exposure to knowledge and strategies for fostering intrinsic motivation. The second reason is theoretical: Every major contemporary theory of motivation considers

intrinsic motivation central to how deeply and how well students learn. The empirical research, our third reason, has provided considerable support for the idea that intrinsic motivation is key to sustained learning.

This book fills a gap in the science education literature by identifying motivational and affective processes involved in science learning, by illuminating experiential differences (and thus differential educational needs), and by focusing on practical ways to apply the information. This knowledge is valuable only if it gets in your hands. After all, you are likely to be your students' primary source of exposure to science. To supplement this book, we have created the E-TEAMS website (<http://www.niu.edu/eteams>), which will provide you with video demonstrations, ancillary materials, additional resources, and links.

## **THE SciMo PROJECT**

For the past several years, our research team has had the opportunity to gather extensive data on students' experiences in high school science classrooms. We have amassed hundreds of hours of classroom video and observations in science classrooms of all levels, have spoken to science teachers, and have gathered information about how male and female students feel when they are doing various science activities. We will draw upon this research extensively throughout the book to illustrate students' experiences in science and demonstrate various motivational constructs. Although there seems to be broad agreement among science teachers that motivation to learn science is a critical factor in student success, there have been few studies of motivation within high school science classrooms. Therefore, although other relevant studies will be cited, many of the research results described in the text will come from a study we conducted with M Cecil Smith called the Science-in-the-Moment (SciMo) Project, which was funded by the National Science Foundation.<sup>1</sup> The SciMo Project documented the daily experiences and activities of male and female students in high school science courses. The methodology for the study is summarized in an appendix at the end of this book so that interested readers can learn about it in more detail.

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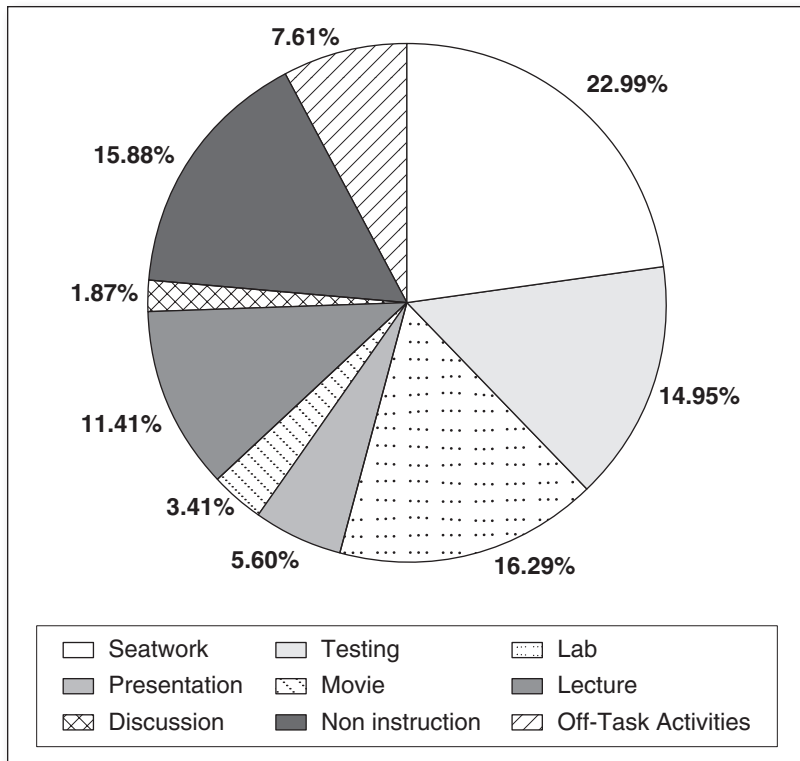
<sup>1</sup>Award number HRD-0927526

## HOW TIME WAS USED IN CLASSROOMS

### Activities During Science Class

One of the most basic ways that we described the classrooms we studied in the SciMo Project was by the type of activity that was going on during science classes. Figure 1.1 shows the proportion of time spent in various activities. In their 50-minute class periods, seatwork took up more time than any other single activity. However, altogether, teachers spent an average of 56 minutes per week (24 percent of their total classroom time) on activities other than instruction, mostly in noninstructional management (38 minutes per week) and less often in off-task activities (18 minutes per week). Lab and testing, including

**Figure 1.1** How Science Teachers Spend Their Classroom Time

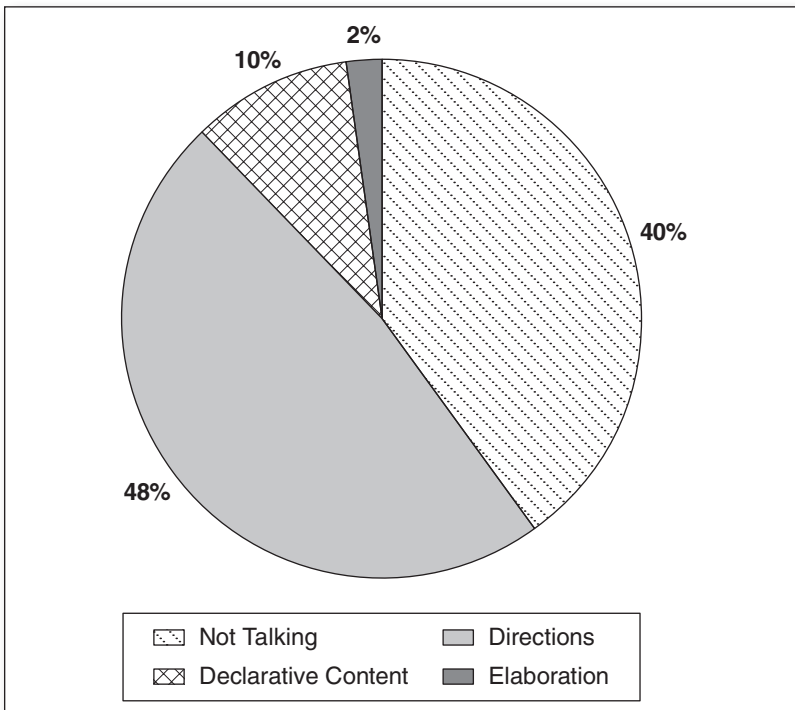


reviewing and going over tests, were also relatively common. Lecture accounted for slightly more than twice as much time as student presentations. Watching movies and class discussion were relatively uncommon. It is important to note that there were considerable differences between teachers in how time was allocated for different activities.

### Teacher Talk During Science Class

In a 50-minute class period, teachers talked 27 minutes, on average. Most teacher talk addressed the whole class and was predominately teacher initiated. As shown in Figure 1.2, teachers talked most in order to move the lesson along, directing students about how to complete their work. They focused on science content knowledge (declarative science knowledge) far less often. Little time was spent focusing on elaboration of content (explanation of why and how) and teacher talk that fostered thinking amounted to

**Figure 1.2** Purpose of Teacher Talk



less than 1 minute of class time per week on average across all classes. In terms of whom the teachers talked to, about 56 percent of teachers' total talk time was spent addressing the whole class (about 15 minutes per class period), with the remaining 12 minutes per class period spent addressing individual students or small groups of students.

## **THE STUDENT PERSPECTIVE ON HIGH SCHOOL SCIENCE CLASSES**

These days, both researchers and teachers agree that it is important to understand the students' perspective in order to be an effective teacher (Dall'Alba & Sandberg, 2006; Daniels & Shumow, 2003; Zhang, Koehler, Lundeberg, Eberhardt, & Parker, 2010). However, most science teacher education programs and professional development programs have not paid much attention to helping teachers to understand their students' perspectives or motivation. This book answers science teachers' need for that information.

Our research in science classes provides a unique opportunity to access students' perspectives on their classroom experience as they are engaged in learning activities. We asked students to carry small vibrating pagers during their science lessons for several days at different points during the school year. Using a remote transmitter, we signaled students at random moments in class. This signal prompted the students to fill out a very brief questionnaire in which they reported their thoughts and feelings. This unique method of data collection, called the Experience Sampling Method (ESM), provided repeated snapshots of students' experience in science and allowed us to understand what students were thinking and feeling in different classroom circumstances (for a comprehensive review of ESM methodology, see Hektner, Schmidt, & Csikszentmihalyi, 2007). We gathered more than 4,000 reports from the students in our study. Because motivational processes are internal, it is often difficult for teachers to assess them by simply observing students, so the ESM affords a unique window into student experience.

We learned that students enjoyed science class "a little" and thought that what they were doing had little relationship to their future goals. They reported very little stress, low challenge, and very little excitement. The students reported feeling somewhat skilled. While students almost always reported being engaged in

some kind of science activity when they were signaled, their thoughts were not always on science. Students told us that they were thinking about science-related things in about 40 percent of their responses to the ESM signals. The remainder of the time, they indicated they were thinking about other things, such as plans for later in the day, lunch time, friends, and romantic interests.

Students' motivation and engagement varied by the activities that they were doing when they were signaled and by their teachers' verbal interaction patterns with them. We found a paradox in that the learning activities that students saw as more enjoyable were relatively unimportant to them, and the less enjoyable activities were viewed as more important. Students' emotions during specific class activities are discussed in greater detail in Chapter 10. Teachers varied widely in the nature and length of their interactions with students. These interaction patterns were also associated with students' learning and motivational outcomes to varying degrees. Specific details about teachers' interaction patterns with students are presented throughout the book.

## **GENDER DIFFERENCES IN STUDENT MOTIVATION AND PERSPECTIVE**

Gender is a theme throughout this book, but the book is not just about female students. Overall, engagement in science class was low for both boys and girls and can be enhanced for both. Therefore, some findings we will present and strategies we will recommend apply equally to boys and girls, while others are specific to one gender or the other.

Before reading on, please stop for a moment and consider the following thought experiment. This was something we did with the teachers in our study and have also done with teachers in professional development settings. Those teachers told us that this was a very enlightening exercise.

### **Thought Experiment**

First, consider what you believe about male and female students. Do you think that there are gender differences in performance, ability, enjoyment, interest, or participation in science?

Second, follow these directions in order to complete the chart displayed in Figure 1.3: Think of one (or each one) of your science classes. Identify your highest-achieving male student in the class and your highest-achieving female student in the class. Write the boy's name in the top left box and the girl's name in the top right box. Then think about a male student and a female student who really struggle in your class. Write the boy's name in the bottom left box and the girl's name in the bottom right box. Jot down a few words that characterize each student. Now, think about and list how the two students in each row are alike and how they are different. Next, compare and contrast the pair of students in each column.

How did you characterize your high-achieving students? Did you think of them as hard workers, curious, naturally gifted, or talented? How about the struggling students? How did you characterize the male compared to the female students?

**Figure 1.3** Thought Experiment: Gender and Science Achievement

|   |   |
|---|---|
| Highest-achieving Male Student  | Highest-achieving Female Student  |
| <div style="border: 1px solid black; border-radius: 10px; padding: 5px;"> <p>Name:</p> <hr/> <p>Characteristics:</p> </div> | <div style="border: 1px solid black; border-radius: 10px; padding: 5px;"> <p>Name:</p> <hr/> <p>Characteristics:</p> </div> |
| Lowest-achieving Male Student   | Lowest-achieving Female Student   |
| <div style="border: 1px solid black; border-radius: 10px; padding: 5px;"> <p>Name:</p> <hr/> <p>Characteristics:</p> </div> | <div style="border: 1px solid black; border-radius: 10px; padding: 5px;"> <p>Name:</p> <hr/> <p>Characteristics:</p> </div> |

Our investigation of teachers' beliefs about gender and science revealed that few teachers explicitly identified gender differences in terms of ability, interest, or future potential in science. However, implicit beliefs were revealed in their descriptions of highest-achieving students—both male and female teachers described their high-achieving male students as having greater natural ability and their high-achieving female students as being harder workers with less curiosity and ability than their male classmates. Teachers in the SciMo study also predicted that more male students were likely to have a future in science than female students.

Teachers' implicit gendered beliefs about curiosity and ability were inconsistent with other data we had gathered that more directly assessed students' curiosity and ability. For example, when we looked at boys' and girls' own reports of interest during science, there were very few differences by gender across the different classroom activities. Likewise, when we examined students' grades in science (an imperfect indicator of ability), few gender differences emerged, and when they did, they suggested that girls were performing better than boys.

## **THE EXPERIENCE OF BOYS AND GIRLS IN SCIENCE**

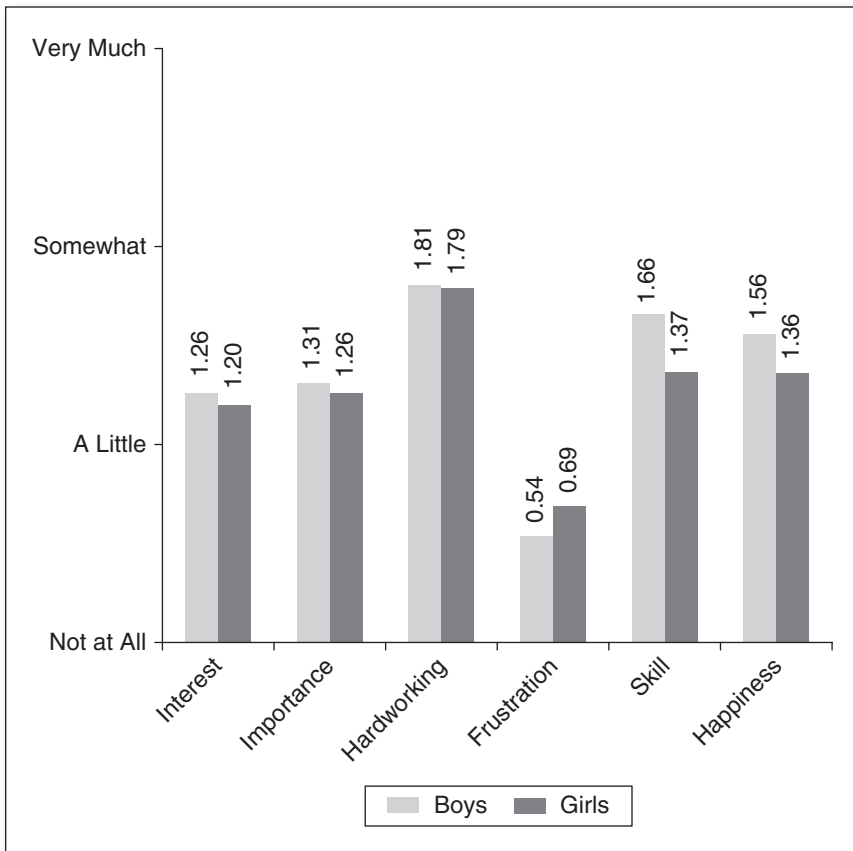
Recently, the gender gap in science has fallen off the radar screen of most teachers, possibly because many teachers believe that the long-standing historic gender gap has been addressed and possibly because girls have been achieving as well as boys in high school science courses (Sadker, Sadker, & Zittleman, 2009; Sanders, 2010). Nevertheless, girls choose to study science less often than boys when they get to college, suggesting that the situation for many female students might be “I can do it, I just don't want to.” Our data illuminated systematic gender differences in the lived experience of students in science class, both in terms of students' internal reactions to specific learning situations and in the quality of their daily interactions with their science teachers.

The data we gathered with the ESM allowed us to compare the way that boys and girls feel in science class by looking at their momentary reports of enjoyment, stress, skill, and the like. Our data suggest that science may hold similar potential for engaging



boys and girls but that this potential is not currently being realized equally for boys and girls. Figure 1.4 shows that boys and girls report similar levels of interest, importance, and hard work in science class. To us, this is hopeful: Boys and girls seem to equally value the activities they are doing in science class and are making similar levels of investment in their daily science activities. However, when we turn to other dimensions of students' lived experience in science, boys and girls start to look very different from one another. On a daily basis, girls report feeling significantly more frustrated and less skilled relative to their male peers. They are also less happy in science class.

**Figure 1.4** How Boys and Girls Feel in Science Class



As you will read in the chapters that follow, several cognitive and affective factors presumed to be critical motivational processes (e.g., challenge, relevance, goal orientation, ability beliefs) operated differently for male students compared to female students in the SciMo study and suggest a motivational disadvantage for girls (Schmidt, Kackar, & Strati, 2010). The particular combination of experiential differences we documented in our study suggests that even though girls are performing as well as boys in science and share similar levels of interest in classroom activities, the actual sentiment among many girls is “I cannot do it, and I don’t want to.” This finding suggests that science teachers may do well to put gender back on their radar screens, despite apparent gender parity in science course-taking and achievement.

## **GENDER AND TEACHER-STUDENT INTERACTION**

Our analysis of classroom video data revealed subtle but quantifiable bias against girls. Science teachers spent 39 percent more class time talking to their male students than their female students (Shumow & Schmidt, 2013). While this figure represents a difference of only a few minutes per day, it adds up to nearly 40 more minutes per month—nearly an entire class period. Teachers spent more time addressing boys than girls for the purpose of conveying basic content (43 percent more), moving the lesson along (17 percent more), elaborating on content (28 percent more), managing behavior (102 percent more), and discussing irrelevant material (92 percent more). Male students initiated a greater proportion of verbal interaction; teachers spent about 27 percent more time in male-initiated verbal interaction than female-initiated verbal interaction, but the fact that males initiated more interaction did not completely account for the observed gender differences in teachers’ talk patterns with their students. There was considerable variation among teachers in these patterns, suggesting that these interaction patterns are not inevitable and can be changed. Notably, the variation we observed in how teachers interacted with their male and female students did not appear to be systematically related to teacher gender.

## **THE IMPORTANCE OF PROMOTING GENDER EQUITY IN SCIENCE**

The inequities we documented are likely to have important implications for students. For one, an inequitable environment is likely to impact a student's perceptions of his or her own and others' abilities in science. Girls may come to doubt their abilities and boys might come to inflate their own abilities in response to unequal attention from teachers during science class. Girls might receive the message that they are valued only for their compliance to rules, while boys might take away the message that they are bad students. Further, both boys and girls may come to devalue the role and possible contributions of women in science, leading to continued gender bias in upper-level science classes and science careers.

Secondly, teachers' expectations of and interaction patterns with students have been implicated repeatedly in the development of long-term interest and persistence in science, technology, engineering, and mathematics (STEM) fields. Unless something changes, we predict that teachers will continue to espouse the implicit belief, which is not reflective of reality, that high school boys are more curious and better equipped to succeed in science than girls. The likely result is that we will continue to see gender gaps in science interest and persistence beyond high school in the United States (see Hill, Corbett, & St. Rose, 2010, for a review).

Finally, facility in scientific knowledge is essential for the future success of both individuals and societies. In our complex technological world, scientific literacy is important in many facets of life, including home, career, and citizenship. Scientific literacy will be enhanced to the extent that students are motivated to learn science. It is wise (and just) for educators to foster the potential and development of all students in scientific literacy. Increasing student motivation to learn is a crucial step and can be achieved!

## **WHAT RESOURCES CAN SCIENCE TEACHERS USE TO GET MORE BACKGROUND INFORMATION?**

The companion website, <http://www.niu.edu/eteams>, contains helpful resources for teachers to use to learn more about the

background information presented here. The following and more can be found on the website:

- Links to detailed information about the methodology of the SciMo Project as well as papers, publications, and reports that were produced from this project, including a paper about parent involvement in science
- Some general information about motivation to learn science
- Resources to better understand current gender gaps in interest and persistence in science