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CHAPTER 3

Motivation to Learn in College Science

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All college science teachers share the important goal of motivating college students to learn science. In this chapter, we discuss motivational theory and research in college science teaching and draw implications for effective practices. We also present a new questionnaire designed specifically to help college science teachers assess their students' motivation to learn science.

Definition of Motivation

Motivation is an internal state that arouses, directs, and sustains students' behavior. The study of motivation by science education researchers attempts to explain why students strive for particular goals when learning science, how intensively they strive, how long they strive, and what feelings and emotions characterize them in this process. As science education researchers respond to current national initiatives to foster students' science achievement, the emphasis placed on motivation has been increasing, as evidenced by recent articles with titles such as "Skill and Will: The Role of Motivation and Cognition in the Learning of College Chemistry" (Zusho and Pintrich 2003).

Today, more than ever, students' motivation to learn college science remains an area of discussion and debate—an area constantly in need of innovative approaches because the societal factors that play a role in learning science are constantly changing. According to a recent national report, "Of those students entering college with plans to major in science or engi-

neering, less than 40 percent graduate with a degree in that field within six years" (Business-Higher Education Forum 2005, p. 6). This report, like many others, concludes that America is in danger of losing its international leadership in scientific creativity.

Motivation to Learn in College Science Courses

According to Brophy (1988), *motivation to learn* is "a student tendency to find academic activities meaningful and worthwhile and to try to derive the intended academic benefits from them" (pp. 205–206). What motivates students to learn in college science courses? The important motivational constructs being examined by researchers include *intrinsic* and *extrinsic motivation, goal orientation, self-determination, self-efficacy,* and *assessment anxiety*; the related attitudinal constructs are discussed by French and Russell in Chapter 2 of this volume.

Intrinsic and Extrinsic Motivation

Motivation to do something for its own sake is mainly intrinsic, whereas motivation to do it as a means to an end is mainly extrinsic (Mazlo et al. 2002; Pintrich and Schunk 2002). Intrinsic motivation taps into the natural human tendency to pursue interests and exercise capabilities (Ryan and Deci 2000; Singh, Granville, and Dika 2002). Students who are intrinsically motivated to learn often experience "flow," a feeling of enjoyment that occurs when they have developed a sense of mastery and are concentrating intensely on the task at hand, such as a lab activity (Csikszentmihalyi 2000).

Students often perform tasks for reasons that are both intrinsically and extrinsically motivated. For example, the student who carries out a science project may enjoy the process, particularly if the student can approach the project in different ways, but may also be motivated by the prospect of receiving an award if the project is entered in a competition.

A survey conducted by Smith, Gould, and Jones (2004) of more than 500 nonscience majors enrolled in college physics or biology courses indicated that the most popular reasons for taking the courses were to complete a general requirement, to fulfill a requirement for a major, to perform well in a job after college, to get ahead in a job, and to be hired for a job—these reasons appear to be extrinsically motivated. The less popular reasons included to better understand the natural world, to lead a better personal life, to satisfy curiosity about the natural world, and to be a better citizen—these appear to be intrinsically motivated. These findings are particularly noteworthy because scientific organizations such as the National Academy of Sciences and the American Association for the Advancement of Science stress intrinsically motivated reasons for learning science.

Goal Orientation

A distinction often is made between *learning goals* and *performance goals* (e.g., Cavallo, Rozman, and Potter 2004). College students with learning goals focus on the challenge and mastery of a science task. They are not concerned about how many mistakes they make or how they appear to others. They view mistakes as learning opportunities and do not hesitate to ask others for feedback and help. For example, in a study of science majors enrolled in either a biology or a physics course, Cavallo and colleagues (2003) found the following:

> *Motivation to learn for the sake of learning was most important for course achievement, followed by reasoning ability. Meaningful learning and a tentative view of science were positively related to learn-*

ing goals, which means these may underlie the motivation to learn for the sake of learning. (p. 22)

Students with performance goals often are preoccupied with gaining social status, pleasing teachers, and avoiding "extra" work. These students frequently compare their grades with others and choose tasks that are easy for them so they can maximize their grade. They are often reluctant to help others achieve. Their self-esteem is based on the external evaluation of their performance, so their esteem can be as fleeting as their last grade on a biology test.

While it can be useful to distinguish among students in terms of their goal orientations in college science courses, it should be kept in mind that these categorizations are relative. Students often have a combination of learning and performance goals.

Self-Determination

Self-determination is the ability to have choices and some degree of control over what we do and how we do it (Reeve, Hamm, and Nix 2003). Most people strive to be in charge of their own behavior—to be captains of their own ships. Most people are unhappy when they feel they have lost control, either to another person or to the environment.

When college science students have the opportunity to help determine what their educational activities will be, they are more likely to benefit from them (Glynn and Koballa 2005). A good example of how to increase students' intrinsic motivation by increasing their self-determination was provided by Garcia and Pintrich (1996). They found that the intrinsic motivation of college biology students increased when the students had input into course policies, such as the selection of course readings and term paper topics, as well as the due dates for class assignments.

When students lack self-determination, it is difficult for them to feel intrinsically motivated. They may come to believe that their performance in a college science course is mostly uncontrollable, and, as a result, they expend less effort on learning. For example, Maria's comments below are typical of some biology majors we recently interviewed who feel they have little control of their learning:

> *Studying biology can be pretty boring sometimes. Like, it can drive me crazy. I wish I could find a course or an instructor that makes it really interesting. It would be really nice to be excited about something in biology—it just hasn't happened yet. I hope I get a good course next semester—if it's interesting and if I think it's relevant, I'll probably get motivated and maybe work harder. I want to go to med school and I want to be sure I can get in.*

Self-Efficacy

Bandura (1997) defined self-efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3). When science education researchers use the term, they refer to the confidence a student has about his or her ability to succeed in a field of science (Koballa and Glynn, Forthcoming).

Self-efficacy is specific. For example, a college student may have high self-efficacy with respect to knowledge and skills in biology, but low self-efficacy with respect to knowledge and skills in physics. Students' judgments of their self-efficacy in particular areas of science have been found to predict their performance in these areas. For example, Zusho and Pintrich (2003) found that students' self-efficacy was the best predictor of grades in an introductory

college chemistry course, even after controlling for prior achievement.

Anxiety

All students experience anxiety from time to time, particularly in college science courses (Seymour 1992; see also Chapter 1 in this volume). A *moderate* level of anxiety is good, in fact, in that it helps motivate learning (Cassady and Johnson 2002).

To ensure that anxiety remains in a moderate range, it is important for instructors to determine how well prepared students are for the learning that will be required of them in college science courses. If students lack adequate preparation, their anxiety will be excessive. In addition, it is important for instructors to gauge individual differences in the students' personalities because some students, even prepared ones, might be threatened by assignments that other students would find enjoyable. For example, introverted students might be extremely nervous about reporting the results of a lab in front of a class, whereas extroverted students might be enthusiastic about it.

Assessing Motivation to Learn in College Science Courses

Guided by the research on the preceding motivational constructs and by individual and group interviews conducted with students learning science in college courses, we developed the Science Motivation Questionnaire (SMQ), which is reprinted in the appendix at the end of this chapter. The SMQ assesses six components of motivation: *intrinsically motivated science learning* (items 1, 16, 22, 27, and 30), *extrinsically motivated science learning* (items 3, 7, 10, 15, and 17), *relevance of learning science to personal goals* (items 2, 11, 19, 23, and 25), *responsibility (self-determination) for learning science* (items 5, 8, 9, 20, and 26), *confidence (self-efficacy) in learning science* (items 12, 21, 24, 28, and 29), and *anxiety about science assessment* (items 4, 6, 13, 14, and 18). Students respond to each of the 30 items on a 5-point Likert-type scale ranging from 1 (never) to 5 (always). The *anxiety about science assessment* items are reverse scored. The SMQ maximum total score is 150 and the minimum is 30. Preliminary findings indicate that the SMQ is reliable in its internal consistency ($\alpha = 0.93$) and correlates positively with students' interest in science careers, number of science courses taken, and science grades.

The SMQ provides instructors and researchers with a convenient means of assessing a student's overall motivation to learn science in college courses, as well as the student's specific motivation in terms of each of the six components. The SMQ can be administered prior to a course for purposes of advisement or on the first day of a course to gauge the motivation of a class and identify students who have particular needs. The SMQ also can be administered at both the beginning and end of a course to show changes that have occurred in students' motivation as a result of instruction. The 30-item SMQ, with its six components, provides information about a student's motivation that is not assessed in other science-motivation questionnaires, such as the 10-item Achievement Motivation Questionnaire (Cavallo et al. 2003). And, because the SMQ is specific to science, it is more relevant to college science instruction than general content-area questionnaires, such as the Motivated Strategies for Learning Questionnaire (Pintrich et al. 1991).

Implications for Practice

The constructs we have described have important implications for understanding and increasing students' motivation to learn in college science courses. These implications include the following:

1. Use inquiry and discovery activities that present college science students with ideas that are somewhat in conflict with their current knowledge and beliefs. These discrepancies between what students think they know and what they are being taught heighten motivation by stimulating interest and curiosity.
2. Encourage college science students to set and pursue goals for themselves. The students who do this will become self-determined learners. Also, help students see the relevance of what they are learning to their personal goals. This promotes intrinsic motivation that goes beyond obtaining an extrinsic reward such as a good grade.
3. Help college science students see that extrinsic and intrinsic motivation can be mutually supportive. In their future careers, students will be motivated by a combination of extrinsic factors (e.g., awards and salary) and intrinsic factors (e.g., confidence and a sense of accomplishment) that together lead to personal success. Questionnaires such as the SMQ can provide information on what motivates students to learn science.
4. Give college science students some degree of control over what they learn and how they learn it. This will foster self-confidence and responsibility for learning. At the same time, reduce anxiety about assessment by incorporating it into tasks that are authentic and performance based, such as laboratories, projects, journals, presentations, and projects.
5. Look for opportunities to model good learning behavior for college science students, because they often identify with their instructors. Also, look for opportunities to promote collaborative learning—the social ties that result will contribute to a positive learning environment.
6. Have high, yet reasonable, expectations of college science students and be sure to communicate these expectations clearly. Give students constructive feedback, but focus it on the students' performance. It is important that students realize that they are valued personally and that any criticism they receive is directed at specific behaviors. Finally, when providing feedback, remember to recognize both effort and outcomes.

Conclusion

All college science instructors share the important goal of fostering college students' motivation to learn science. All instructors have a stake in determining how students learn science best, what feelings characterize them during learning, and why some students become autonomous lifelong science learners while others do not. An evolving understanding of the constructs involved in the motivation to learn science is essential if college instructors are to meet the challenge of successfully preparing students who can preserve and extend America's international leadership in scientific creativity and innovation.

Appendix

Science Motivation Questionnaire (SMQ)

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In order to better understand what you think and feel about your college science courses, please respond to each of the following statements from the perspective of:
"When I am in a college science course..."

01. I enjoy learning the science.
O Never O Rarely O Sometimes O Usually O Always

02. The science I learn relates to my personal goals.
O Never O Rarely O Sometimes O Usually O Always

03. I like to do better than the other students on the science tests.
O Never O Rarely O Sometimes O Usually O Always

04. I am nervous about how I will do on the science tests.
O Never O Rarely O Sometimes O Usually O Always

05. If I am having trouble learning the science, I try to figure out why.
O Never O Rarely O Sometimes O Usually O Always

06. I become anxious when it is time to take a science test.
O Never O Rarely O Sometimes O Usually O Always

07. Earning a good science grade is important to me.
O Never O Rarely O Sometimes O Usually O Always

08. I put enough effort into learning the science.
O Never O Rarely O Sometimes O Usually O Always

09. I use strategies that ensure I learn the science well.
O Never O Rarely O Sometimes O Usually O Always

10. I think about how learning the science can help me get a good job.
O Never O Rarely O Sometimes O Usually O Always

11. I think about how the science I learn will be helpful to me.
O Never O Rarely O Sometimes O Usually O Always

12. I expect to do as well as or better than other students in the science course.
O Never O Rarely O Sometimes O Usually O Always

13. I worry about failing the science tests.
O Never O Rarely O Sometimes O Usually O Always

14. I am concerned that the other students are better in science.
O Never O Rarely O Sometimes O Usually O Always

15. I think about how my science grade will affect my overall grade point average.
O Never O Rarely O Sometimes O Usually O Always

16. The science I learn is more important to me than the grade I receive.
O Never O Rarely O Sometimes O Usually O Always

17. I think about how learning the science can help my career.
O Never O Rarely O Sometimes O Usually O Always

18. I hate taking the science tests.
O Never O Rarely O Sometimes O Usually O Always

19. I think about how I will use the science I learn.
O Never O Rarely O Sometimes O Usually O Always

20. It is my fault if I do not understand the science.
O Never O Rarely O Sometimes O Usually O Always

21. I am confident I will do well on the science labs and projects.
O Never O Rarely O Sometimes O Usually O Always

22. I find learning the science interesting.
O Never O Rarely O Sometimes O Usually O Always

23. The science I learn is relevant to my life.
O Never O Rarely O Sometimes O Usually O Always

24. I believe I can master the knowledge and skills in the science course.
O Never O Rarely O Sometimes O Usually O Always

25. The science I learn has practical value for me.
O Never O Rarely O Sometimes O Usually O Always

26. I prepare well for the science tests and labs.
O Never O Rarely O Sometimes O Usually O Always

27. I like science that challenges me.
O Never O Rarely O Sometimes O Usually O Always

28. I am confident I will do well on the science tests.
O Never O Rarely O Sometimes O Usually O Always

29. I believe I can earn a grade of "A" in the science course.
O Never O Rarely O Sometimes O Usually O Always

30. Understanding the science gives me a sense of accomplishment.
O Never O Rarely O Sometimes O Usually O Always

Note: College science teachers who wish to use the Science Motivation Questionnaire for teaching and research have permission to do so if they comply with the fair use of a copyrighted and registered work, acknowledge the authors, and cite this book and chapter.

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