ACCELERATED INTEGRATED SCIENCE SEQUENCE:

INTERDISCIPLINARY UNDERGRADUATE SCIENCE FOR THE 21ST CENTURY

BY

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A Dissertation submitted to the Faculty of Claremont Graduate University in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Graduate Faculty of Education

Claremont, California
2011

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Accelerated Integrated Science Sequence:

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Numerous reports cite the need to improve the quality of undergraduate STEM education in order to attract and train a diverse pool of talented students prepared to meet the scientific and technological challenges of the 21st century. A growing body of research reveals that the nature and quality of science instruction in introductory college courses strongly contribute to whether capable students, including women and underrepresented minorities, persist in or leave the science major.

The Joint Science Department of the Claremont Colleges has developed a new introductory course sequence for science majors that integrates the principles and concepts of biology, chemistry, and physics in both lecture and lab, confers early eligibility for research opportunities, and accelerates student progress in the major. Unique among interdisciplinary courses across the nation, the Accelerated Integrated Science Sequence (AISS) is taught by three senior professors.

The purpose of this longitudinal study was to characterize the effectiveness of AISS in retaining capable students in science majors. Empirical data from student records and researcher-generated surveys of the first four cohorts of AISS students and a comparison group of science majors (Total N=140) were analyzed using descriptive and multivariate statistical methods. The focus was on the first cohort, where longitudinal

effects could be traced most effectively. College student development theories by Astin and Tinto provided the theoretical framework against which to assess impact. Results indicated more STEM course taking, higher STEM achievement, greater participation in research, and more double STEM majors for AISS students compared to other science majors. Strongest predictors of achievement in AISS were the SAT-Critical Reading score and a high mathematical self-concept.

AISS professors engendered a supportive learning community and reported a shift in their teaching away from lecture-style presentation. Significantly, more than eighty percent of AISS students were women; therefore, AISS served as a mechanism to attract capable students of both genders to science majors. AISS is a national role model of how a liberal arts college can revitalize its introductory science curriculum. It offers exportable elements for curriculum innovation and practice to other institutions anxious to present an interdisciplinary pathway into the science major.

Dedication

To my mother, Eileen, for her love and for the courage and compassion with which she lives life, and to Louise, for her friendship, generosity, and encouragement over for the past thirty years—thank you both for showing me the way.

Acknowledgements

There were many individuals who guided, supported, and encouraged me during my graduate studies. I gratefully acknowledge their role in this adventure and in the completion of this dissertation.

First and foremost, I am most grateful to my advisor and committee chair, David Drew, for his unwavering support, counsel, guidance, generosity, patience, and optimism throughout the numerous drafts of this dissertation and my years as a doctoral student. This dissertation began with his invitation to join him in the evaluation of a new science course at the Claremont Colleges.

I extend my sincere thanks to my committee members, Phil Dreyer and Mary Poplin, for their guidance and insights throughout my graduate studies, and for their helpful comments and clarifying questions about this study.

I wish to thank Newton Copp, Professor of Biology and Principal Investigator of the AISS NSF-STEP grant, for allowing me to study the course for this dissertation and for his dedication to undergraduate science education and innovation. Thanks also to AISS professors Gretchen Edwalds-Gilbert, Katie Purvis-Roberts, Adam Landsberg, Mary Hatcher-Skeers, Scot Gould, and Kersey Black for allowing me into their classrooms to conduct surveys, and for the many helpful conversations about the Joint Science Department and undergraduate students. Finally, I want to thank the AISS students who year after year responded to the questionnaires in this study. You are our future and the most important reason for this work.

My deep appreciation goes to Velda Ross, Assistant to the Dean of Science/Program Administrator, W.M. Keck Science Center, for her graciousness, good humor, and invaluable assistance with student data.

My friends and colleagues at Westridge School have supported me and cheered me on for the past six years. My special thanks to Mary Tuck for understanding how important this work was to me and for generously allowing me the time to complete it.

Diana Day first planted the seed for returning to graduate school. She is my staunchest cheerleader and a true friend in every sense of the word. I will be forever grateful for her careful reading and critique of this dissertation. My friend and colleague, Virginia Kelsen, provided sage advice and inspiration during our graduate studies and dissertation writing. Your commitment to public education is an inspiration.

Finally, to my family who has supported this lifelong goal with patience and grace—without your love, I could not have done this. I know how fortunate I am to have all of you in my life. To my sons, Ben and Nate, you are the heart and soul of my life.

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CHAPTER 1 – INTRODUCTION

The Problem

In order to increase the number and quality of home-grown science graduates, the United States must focus on science teaching and learning at both the K-12 and undergraduate levels. While K-12 reforms have been underway for several decades, reform attempts at the undergraduate level have been slower to follow (NRC, 1997). However, these efforts are necessary in order keep pace with K-12 efforts, increase the overall quality of college-level science education, improve the participation of minority students and women in undergraduate and graduate STEM fields, enhance the ability of all citizens to function in an increasingly technological society, and to maintain our competitiveness as a nation in the global economy.

It has become clear that the quality of undergraduate science teaching, particularly at the earliest levels, must improve in order to attract talented students and retain them once they have chosen to major in a STEM field. Introductory-level science forms the basis of science knowledge for the vast majority of college graduates, yet the poor quality of introductory courses is the single most important factor responsible for university science major dropouts (Seymour & Hewitt, 1997; Tobias, 1992; Oakes, 1990)

Recommendations to reform and improve introductory undergraduate science course content and instruction have met with considerable institutional and instructor resistance. These recommendations—both pedagogical and content related— include more interaction and fewer one-way lectures, greater awareness of different learning styles, more relevant hands-on experiences, and more real-world applicability of course content. In addition, numerous reports have emphasized the need for students to develop skills for problem solving in an interdisciplinary context and accrue experience in conducting scientific research (Lopatto, 2009; NRC, 1997, 1999, 2003a, 2003b; NAS, 2006).

Traditionally, university faculty members care deeply about science and about education, but few have received specific training in college student development and pedagogical principles (Laws, 1999; Seymour & Hewitt, 1997). However, in recent years more universities and colleges have made efforts to create introductory courses that are responsive to today's incoming college students and the reality that they will not settle for outdated modes of instruction. Such courses aim to prepare students for the demands of the 21st century workplace by incorporating collaboration, technology, and integration of science disciplines (Purvis-Roberts, et al, 2009; Arnaud, 2006; Van Hecke, 2002; Tabbutt, 2000; Wolfson, Hall, & Allen, 1998). This study focuses on one such course, a new interdisciplinary introductory science sequence in the joint science department of three highly selective liberal arts colleges, the first cohorts of students who took the course, and the faculty members who created and taught it—in an effort to learn how it contributes to persistence in a science major.

Background

The Joint Science Department

Forty years ago, three of the five undergraduate liberal arts colleges in The Claremont Consortium at the Claremont Colleges, Claremont McKenna, Pitzer, and Scripps Colleges, established the Joint Science Department (JSD) to better serve the students at their three colleges. Originally intended as a service department for colleges emphasizing economics and policy studies (Claremont McKenna), social and behavioral studies (Pitzer College), and art and humanities (Scripps College), its sole focus is on undergraduate education. Currently, the department consists of 27 faculty members, 13 visiting faculty members, and 11 staff members. The Joint Science Department offers full major programs in Biology, Chemistry, and Physics, as well as a variety of interdisciplinary majors, such as Neuroscience; Environment, Economics, and Politics; Science and Management; and Economics and Engineering.

The Joint Science Department is housed in a state-of-the-art science facility, the W.M. Keck Science Center where students and faculty interact in course work, advising and research. This proximity allows the department to enact its motto, "Three Colleges, Three Disciplines, One Department." Small classes are offered at both the introductory and advanced levels, and students have ample opportunities for independent and collaborative research with faculty members.

The table below indicates the number and percentage of science majors from each of the participating colleges in 2009 (Table 1). Students from Scripps College and Claremont McKenna College consistently outnumber those from Pitzer College, and female students from Scripps College are strongly represented in the Joint Science Department.

Table 1.

Joint Science Department Majors and Graduates, 2009

College	Total Graduates	Science Majors	N
CMC	**281**		
		Biology	8
		Human Biology	1
		Molecular Biology	7
		Organismal Biology	3
		Biochemistry	3
		Chemistry	2
		Economics and Engineering	2
		Environment, Economics and Politics	2
		Environmental Science	2
		Management-Engineering	5
		Neuroscience	10
		Physics	1
		Science and Management	2
		Total Science Majors:	**48**
		% of Graduating Class:	**17.1%**
PITZER	**242**		
		Biology	1
		Human Biology	8
		Chemistry	1
		Environmental Science	2
		Environment, Economics and Politics	1
		Management-Engineering	1
		Neuroscience	5
		Total Science Majors:	**19**
		% of Graduating Class:	**7.9%**
SCRIPPS	**228**		
		Biology	12
		Human Biology	1
		Molecular Biology	5
		Organismal Biology	6
		Biochemistry	6
		Chemistry	3
		3/2 Engineering	2
		Environment, Economics and Politics	1
		Environmental Science	1
		Motion Science	1
		Neuroscience	7
		Physics	1
		Science and Management	1
		Total Science Majors:	**47**
		% of Graduating Class:	**20.6%**

Accelerated Integrated Science Sequence

The development and implementation of the Accelerated Integrated Science Sequence (AISS) took place under the auspices of a National Science Foundation Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP) grant awarded to the Joint Science Department of the Claremont Colleges in 2005. The stated goals of AISS are 1) to increase the visibility and attractiveness of the sciences at Claremont McKenna College, Pitzer College, and Scripps College by offering an innovative introductory sequence; 2) to increase recruitment of incoming students into STEM majors, to streamline progress through STEM majors, and ultimately to increase the number of students who graduate with majors in STEM fields; 3) to offer early summer research opportunities to AISS completers; and 4) to strengthen interdisciplinary work by Joint Science Department faculty.

The Accelerated Integrated Science Sequence is an intensive, year-long, honors-level course for first-year students with broad interdisciplinary interests and strong high school mathematics and science preparation. It features an integrated approach to the fundamental principles, skills, and findings in physics, biology, and chemistry, and serves as a gateway to all science majors offered by the Joint Science Department. Offered for the first time in 2007-2008 and taught by an interdisciplinary team of faculty (a chemist, a biologist, and a physicist), it provides an alternative to the traditional six-course introductory curriculum (Bio 43-44, Chem 14-15, Phys 33-34) which takes students two years to complete. The double-credit class meets five days a week for a total of twelve hours. Lecture, laboratory, and discussion are integrated and organized around interdisciplinary themes that expose students to the fundamentals of the three disciplines while emphasizing the connections between them.

AISS features lectures, seminars, interdisciplinary laboratories, and hands-on activities, including computer modeling as a common thread that runs throughout the year. The lecture (1A, 2A) and laboratory (1B, 2B) components are designed to be taken concurrently and for both semesters of the academic year. Students receive double course credit each semester for this course. In addition to accelerating students' progress through a science major, successful completion of the AISS course confers students eligibility for NSF-funded summer research opportunities with faculty members in the Joint Science Department. Many of these research projects involve an interdisciplinary approach and lead to additional research opportunities in future years. In addition, arranging study abroad opportunities will also be easier for science majors who take this course because they will have more flexibility in their schedule during the sophomore and junior years.

The selection criteria for acceptance into this demanding first-year course consist of a strong high school science background (at least 2 years of upper division science, including Advanced Placement when offered), in addition to strong math preparation (at least one year of high school Calculus (either AB or BC) and a score of 700 or higher on the math section of the SAT-I, or a score of 4 or 5 on the Calculus Advanced Placement exam. From an impressive first applicant pool of 46, twenty-nine students were enrolled in the first cohort in the fall of 2007. In 2008, 64 students applied and 30 were enrolled in the second cohort; in 2009, 30 of the 51 applicants were enrolled in the third cohort;

and in 2010, 29 of the 59 applicants were enrolled in the fourth and final cohort in this study.

AISS faculty members were male and female professors with an expressed interest in interdisciplinary teaching. In the first year of the course, faculty consisted of a female biologist, a female chemist, and a male physicist. During the second year, the chemist was replaced by another female chemist. During the third and fourth years, all three professors were male. In some cases, AISS professors also served as academic advisors for students in AISS. In other cases, students had other professors in the department as their academic advisors.

Incoming freshman are made aware of this new course offering through the Joint Science Department web site, mailings to students accepted to the colleges, college tours and visits to the Joint Science Department, and conversations with faculty members and students.

Purpose of the Study

This research builds on the existing scholarship in K-12 and undergraduate science education, college student development, and persistence. A review of the extant literature brings to light the need to improve the quality of undergraduate science education, particularly at the introductory level, in order to produce more science majors who are prepared and motivated to enter science careers. Numerous studies cite a poor introductory science experience as the main reason why many interested and qualified students, including women and underrepresented minorities, choose not to continue in a science major. Additionally, the length of time required to complete a science major deters students from pursuing an undergraduate science degree. Other factors, such as the practice of reserving undergraduate research opportunities for upper division students and a "chilly culture" between beginning students and faculty members further discourage capable freshmen from forming an affinity to the undergraduate science experience and persisting in a science major.

AISS is a new introductory course sequence, taught by faculty from biology, chemistry, and physics that utilizes an interdisciplinary approach in both lab and lecture, and that accelerates entry into upper-division coursework and offers early opportunities for funded summer research with JSD faculty. The purpose of this study was to learn about the students who elected to take this accelerated, interdisciplinary introductory sequence, to assess the impact of AISS on their experience as science majors over the next three years, and to understand the faculty's perspective on AISS' impact on students in the science major and their own teaching and pedagogy.

Data from the first four cohorts of students to complete the course yielded a rich profile of key student characteristics, including demographics, pre-collegiate preparedness, self-concepts, aspirations, research experiences, and achievement in STEM courses. Further, this research compared the students who took AISS and those who took the traditional introductory course sequence to try to determine whether AISS-completers differ from other science majors in their involvement with science, in and out of the classroom. This report will present a rich description of the factors, including but not limited to AISS, within the culture of the Joint Science Department of the Claremont Colleges that influence students' decision to persist in a science major. Additionally, insights from a focus group held with AISS faculty yielded insights on the impact of the AISS initiative on their attitudes and practices as science educators.

Significance of the Study

This study is important for several reasons. It describes an innovative introductory science course, taught entirely by full-time faculty members, for science majors that fully integrates biology, chemistry, and physics throughout both the lecture and laboratory portions of the course. This is currently the only introductory undergraduate science course with this fully interdisciplinary structure and this strong faculty commitment of which this researcher is aware. Students who graduate from their undergraduate programs with significant exposure to challenging coursework and with substantial research experience are likely to be successful in graduate training programs (NRC, 2003a). One important goal of AISS is to produce young scientists able to approach complex problems from an interdisciplinary perspective. More scientists, including those with rigorous interdisciplinary training, are needed not only for the U.S. to be competitive in the global economy and to maintain our pre-eminence in the scientific community, but also to engage the increasingly complex problems of the 21st century. AISS' innovative interdisciplinary approach to introductory science seeks to provide an orientation to undergraduate science through rich course content and laboratory experiences that prepares students for the complexity of scientific issues and the ways in which rising scientists will need to work across traditional disciplines to solve them.

Secondly, this study looks deeply at AISS students' experiences in the science major from a longitudinal perspective. Students who complete AISS in their freshman year are able to enroll in upper division STEM courses ahead of their peers who take the traditional introductory science coursework. Also, they are eligible to work in research settings in the summer after freshman year because they have completed the full complement of introductory courses. This enables them to work side-by-side with faculty in the community of scientists within the Joint Science Department and beyond. Students who do early research are able to continue their involvement research in subsequent summers and during subsequent years of college, and may attend professional conferences and present original research as undergraduates. This study examines the ways in which AISS completers capitalized on their accelerated launch into the major and whether this was different in important ways from other science majors.

Thirdly, this study looks at how AISS might serve as an alternative model for teaching introductory science at other colleges and universities. While the accelerated pace and integrated format do not suit all incoming freshmen, they are features that serve students with strong high school preparation who might not otherwise be attracted to a science major because of the year and a half of introductory coursework traditionally required. Liberal arts colleges are known for producing a disproportionate number of high-level scientists, because they attract and retain highly talented students with innovative courses and excellent undergraduate teaching. AISS is one such course that may serve as a model for increasing enrollment of capable students, including women and traditionally underrepresented minorities, in the sciences. Potentially, elements of this course can be adapted by other institutions interested in improving introductory science education through an interdisciplinary and collaborative approach to teaching and research.

Theoretical Rationale

Theories of the environmental or sociological origins of change in college students constitute a major family of models of student change. These "impact models" concentrate on the processes and origins of change rather than on internal processes and dimensions of change. They provide a useful conceptual orientation to the dynamics of how students develop during their college years. Theories that have informed the current study on student development and persistence in the science major are Astin's theory of involvement (Astin, 1984, 1985, 1993) and Tinto's theory of departure (1987, 1993).

Astin collected data for his book, *What Matters in College: Four Critical Years Revisited,* through the Cooperative Institutional Research Program (CIRP) survey from approximately 25,000 students, 25,000 faculty members, and 200 institutions. By surveying students as they entered college as freshmen and then again four years later, Astin focused on the college effects of more than eighty student outcome measures to document how students changed from their freshman to their senior year. Astin controlled for students' varying input characteristics, such as high school preparation, race, gender, and socioeconomic group to determine the college environmental factors responsible for various affective and cognitive outcomes. Astin's findings indicate that measures of academic program quality such as expenditures per student, faculty/student ratios, faculty salaries and research productivity had little direct effect on student development. Instead, learning, academic performance and retention rates were associated with students' interactions with their peers, with faculty, with involvement in out-of-class activities, and with their leadership roles on campus. Astin's Theory of Student Involvement explains how and to what degree a student changes during the four years of college. The amount of a student's learning is directly proportional to the quantity and quality of that student's involvement in the intellectual and social environment of the college.

Astin's involvement theory combines the Freudian notion of cathexis (investment of psychological energy) and the learning theory concept of time-on-task. The five basic postulates of this theory are (1) involvement requires the investment of psychological and physical energy in "objects" (such as tasks, people, activities) of one sort or another, whether specific or highly general; (2) involvement is a continuous concept—different students will invest varying amounts of energy in different objects; (3) involvement has both quantitative and qualitative features; (4) the amount of learning or development is directly proportional to the quality and quantity of involvement; and (5) educational effectiveness of any policy or practice is related to its capacity to induce student involvement (Astin, 1985).

In contrast, Tinto's theory of student departure is another model of institutional impact that seeks to explain the college student attrition process. This theory suggests that students enter college with varying patterns of personal, family, and academic characteristics and skills, including initial dispositions and intentions with respect to college attendance and personal goals. These intentions and goals are subsequently modified and reformulated on a continuing basis through a longitudinal series of interactions between the individual and the structures and members of the academic and social systems of the institution. Rewarding encounters with formal and informal academic and social systems of the institution lead to greater integration in those systems and thus to student retention. Negative interactions and experiences tend to reduce integration, promoting the individual's marginality and, ultimately, withdrawal or field change. The term "integration" refers to the extent to which the student shares the normative attitudes and values of peers and faculty in the institution and adheres to the formal and informal structural requirements for membership in that community.

Tinto's model can be used to conceptualize the extent to which a student is or is not drawn into the community of the institution or academic department. The underlying dynamic of Tinto's theory of departure—student integration into the academic and social systems of an institution—is similar to Astin's theory of involvement. However, Tinto devised an explicit theoretical model, the Model of Institutional Departure, to describe the college student change process, and the attributes and interactions that influence it. These two theories share the underlying assumption that individual performance is optimized when students' needs and abilities are congruent with the demands of the environment, and help explain why some students find certain institutional environments compatible and others unappealing.

AISS provides an accelerated and demanding introduction to the science major, and as such, provides a milieu in which involvement, effort, and integration are all possible and present for students qualified for the course. One goal of this study is to try to ascertain whether AISS completers' development in the science major is different from that of other science majors in the Joint Science Department. Taken together, Astin's theory of involvement and Tinto's theory of departure provide a conceptual lens through which to study student development in the AISS course and in subsequent years as a science major in the Joint Science Department of the Claremont Colleges, and compare it to that of other science majors.

Research Questions

This study is a four-year longitudinal study of the students who enroll in AISS and the influence of this introductory course on the student experience in the science major during the undergraduate years. Additionally, this study examines the experience of faculty who developed and taught the course, and the ways in which the AISS teaching experience influenced their pedagogy and attitudes as science educators. The specific research questions are:

1) What are the characteristics and attributes (background, aspirations, self-concept, perceptions) of students who enroll in AISS? How do AISS students compare with other science majors on outcome variables measured in the junior year?
2) What are the strongest predictors of achievement in AISS?
3) Which aspects of the student experience in the Joint Science Department most strongly influenced the decision to persist in a science major?
4) How do AISS faculty members perceive the course, its influence on students' development in the major, and its influence on them as science educators?

Definition of Terms

For the purposes of this study, commonly used terms are defined as follows:

AISS—Accelerated Integrated Science Sequence; referred to as AISS or the AISS course

AISS students or AISS-completers—students who completed both semesters of AISS in the freshman year, thereby fulfilling introductory course requirements in biology, chemistry, and physics for all majors in the Joint Science Department

Other science majors—science majors who took the three standard or traditional introductory courses (each one year long) in biology, chemistry, and physics over two year; peers and classmates of AISS students; these students were surveyed in various upper division science courses, including Advanced Lab in Chemistry (Chem 127), Biochemistry (Chem 177), Molecular Biology (Chem 170L), Tropical Ecology (Bio 176), Computational Partial Differential Equations (Phys 105) in their junior year and they serve as the comparison group for the AISS juniors

JSD—The Joint Science Department of the Claremont Colleges; it offers majors in biology, chemistry, and physics, as well as in several interdisciplinary programs to undergraduates from Claremont McKenna, Pitzer, and Scripps Colleges; also referred to as Joint Sciences

STEM—The acronym for science, technology, engineering, and mathematics

Assumptions

The underlying assumption of this study was that the factors that contributed to student success and persistence in the science major could be identified and understood. It was assumed that students responding to the questionnaires were forthright and truthful in the answers. It was assumed that the survey questions were understood by the respondents and that the survey instruments were valid and reliable. It was assumed that the Other Science Majors represented a representative sampling of junior science majors who had taken the traditional two years of introductory science coursework.

Delimitations

A delimitation of this study is that the unit of analysis was confined to students in the Joint Science Department of the Claremont Colleges. The Claremont Colleges are highly selective liberal arts colleges; therefore, the results of this study cannot be generalized to undergraduates pursuing a science major in all college and university settings. The limited size of the student sample is another factor that will limit generalization of this study

Limitations

This study has several limitations that merit comment. Purposive sampling, used in this study, is non-probability method of sampling and hence can be subject to bias and error. It does not have the theoretical properties of a randomized, controlled trial, where random assignment of participants to treatment and control groups allows for theoretical balancing of unmeasured variables. No claim of causality can be made; therefore, the results must be viewed as a significant association that may be due to other factors beyond the control of this design.

Another limitation to this quasi-experimental design is that the experimental group, the AISS students in each cohort, knowing that they are participating in a unique new course, may improve their performance due to the Hawthorne Effect and that effect may influence some of the performances-based outcomes that were chosen to be measured.

The Hawthorne Effect is often mentioned as a possible explanation for positive results in intervention studies such as this one. It is used to describe behavioral changes due to an awareness of being observed, active compliance with the supposed wishes of researchers because of special attention received, and positive response to the stimulus being introduced. While there is considerable debate about the efficacy of the initial research on this effect and the role of confounding variables, it is still important to be mindful of variables that might affect the results observed in this study, including specific psychological, social, and academic variables associated with participation in the AISS course as freshmen and the subsequent benefits accrued throughout the next three years as a science major in the Joint Science Department.

Other selection effects, such as differences in pre-college preparation and achievement on standardized examinations also must be considered and addressed in order for conclusions drawn about the impact of AISS on student development in the science major to be credible.

Additionally, although every attempt was made to optimize the response rate on student surveys, not every survey yielded a 100% percent response rate due to factors such as student absence or unwillingness to participate.

Outline of the Study

This chapter, Chapter One, presented the background, introduction, purpose and significance of the study, as well as the theoretical framework for and limitations of the study. It also provided the research questions along with terms commonly used in this study.

The remaining sections of this dissertation are organized into five chapters. Chapter Two presents a review of the literature on reform efforts in K-12 and undergraduate science education, factors that affect persistence in STEM majors, and innovations in undergraduate science—all of which provide the backdrop for and situate this study of a new interdisciplinary science course at the Claremont Colleges. Chapter Three describes the research methodology used in this study. It includes the research design and procedures for collection and analysis of the data. Chapter Four outlines the findings of the first cohort of AISS students from freshman year through the first semester of senior year, through the presentation and analysis of survey and student record data. In the junior year, AISS students and other science majors were compared on certain outcome variables. This chapter also contains rich textual description of a focus group conducted with AISS faculty members. Survey results for the subsequent three cohorts of AISS students are presented in the Appendices. Chapter Five presents a discussion of the significant findings from this study, discusses their implications, and offers recommendations for practice and further research.

CHAPTER 2 – REVIEW OF THE LITERATURE

Numerous studies call for the reform high school and undergraduate science education to make it more relevant and accessible to a more diverse student population (National Research Council, 1996, 1997, 1999, 2000c; Bybee, 1993), to base it on advances on cognitive science (NRC, 2000a, 2000b; Seymour and Hewitt, 1997), and to make it more interdisciplinary so it is more like real world science (American Association of Medical Colleges, 2009; NRC, 2003a; National Science Foundation, 1998, 1996). This review of the literature begins with a historical perspective on science reform at the K-12 and undergraduate levels as a way to situate the efforts to revitalize undergraduate science education. It then explores factors that influence college student persistence in the science major. Finally, it looks at how reform in undergraduate science is taking hold for science majors as well as non-science majors, at small colleges and large universities alike, as a way of contextualizing the new introductory science course at the Claremont Colleges.

A Historical Perspective on Science Education in the U.S.

The launching of Sputnik in 1957 damaged the nation's pride, signaled the end of American supremacy in science, and called into question our educational system. This single event triggered a fifty year obsession with reform efforts focused on improving the education system in general, and the preparation of American students in science, technology, engineering, and mathematics (STEM) in particular. These improvement efforts have included ongoing debate about what should be taught, and to whom and how it should be taught. Numerous reports and position statements have been created by private and public entities. Curriculum development projects and teacher training programs have been championed by professional organizations and governmental agencies. While much of this effort has focused on K-12 science and on improving teacher preparation for the pre-college level, higher education has always been a stakeholder in these reform efforts (McCormick, 2004).

As the debate over the competing purposes of K-12 science education—educating students to enter the STEM career pipeline versus scientific literacy for all citizens—raged during the waning decades of the 20th century, undergraduate science departments watched retention rates suffer and student dissatisfaction with the quality of teaching grow. National organizations and governmental agencies began to call for reforms in science teaching to extend beyond the K-12 level and into the university classrooms in order to ensure preparation of future scientists, teachers of science, and scientifically literate college graduates in the 21st century.

Calls for reform are not new in the history of American education, including science education. They are the defining characteristic of our attempt to maintain our prominence in the world economy and our security as a nation. Three major goals that have shaped the debates on how science education should proceed are "understanding scientific knowledge, understanding and using scientific process, and promoting personal-social development" (Bybee & DeBoer, 1993). The resulting tension is whether the aim of science education is to prepare future scientists, to prepare teachers of science, or to produce a scientifically literate society. The shifting emphasis over the past fifty years between content knowledge, process, habits of mind, and real-world application is driven by these aims. The debate on reforming K-12 science and improving teacher preparation has focused on the competing purposes of educating students to enter the

STEM pipeline or promoting science literacy for all citizens. This debate has been influenced by competing emphases on the content of the science disciplines and the pedagogy of science teaching (American Association for the Advancement of Science, 1990). The driving question focuses on what is worth knowing in science and how to transfer this knowledge in meaningful ways to pre-college and college students.

In the early decades of the twentieth century, university departments of science and mathematics determined what should be taught in high schools. Debates centered on the types and number of science and mathematics courses required for matriculation to college (DeBoer, 1991). The emphasis was on what should be taught at the K-12 level, or more specifically the high school level, in order to prepare students for college, with little or no mention of their experience once they got there. With the exception of John Dewey's and other progressive educators' dissenting influence and call for a K-12 curriculum based on inquiry, student-centered pedagogy and social relevance, the predominant paradigm for science education was the obtainment of science content knowledge. This dominating influence continued until the end of World War II and into the late 1950's, and probably would have endured longer had the Soviets not rattled the United States with the launch of Sputnik.

This event spurred nationwide reform efforts to modernize the science curriculum to reflect the structure of disciplines and to increase the number of students choosing science as a career (Bybee & DeBoer, 1993; Duschl, 1990). In addition, because scientific and technological achievements were viewed as critical to our nation's security, funding from the federal government began to flow and shape reform in science education. In 1958, National Defense Education Act was signed into law to provide funding for all levels of education, but especially for the rapidly increasing numbers of students attending college. For 1959, Congress increased the National Science Foundation's (NSF) appropriation to $134 million, nearly $100 million higher than the year before and authorized the agency to expand its initiatives to support science, math, and engineering at all levels of the educational system. These initiatives funded high school curriculum reform projects such as the Physical Science Study Committee (PSSC), the Biology Sciences Curriculum Study (BSCS), and the Chemical Bond Approach (CBA) that focused on in-depth coverage of significant concepts within the disciplines and on the process of science. Academic scientists worked with school teachers to develop these curriculum projects and the NSF funded teacher institutes to strengthen the content knowledge of high school teachers.

During the 1960's the NSF funded several influential elementary curriculum projects, known as the "alphabet soup" projects. These included the Elementary Science Study (ESS), Science: A Process Approach (SAPA), and Science Curriculum Improvement Study (SCIS) (Shamos, 1995). Two important features that these projects had in common were that students had direct, hands-on experience with materials and objects to develop their understanding of science concepts and that the curriculum was "teacher proof." The written materials and activities rather than the teacher were most important in the learning experience of students. The assumption was that most teachers could not accurately teach the science concepts (Bybee, 1993).

Academic scientists dominated both the elementary and secondary curriculum projects. The role of teachers and administrators was merely to test newly developed curriculum and provide feedback to the scientists (Duschl, 1990). The focus was on the structure of the scientific disciplines and the way scientists thought and created knowledge (Bybee & DeBoer, 1993). Although these projects were widely used and were designed to actively engage students in the learning process, they did not persist. One of the reasons for their failure was that the academic scientists developed the curriculum without equal input from teachers who would implement the programs and with little involvement of these science educators (Duschl, 1990). It was an exciting era of curriculum reform that failed because academic scientists failed to see the value of training the teachers who would actually deliver their curricular innovations to the students.

Besides that, the space race had been won by the Americans when in 1968 America put a man on the moon. The "crisis" was over and the United States was once again at the forefront of achievement in science and technology. Since World War II, more than two billion dollars had been spent to revise science curriculum in elementary and secondary schools to reflect the perspective of the academic scientists (Shamos, 1995). Funding levels for reform began to be reduced and support for science reform came to an abrupt halt in 1981 when funds to the NSF's Education Directorate were cut by the Reagan Administration.

In 1983, the National Commission on Excellence in Education published the now well known report, *A Nation at Risk* (NCEE, 1983). This report described the threat to the nation caused by the overall decline in the quality of our educational system. The lack of qualified teachers, declining test scores, low standards in public schools, poor performance of American students on international examinations were among the indicators cited. This report called for more stringent standards for high school and colleges, including higher expectations for academic performance at all levels and stricter standards for admission to four-year colleges (NCEE, 1983). Specifically, the report called for all high school students to take three years of science and mathematics that included both the concepts and laws of the disciplines, and the methods, applications, and implications of science and technology. This was a clear call to governmental agencies, professional organizations, and all levels of the educational system to work in concert to ensure that Americans were prepared to participate in a global economy that was becoming more technologically based.

Beyond K-12 Reforms: Undergraduate Science Education

While most of the reform efforts before the 1980's were aimed at elementary and secondary science curriculum, *A Nation at Risk* forced academic scientists at the university level to recognize that they were responsible for the courses that inadequately prepared science teachers to be effective teachers of science content. They were also partially responsible for the lack of science literacy and loss of interest in science at a time when increasing numbers of students were matriculating to colleges and universities yet fewer were choosing to major in STEM fields (NSF, 1996). This report was a call to action for undergraduate educators to bring the reform effort to their own classrooms by ensuring that science was taught at the undergraduate level in a manner consistent with the contemporary K-12 reform efforts. No longer could academic scientists simply serve as consultants and advisors to K-12 reform; they had to get their own houses in order.

In the mid-1980's, the National Science Board of NSF commissioned a panel to address the problems of courses in undergraduate science, mathematics, and engineering. The commission's 1986 report, *Undergraduate Science, Mathematics, and Engineering*

Education, also known as the Neal Report (NSB, 1986), called for the NSF to take immediate action to bring its programmatic efforts in the area of undergraduate science in alignment with those in pre-college and graduate science education. As a result, the NSF established a separate directorate for undergraduate education (DUE) and funded proposals to improve undergraduate science education by promoting undergraduate research opportunities, developing multidisciplinary curricula with active learning experiences, and supporting access for students at community colleges (who planned to matriculate to 4-year colleges and comprehensive universities). Importantly, this report called for an improvement in efforts to increase the participation of women, minorities, and the physically handicapped in undergraduate STEM programs.

In the early 1990's, the American Association for the Advancement of Science created Project 2061 which had as its goal science literacy for all Americans by the time Halley's Comet returned in the year 2061. This long term goal recognized the need for sustained, systemic reform effort over a long period of time and was in stark contrast to then President H.W. Bush's goal that American students become first in the world in science and mathematics by the year 2000. Project 2061's first publication, *Science for All Americans* (AAAS, 1990), argued that science literary for all members of society was important not only for our economic viability, but also because knowledge of science and technology was crucial to solving global problems related to the environment and human health.

Science for All Americans focused on the nature of science, mathematics, and technology, and the basic knowledge required for literacy, but it went a step further. Its recommendations were concerned with students' prior knowledge, with inquiry, and with students having opportunities to practice and apply their learning. It called upon college and university science and mathematics departments to make changes to ensure that all graduates had sufficient knowledge of and experience with science and technology to make informed decisions as citizens (NRC, 1999). And it challenged colleges and universities to design science courses aligned with existing K-12 reforms that would provide excellent preparation for pre-service teachers.

Project 2061 set in motion committees and reports aimed at defining the problems and proposing solutions for STEM education, including *Benchmarks for Scientific Literary* (AAAS, 1993) and the *National Science Education Standards* (NSES) (NRC, 1996). Against this backdrop, the NSF and other professional societies were examining the problems with undergraduate education in STEM fields. Numerous reports had documented the need for America to produce an increased number of science- and mathematically-literate graduates in order to be competitive in the global economy of the 21st century (National Commission on Mathematics and Science Teaching for the 21st Century, 2000; NRC, 1996, 1999, 2003a; NCEE, 1983). Yet, American universities continued a disturbing trend of producing fewer mathematics and science majors prepared to enter graduate education in science (National Academy of Sciences, 2006). Instead, many of the most competitive graduate programs in these fields are dominated by qualified students from other countries. Women and minorities, although growing in number, continue to be underrepresented in certain scientific and engineering fields, especially at the upper level of these professions (NSF, 2008; Oakes, 1990). Attracting and retaining a more diverse STEM workforce will increase our innovation, creativity, competitiveness in the global market. .

Student Persistence in STEM Majors

The following section will focus primarily on the issues that influence persistence in college, and specifically in majors in science and mathematics. Tinto's (1987, 1993) analysis of student attrition is largely in agreement with Astin's (1984, 1993) involvement theory. Both agree that the decision to stay in college or drop out is influenced greatly by the student's social and academic experiences. Astin concentrated on how and to what extent involvement with the college environment and personnel enhanced student development; Tinto focused on what happened when students did not become integrated into the college experience. Tinto based his findings on analysis of several large data sets, including the National Longitudinal Survey of the high school class of 1972 and the High School and Beyond studies of the high school class of 1980.

Tinto constructed a longitudinal Model of Institutional Departure in which the student's intentions and commitments are modified and reformulated on a continuing basis through a longitudinal series of interactions between the student and the structures and members of the academic and social systems of the institution. Satisfying and rewarding encounters with these systems lead the student into greater integration into those systems, thereby promoting retention. Negative interactions and experiences reduce integration and distance the student from the institution, promoting the student's marginality and ultimate withdrawal from the institution. Students' interactions with faculty, both formal and informal, play a central role in students' integration into the life of the institution and are particularly important elements in student persistence.

According to Tinto, the absence of sufficient contact with faculty and peers is the single most important predictor of eventual departure, even after controlling for the effects of background, personality and academic performance. Tinto also found an important linkage between learning and persistence that arises from the interplay of involvement and quality of student effort. Involvement with one's peers and with the faculty both inside and outside the classroom is positively related to the quality of student effort.

Science, mathematics, and engineering majors have always experienced greater student attrition than other majors, and women are under represented in these majors and drop out in disproportionately higher numbers than men. Even though in the past twenty years, all science, math and engineering majors except computer science have made considerable strides in their recruitment and retention of women, a report by the American Association of University Women (2010) presents eight recent research findings that provide evidence that social and environmental factors contribute to the under representation of women in STEM fields. Some of those factors, including departmental culture and poor introductory courses, are directly relevant to the research conducted in this dissertation study.

The Role of Departmental Culture

Many young women graduate from high school with the skills and confidence needed to enter and succeed in majors in science, technology, engineering and mathematics, yet college-bound women are less likely than their male peers to pursue majors in these fields (NSB, 2010). The culture of academic departments in colleges and universities has been identified as a critical factor for women's success in degrees in STEM fields (NAS, 2006; Seymour & Hewitt, 1997).

Jane Margolis and Allen Fisher's research on women in computer science at Carnegie Mellon and Barbara Whitten's work on women in college physics departments found departmental culture to be a key factor in whether women stayed in or left the major. Both groups of researchers demonstrate that small changes in recruitment, admissions, course work, and creating and promoting opportunities for positive interactions between students and between students and faculty can make a big difference in students' experience.

Between 1995 and 1999, Margolis and Fisher conducted a four-year study of women and computing at the School of Computer Science at Carnegie Mellon University. They interviewed over 100 students multiple times, beginning in the first semester of freshman and ending when the student either graduated or left the major. In addition they interviewed faculty, analyzed student journals, and observed classes. When they began their study, only 7% of the undergraduate computer science majors were women and they were almost twice as likely as their male counterparts to leave the major (Margolis & Fisher, 2002). The high rate of attrition for females from the major was a concern and the impetus for the study.

Departmental culture includes the expectations, assumptions, and values that guide the decisions and actions of the administrators, professors, staff, and students. Often individuals are not aware of the influence of departmental culture as they design and teach classes, advise students, organize activities, and take classes. Margolis and Fisher found that the culture of computing reflects the norms, desires, and interests of a subset of males who take an early interest in computing and pursue it passionately throughout high school and into college. This culture is reinforced by external societal forces that associate success in computing more with men and boys than with women and girls. The leads women and girls who might be interested in computing to feel that they don't belong simply because of their gender.

Because men who predominate in computing departments, both as professors and students, have different experiences with computers and different motivations for studying computer science than do women, this culture can alienate women. In spite of the fact that today's women and men are both interested in computers and technology and equally likely to use them for educational and communication purposes, the dominant culture is still set by a male-influenced way of doing computer science. This harms the confidence and interest of capable women students and contributes to the gender gap in undergraduate computer science participation and degree attainment (Margolis & Fisher, 2002).

Departmental culture affects curriculum and curriculum plays a part in signaling who belongs in the major. Traditionally, computer science programs have focused on the technical aspect of programming in the introductory classes and left the broader applications for later. Student, both men and women, who are interested in broader, multidisciplinary applications rather than purely technical level work may be put off by a curriculum designed this way. In their interviews with students, Margolis and Fisher found that male students as well as female students express an interest in broader applications of computer science. These researchers argue that all students would benefit from a close examination of the unseen biases in departmental curriculum design.

Margolis and Fisher found that culture influences what faculty, students, and the public believe a computer science student should look like. The image of a computer major as a social “geek” who hacks away at a computer day and night to the neglect of everything else still persists even though it has softened some with the integration of computers into other disciplines like digital media, music, and film. Two-thirds of the women (and almost one-third of the men) in Margolis and Fisher’s study at Carnegie Mellon said this image didn’t fit them. This geek/hacker stereotype was particularly damaging to women. One-fifth of the women interviewed questioned whether they belonged in computer science because they worried that they lacked the intensity and focus they saw in their male peers.

Collectively, three factors—the male-dominated norms, the focus on programming and the geek stereotype—contribute to an environment and culture that are major deterrents to the recruitment and retention of women (Margolis & Fisher, 2002). These authors further stress the need to have greater gender balance and diversity among the students and faculty in the department, and to pay attention to the student experience in the department in order to attract and retain women to the field.

In another study, Barbara Whitten found that departmental culture can also be a barrier to women in physics. Physics continues to be one of the most male-dominated of the STEM fields, with women earning only 21 percent of the undergraduate degree (NSF, 2008). In her study of nine physics departments, Whitten compared physics departments that were successful in retaining female students (those in which 40% of the graduates were women) with those that were “typical” (those in which women’s representation in the graduates was closer to the national average of 20%). Like Margolis and Fisher, Whitten gathered data through interviews with faculty, students, administration, and staff and observed classes and labs. She found that the difference between successful and typical departments was departmental culture (Whitten, et al., 2003).

Whitten found that successful departments do more of the things that are supportive and welcoming to female students—and do them more consistently and more personally—than do typical departments. For example, these departments made concerted efforts to create a broader and more inclusive culture by reaching out to students in the introductory courses who might potentially major in physics and by integrating them into the department soon after they declared a physics major. Successful departments often had a physics lounge and sponsored seminars and other social events. This provided opportunities for students and faculty to interact more informally to forge relationship and for students to learn about different areas of physics (Whitten, at al., 2003).

Treisman's study of minority students in calculus courses at UC Berkeley challenged the assumption that the pool of pool of students "able" to succeed in science and mathematics is limited. It called into question theories of attrition based on extrinsic variables rather than learning experiences. In his now famous series of experiments, Treisman (1992) identified, and successfully replicated the interactions and study patterns of Asian American students who did well in his calculus courses with African American students who performed poorly. He discovered that key elements in student success were group study and support, high expectations by the professor, shared experience of success in solving progressively harder problems, and increasing student's self-confidence in their abilities. Drew and Bonsangue (1992) evaluated a calculus workshop program for Latino students built on Treisman's model that showed similar results. In both cases, the prevailing assumptions about who can and can't succeed in challenging college mathematics courses were shattered by a willingness to modify the classroom climate and learning experiences of the students.

Poor Quality Undergraduate Science Teaching

In an effort to increase the number and quality of home grown science graduates, the United States focused on science teaching and learning both prior to and during enrollment in higher education. These efforts had as goals increasing the quality of science education, improving participation of minority students and women, increasing the science literacy of all higher education students, and increasing the ability of students to function in an increasingly technological society (NRC, 1996). It had become clear that the quality of undergraduate science teaching, particularly at the earliest levels, needed to improve in order to achieve these goals. Introductory science courses are required as the prerequisites to all upper division courses for science majors. Yet, the quality of teaching in introductory courses is the single most important factor responsible for university science major dropouts (Tobias, 1992).

Recommendations for reform emphasized the need to change course content and instructional at the state level. But bringing about reform in the way science is taught at the college level is more challenging than in the K-12 system where reform is administered reform flows from governmental agencies and professional societies to individual faculty members. In higher education, dissemination of requirements for systemic reform flows from governmental agencies such as the National Science Foundation and National Academy of Sciences to individual faculty members (Shamos, 1995). The major conduits are membership in professional groups, participation in professional development, and funding opportunities to improve undergraduate curriculum and teaching. As a result, interested and receptive faculty members or small groups of faculty often function as the mechanism for change in collegiate settings.

The Society of College Science Teachers (SCST) examined the problems of introductory science curricula and developed a position paper outlining recommendations to improve these courses. In addition to acknowledging that introductory science courses are where students learn to love or hate science, the SCST stated that these courses should "contribute to the scientific literacy of all college students and should provide a conceptual base for subsequent courses" (Halyard, 1993). This organization of college professors recommended inquiry-based laboratory experiences, research-based teaching practices, and emphasis on problem solving, critical thinking and collaboration—a dramatic shift away from the lecture format and cookbook laboratory exercises prevalent on most college campuses and more aligned with the way students wee being educated in science at the K-12 level. *College Pathways to the Science Education Standards,* published by the National Science Teachers Association in 2001, encouraged college science faculty to design their course content and to use instructional strategies that were aligned with the National Science Standards for K-12. The rationale was that students entering university education were the product of K-12 reforms and were poised to continue their interest in science if science were presented in any engaging, inquiry-based manner (NSF, 1998).

Seymour and Hewitt (1997) published an ethnographic study of 335 current and former science, mathematics, and engineering students with math SAT scores (or their equivalent) of 650 or above at seven undergraduate institutions. More than half of these students had switched their major from SME (science, engineering, and math) to another field. Among “switchers’ and those students who persisted in SME majors the greatest concern was poor teaching by SME faculty. Students were critical of one-way lectures, lack of discussion, and failure to show real-world applicability of the material they were required to memorize.

Seymour & Hewitt found that switchers and non-switchers did not differ in performance, attitude, behavior, abilities, motivation and study-related behaviors. Instead, the two groups expressed similar concerns and reservations about the SME majors. What distinguished those who persisted from those who switched was the development of particular attitudes and coping strategies, and sometimes a serendipitous intervention on the part of faculty when the students may have been at a critical turning point in their academic studies. These researchers use the iceberg metaphor to convey the overarching findings of their research: the issues, which contribute most to the decision to switch from an SME major, are experienced to some degree by all SME students. The implication is that the root of the problem is with the structure and culture of undergraduate SME teaching.

Through extensive interviews with SME switchers and non-switchers, Seymour & Hewitt isolated 23 factors of greatest concern to SME majors. Non-switchers cited an average of five of these factors as concerns, while switchers cited an average of eight. Women and men largely identified the same concerns that were critical to their switching decision; however, women and men rated the degree of importance of a factor in their determination to switch differently.

Factors in the switching decision cited more often by women included a greater concern in making their education, career goals, and personal priorities fit; choosing another major which offered greater intrinsic interest and a better overall educational experience; believing the SME careers are less appealing than other choices; and experiencing more conceptual difficulties and academic problems. For men, factors that influenced the decision to switch from a SME major included a willingness to change majors to improve their career prospects, deciding that the costs outweighs the benefits of a SME major, and being impacted by the pace, workload, competition, and lower than expected grades in SME courses. Factors in the switching decision cited nearly equally by women and men included inadequacy in their high school preparation to prepare them for the SME major and criticism of the quality of instruction by SME faculty.

The NSF report, *Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology* (NSF, 1996) examined these concerns in the context of the entire continuum of STEM education from pre-school through post-graduate work, the post-Cold War political and economic climate, and the changing demography of America's student population. This report recognized that all of the stages of the STEM continuum are interdependent: undergraduate STEM education depends on K-12 students, who rely on faculty who come out of graduate programs and prepare teachers for the K-12 system and college students for graduate education. As K-12 science education changes, as a result of state and national standards, increased emphasis on inquiry, active learning, and technology integration, students will arrive on college campuses with new expectations for undergraduate education. The poor instructional practices, such as reading or copying material from the textbook, described by the students in Seymour and Hewitt's work, would not be tolerated by these students. In fact, students in their focus groups identified poor teaching in introductory courses as the major barrier to continuing in a science major (Seymour & Hewitt, 1997).

Blueprints for Reform (AAAS, 1998) described recommendations for reforming undergraduate science education, including introductory courses. This report recommended an emphasis on the process of learning with an awareness of different learning styles; focus on the central ideas of each discipline instead of broad, shallow coverage; concentration on the links among fields and disciplines of science, and active involvement of students in relevant laboratory work. Colleges and universities began offering interdisciplinary sciences courses even before this AAAS publication, particularly to non-science majors. For example, introductory and general education courses have integrated astronomy, biology, and geology (Lattanzio, 1991); biology, chemistry, environmental studies, mathematics, and physics, (Boersma, Hluchy, Godshalk, Crane, & DeGraff, 2001); and biology, chemistry, geosciences, and physics (Duschovic, Maloney, Majumdar, & Manalis, 1998); and biology and chemistry (Wolfson, Hall, & Allen, 1998).

Innovations in Undergraduate Science Education

Most introductory science courses in colleges and universities rely primarily on outdated pedagogies involving lectures and recipe-based laboratory sessions that require students memorize facts and concepts, but have little opportunity for reflection, discussion, or testing of ideas (NRC, 2003b). However, there is a growing pressure to change the way undergraduate science is taught to better reflect the complex nature of how science is done and the complex problems is must address. *Bio2010* (NRC, 2003a) calls for greater integration of chemistry, physics, and mathematics in the teaching of undergraduate biology, for both non-science majors and majors. This report also encourages faculty to implement active learning strategies, promote skills required for problem solving, focus curriculum on real-world issues, and teach with an interdisciplinary approach.

A recent report, *A New Biology for the 21st Century* (NRC, 2009) proposes a bold new integrated research agenda, with important implications for undergraduate science education. The report calls for greater integration within biology, and closer collaboration with physical, computational, and earth scientists, mathematicians and engineers— be used to find solutions to four key societal needs: sustainable food production, ecosystem restoration, optimized biofuel production, and improvement in human health. "New Biology" relies on integrating knowledge from many disciplines to derive deeper understanding of biological systems, allowing the development of biology-based solutions to societal problems. This approach may be particularly attractive to students who would otherwise be disenfranchised from science through traditional approaches to teaching and learning. Emerging research shows that allowing students to make connections between the science they study and the problems that they, their families, and their communities face can encourage greater interest in science as well as the motivation to learn science concepts more deeply (NRC, 2000a).

The preparation of scientists trained to work collaboratively across disciplines requires significant change in how colleges and universities attract, educate, and retain undergraduates. Solving complex, interdisciplinary problems will require students to move well beyond traditional science majors in order to see that connections exist across disciplines and how to make those connections. Future scientists will need exposure to and experience with engineering, technology, computer science as well as a broad base of biology, chemistry, physics, and mathematics. Scientists will need highly developed quantitative skills, therefore more quantitative training, in mathematics, statistics, and computer science must be integrated into the science major. A recent report from the Association of American Medical College and the Howard Hughes Medical Institute (2009) suggests that premedical students need more experience applying quantitative reasoning, interpreting data, making statistical inferences, and quantifying and interpreting changes in dynamics systems. Currently, structural impediments in most university mathematics and science departments limit the extent of true integration of mathematics and quantitative literacy into the science major and the premedical curriculum.

In response to these recent reports, colleges and universities around the country have begun to develop and implement genuinely interdisciplinary courses. These courses vary widely in their audience focus (non-majors versus majors, introductory versus advanced), the disciplines integrated (two or more science disciplines versus science and non-science disciplines), and the mode of instruction (lecture or laboratory or both). Some courses combine a basic science with a humanities or social science theme to examine a larger societal issue. One such course for non-majors at Evergreen State College uses a unifying theme such as water for teaching the chemistry, geology, environmental science and environmental policy integral to regional and national water issues (Tabbutt, 2000).

Other interdisciplinary courses have integrated biology, chemistry, and physics laboratory sections while keeping the lecture sections discipline specific. In the year-long Interdisciplinary Lab (ID) for science or engineering majors at Harvey Mudd College, a team on faculty from all three disciplines teaches the commonality of investigative methods and laboratory techniques in the sciences and introduces discipline-specific principles (Van Hecke, Karukstic, Haskell, McFadden, & Wattack, 2002).

In 2005-2006, Harvard University launched Life Science 1a as two semester-long introductory courses that provide interdisciplinary introduction to chemistry and biology. Taught by a team of five biology and chemistry faculty, the first semester covers essential topics in chemistry, molecular biology, and cell biology, and the second course synthesizes topics in genetics, genomics, probability, and evolutionary biology.

Princeton University offers an interdisciplinary introductory course which connects biology, chemistry, and physics for students who already want to be science majors. Created by David Botstein and funded largely by the institute he heads, the double-credit course is targeted at students with strong science and mathematics backgrounds. Although faculty members from all three disciplines are involved in the course, the laboratory sections are conducted by post-doctoral fellows rather than tenured faculty members (Arnaud, 2006).

Haverford College's Interdisciplinary Science Scholars Program, begun in 1988 through a grant from the Howard Hughes Medical Institute, is an exemplary model of interdisciplinary science education. Students who apply and are accepted into this program take additional coursework to broaden their course of study beyond the requirements of their chosen major. This additional coursework includes an additional mathematics credit, a total of at least four semesters of computer science and/or laboratory-based experimental science courses in two departments, an advanced one-semester course that explores aspects of interdisciplinary science or math outside of the major; and two semesters of research with a faculty mentor. According to the program's web site, "most graduates of the HHMI Interdisciplinary Scholars program continue to work in the sciences. Over 40 percent of graduating HHMI Scholars enter medical school, 32 percent continue their scientific studies in graduate school, 13 percent enter MD-PhD programs, and others attend veterinary school, become laboratory research associates or pursue other careers."

Building on successful programs and incorporating several novel features, The Joint Science Department at the Claremont Colleges developed a new double-credit, honors-level course for accelerated students intending to major in science in 2005. The Accelerated Integrated Science Sequence (AISS) integrates Biology, Chemistry, and Physics in the lecture, discussion and laboratory portions and is taught by tenured faculty members from each of the disciplines. A unique aspect of this course, in addition to the integrative interdisciplinary presentation of the course content, faculty commitment, and acceleration into the major, is the opportunity for students to engage in funded summer research upon completion of the course (Purvis-Roberts, Edwalds-Gilbert, Landsberg, Copp, Ulsh, & Drew, 2009).

In addition to changes in how curriculum is designed and delivered, a study published by the Research Corporation for Science Advancement (Lopatto, 2009) points to the importance of providing opportunities for research as a component of undergraduate science education. Lopatto contends that an undergraduate research experience contains the potential for a rich interaction between the student and the faculty mentor. The underlying dynamic is development and growth in the student in both scientific understanding and knowledge and integration into the larger scientific community. A now classic study (Roe, 1952) of prominent biologist, physicists, and social scientists found that the most compelling influence on the scientist's career choice was an undergraduate research experience

Interdisciplinary capstone courses have also been created for upper division science majors (Souders, 1993). These courses attempt to address the challenge of extending innovations up the curriculum. An interdisciplinary approach to the sciences, not only at the introductory level but throughout the major, has been strongly suggested as the best preparation for undergraduates intending to go to medical school (AAMC, 2009). Regardless of whether at the introductory or advanced level or at a research university or liberal arts college, all of these courses share the common characteristic of encouraging students to see the applicability of science coursework to the real world, to make connections between individual disciplines, and to work collaboratively as they will be called upon to do in the workplace.

Recent advances in cognitive science have provided educators with insights into how people best learn. The National Research Council has published two reports, *Science Teaching Reconsidered: A Handbook* (1997) and *Transforming Undergraduate Education in Science, Mathematics, Engineering, and Technology* (1999) that suggest undergraduate science should be taught utilizing this knowledge and the pedagogies that have grown out it. Specifically, according to these reports, undergraduate science should follow be taught in an engaging, active, and collaborative environment. Students should have numerous opportunities to interactive with each other and the professor during a class session. New materials should be presented so as to allow student to connect it to their prior knowledge. Traditional lectures and cookbook laboratory sessions should be relegated to the 20th century, where even then they were less than optimal strategies for most students.

According to Millar (2002), STEM faculty innovators willing to engage in curricular and pedagogical change share certain characteristics. They are risk takers and very hard workers. They make commitments and stick with them to the end. Many are inspired by a sense of mission. They are savvy and persistent about obtaining resources, including moral and material support from proactive administrators and external funding sources. They take pride in doing a good job for their students, departments, disciplines and institutions. They take an intentional, systematic, and sustained approach to solving their problems with teaching and learning. They constantly seek and reflectively use feedback information. They purposefully engage with peer learning communities (2-10 people) and/or networks (up to 100) of people who are interacting about shared problems and pursing similar action strategies. Usually these peer groups are cross-departmental or cross-institutional, and are often funded by a foundation (predominately the National Science Foundation or the Howard Hughes Medical Institute).

Many university faculty members care deeply about education, but most of them have received no training in how to teach. The demand to adopt new pedagogies to address the learning needs and high school preparation of most students must be accompanied by support and training for professors, at both liberal arts colleges and at large, research-oriented universities (NRC, 1997 , 2000b, 2003c). Well beyond the challenges of faculty interest and student preparation are larger structural impediments to shifting the way undergraduate science is taught. Interdisciplinary courses put draining demands on laboratory facilities and equipment, as well as human capital, in participating departments. In order for such courses to be sustainable, they cannot be identified with individuals; new faculty members and teaching assistance must be trained and rotated into these courses. Deep commitment from the administration of the colleges and universities to interdisciplinary science teaching is necessary in order to ensure financial sustainability beyond the initial funding phase.

Conclusion

What students learn, how they learn and how they are taught in college science, technology, engineering, and mathematics (STEM) courses are issues that have occupied educators for many years. The existing research literature makes it clear that learning and persistence can be enhanced when undergraduate science faculty design courses and incorporate teaching strategies that are student-centered, interactive, and relevant to real life. Research has also shown that there is growing support for educational reforms at all levels of science education. Reforms at the K-12 level, a more diverse student population, and our growing understanding of how student best learn have prompted and necessitated reforms at the undergraduate level.

While undergraduate science reform can and does take many shapes at different institutions, the literature suggests certain common threads such as a move away from lecture and cookbook-style laboratories, greater involvement of students in the learning process, more interdisciplinary orientation, and opportunities for students to engage in research opportunities during the college years. Numerous institutions are creating new introductory and upper-division courses that incorporate these characteristics and pedagogies for majors and non-majors. The effects of these reform efforts is not yet fully known, but efforts are underway to assess the quality of the student experience, degree persistence in STEM fields, graduate degrees awarded in interdisciplinary fields, and the number of scientists who enter the workplace.

The findings from this study focus on the role of an interdisciplinary introductory-level science course in student development in the science major at several highly selective liberal arts colleges. Insights from the student experience and the faculty perspective can help us better understand how to draw students into science and retain them as science majors, how to prepare them for complex problems they will encounter in the scientific work place, and how to make possible broader dissemination of interdisciplinary teaching and research in undergraduate science. This study contributes to the growing body of knowledge on curricular reform at the introductory undergraduate level and provides faculty and administration with useful data and analysis of a course model that fully integrates three science disciplines, accelerates progress through the major, and facilitates early participation by students in independent research.

CHAPTER 3 – METHODOLOGY

Restatement of the Problem

Introductory science education is a critical crossroads for entry into the science major. Recent reforms in K-12 education have been aimed at making science education more accessible to a more diverse student population, more interactive and hands-on, and more relevant to today's technologically savvy students. However, undergraduate science education has been, by and large, slower to follow. Instead, many introductory courses at small colleges and large universities alike still rely heavily on a lecture style format and cookbook laboratory exercises (Tobias, 1990). As a result, many qualified students decide that a STEM major is not for them and abandon science and math for other majors that are more engaging, take less time to complete, and require less effort (Seymour & Hewitt, 1997).

This is a problem for the United States because although more students are attending college than ever before fewer undergraduates are choosing STEM majors (Tobias, 1990; NSF, 2008), resulting in a truncating of the potential talent available to refuel science- and math-related career fields. In particular, women and students of color, who are perfectly capable of majoring in these fields, shy away from the authoritative and competitive manner in which introductory science is taught at many colleges and universities (Seymour & Hewitt, 1997). In order to capture this talent and fully realize the diverse potential it represents, undergraduate science educators must improve the quality of teaching at the introductory level.

To this end, the Joint Science Department at the Claremont Colleges, developed and has offered for the past four years, the Accelerated Integrated Science Sequence

(AISS). AISS is an accelerated course that allows students with strong high school preparation in science and mathematics to complete the two years of required introductory science coursework in a single year. Biology, chemistry, and physics are taught in an integrated manner in lecture and lab to allow students to better understand connections between the disciplines. Students who complete the course are able to move into upper division courses and research opportunities a full year ahead of their peers. As a result, they are able not only to complete their major requirements earlier, but also to engage in research opportunities earlier (in many cases as early as the summer after freshman year), take more required and elective science and math courses, and have the freedom in the schedules to study abroad in the junior year.

The purpose of this study is to describe the attributes of students who enroll in AISS, to examine the student experience in AISS, and to characterize the impact of AISS in subsequent years as students pursue an undergraduate science major. The primary focus of this longitudinal study is the first cohort of AISS students who are now in their senior year. Data and analysis for the subsequent three cohorts are presented in the Appendix. A selected sample of science majors in the junior year, who took the traditional introductory science course work, serves as a comparison group. Additionally, this study examines the experience of faculty who developed and taught the course, and the ways in which the AISS teaching experience impacted their pedagogy and attitudes as science educators.

This chapter describes the methodology used to conduct research on four cohorts of AISS students and the AISS faculty. The specific research questions investigated are:

1) What are the characteristics and attributes (background, aspirations, self-concept, perceptions) of students who enroll in AISS? How do AISS students compare with other science majors on outcome variables measured in the junior year?

2) What are the strongest predictors of achievement in AISS?

3) Which aspects of the student experience in the Joint Science Department most strongly influenced the decision to persist in a science major?

4) How do AISS faculty members perceive the course, its influence on students' development in the major, and its influence on them as science educators?

Participants

The population that was studied consists of undergraduate students in the Joint Science Department (JSD) at the Claremont Colleges in Claremont, California. The Joint Science Department serves students from three of the four undergraduate institutions in the Claremont College Consortium: one all-women's college (Scripps College) and two coeducational colleges (Claremont McKenna College and Pitzer College). The study sample consists of the first cohort of students who enrolled in the Accelerated Integrated Science Sequence (AISS) as freshman in order to fulfill introductory course requirements in biology, chemistry, and physics, and a comparison group of junior science majors who took the traditional introductory science sequence.

As freshmen, AISS students were surveyed in the fall semester and at the end of the spring semester. Students who completed AISS were surveyed in the late fall or early spring of their sophomore, junior, and senior year. A comparison group of science majors, which included students who had applied to AISS but were not accepted and students who had never applied to AISS, was also surveyed in the spring semester of the junior year. This group followed the traditional introductory coursework (one year each of introductory biology, chemistry, and physics) as the gateway into a science major.

Students completed the surveys in a classroom with the researcher present, but without Joint Science Department faculty members present. Students who were absent when the surveys were distributed or who were studying abroad were sent the surveys through email and returned them through email to the researcher.

Protection of Human Subjects

A proposal for this longitudinal study was submitted to the Institutional Review Boards of Claremont Graduate University, Claremont McKenna College, Pitzer College, and Scripps College for approval. Approval from all four institutions was granted in the first year of the study (Appendix A), and has been renewed each subsequent year. Data collection did not commence until approval from all of the institutions was received each year. The informed consent forms and minor assent/parental consent forms (for students under 18 years old) indicated to survey respondents the voluntary nature of their participation and assured them of confidentiality.

Instruments

Survey instruments, consisting of dichotomous, Likert-style, and open-ended questions, were constructed by the researcher each year as the study developed. This allowed the researcher to delve into issues that were raised in previous years' studies. These survey instruments drew from the existing literature in college student development and science education, including the work of Seymour & Hewitt. They contained questions modeled after the Cooperative Institutional Research Program (CIRP) Freshman Survey and the National Survey of Student Engagement (NSSE), as well as researcher-generated questions. The informed consent forms, survey instruments and coding for the variables in each survey are included in Appendices B-G.

The fall freshman survey consisted of 54 items that focused on demographic characteristics and self-concept measures, intended major, factors that contributed to achievement in the course, aspirations for major field and educational attainment, and students' experience of the newly developed course. The response rate to this survey was 97% for Cohort 1, 93% for Cohort 2, 96% for Cohort 3, and 100% for Cohort 4.

The spring freshman survey contained 66 items that focused on demographic characteristics and self-concept measures, intended majors, summer research aspirations, effectiveness of pedagogies used in the course, and confidence regarding skills, understanding, and experience at the end of the course. The response rate to this survey was 90% for Cohort 1, 96% for Cohort 2, and 88% for Cohort 3.

The sophomore survey focused on students' perceptions of preparedness for upper division science and mathematic courses, science and mathematics course taking and achievement, summer and academic-year research experiences, and intended majors. In addition, several practical questions about the course structure were included. The response rate to this survey was 60% for Cohort 1 and 73% for Cohort 2.

By junior year, students had committed to a science major; therefore, this survey focused on measures of self-concept and academic development, factors that affected the decision to pursue and persist in a science major, summer and academic-year research experiences, senior thesis plans, and graduate school and career aspirations. Three of the original AISS students had transferred to other institutions (and were continuing as science majors) and six others were studying abroad at the time of the survey; all were contacted and sent the survey through email and seven responded. One student who had withdrawn from college after sophomore year could not be contacted. The response rate of Cohort 1 to this survey was 71%.

Thirty junior science majors, who had taken the traditional introductory course sequence rather than AISS, were surveyed in the same week as the AISS juniors. The researcher contacted professors who taught courses in which juniors were enrolled (some of whom were AISS juniors) and asked permission to solicit volunteers to take a survey similar to that given to the AISS juniors. These students do not comprise a true control group for the AISS juniors because they were not selected completely randomly, nor were they matched with AISS students on any pre-collegiate criteria. However, they were all declared science majors in the Joint Science Department and were drawn from eight different junior-level science courses, so they provided a reasonable comparison to the AISS juniors. Additional student data, including SAT scores and unofficial transcripts on all students surveyed, were obtained through the Joint Science Department from the registrars of the colleges.

The final survey in this study, administered to AISS students in the late fall of senior year, consisted of 23 items that focused on measures of demographics, self-concept, science and mathematics achievement, senior thesis research, and aspirations for graduate school and careers. Fifteen seniors responded to the survey. By senior year, twenty-one of the original 28 AISS students remained in science majors in the Joint

Science Department; three students had transferred to other institutions and four had switched to non-science majors. The response rate to this survey was 71%.

Additional data on key variables were obtained through access to AISS applications, course grade records, standardized test results, and student transcripts for each cohort of students.

Key outcome measures for the survey are listed below.

Freshman Surveys
1. Demographics
2. Self-concept measures
3. AISS achievement
4. Preparedness for upper division coursework
5. Open-ended questions concerning the AISS course

Sophomore Survey
1. Demographics
2. Self-concept measures
3. Science and mathematics achievement
4. Preparedness for upper division coursework
5. Summer research
6. Open-ended questions concerning the AISS course

Junior Survey
1. Demographics
2. Self-concept measures
3. Science and mathematics achievement
4. Factors that influenced the decision to major in science
5. Career aspirations
6. Open-ended questions concerning the AISS course

Other Science Majors Survey
1. Demographics
2. Self-concept measures
3. Science and mathematics achievement
4. Preparedness for upper division coursework
5. Factors that influenced the decision to major in science
6. Career aspirations
7. Open-ended questions concerning the introductory science coursework

Senior Survey

1. Demographics
2. Self-concept measures
3. Science and mathematics achievement
4. Senior thesis research
5. Graduate school and career aspirations
6. Open-ended questions concerning AISS, major choice, and thesis topic

Faculty Focus Group

In the fall of 2010, AISS faculty members were invited to participate in a focus group. Five of the seven professors who created and taught the course participated in or gave written responses to the questions in the semi-structured interview schedule (Appendix H). Questions were designed to allow the faculty to reflect on how the AISS course impacted the science experiences of the students they taught, specifically how an accelerated and interdisciplinary approach to introductory science differed from a more traditional approach, and how this may have influenced students' experiences as majors in the Joint Science Department. Additionally, instructors were asked about how designing and teaching AISS influenced them as science educators.

Methods of Analysis

Analysis of data from Cohort 1 is the primary focus of this four-year study and is reported in Chapter 4 of this dissertation. Additionally, survey data from the next three groups of AISS students—Cohorts 2, 3, and 4—were collected and analyzed, and are reported in tabular format in Appendices I, J, and K. Data were analyzed using Statistical Software for the Social Sciences (SPSS), Versions 15.0 and 18.0. Descriptive statistical analysis and inferential multivariate analysis were used in this study.

Data Analysis

To answer the first research question, "What are the characteristics and attributes (background, aspirations, self-concept, perceptions) of students who enroll in AISS? How do AISS students compare with other science majors on outcome variables measured in the junior year?" descriptive data analyses were conducted. Demographic profiles of the students, as frequency tables containing raw data and valid percentages, were constructed for the key outcome variables. Frequencies were reported as valid percentages in order to account for missing responses, either because respondents chose not to answer a question or inadvertently skipped a question. Means and standard deviations were used to report other key outcome variables. T-tests for paired means were used to look for significant differences from year to year on certain outcome variables.

To answer the second research question, "What are the strongest predictors of student success in AISS?" multiple regression analyses were used. These analyses seek to identify the variables that predict success, or achievement, in AISS as measured by AISS fall and spring semester grade. Stepwise multiple regressions with mean replacement of missing data were conducted to predict science achievement in the freshman year (fall and spring semesters).

To answer the third research question, "Which aspects of the student experience in the Joint Science Department most strongly influenced the decision to persist in a science major?" descriptive data analyses were used. Survey frequency distribution tables and summary statistics of data from the junior year survey were used to elucidate which elements of the program offered by the Joint Science Department and the students' experience in that program most strongly influenced their decision to persist in a science major. Additionally, T-tests for samples with independent means were conducted to indicate whether AISS science majors experience the academic offerings and human capital of the Joint Science Department differently than other science majors in the junior year.

To answer the fourth research question, “How do AISS faculty members perceive AISS, its influence on students’ development in the major, and its influence on them as science educators?” qualitative analysis of the faculty responses in the focus group was conducted. Themes that provide insight into the faculty’s perceptions of AISS and its impact on their attitudes and teaching methodologies were identified through rich textual description.

CHAPTER 4 – RESULTS

The results presented in this chapter will focus on the first cohort of AISS students, Cohort 1, and will present analyses of data collected on these students as they progressed through college. This study also encompasses three subsequent cohorts of AISS students, Cohorts 2-4, in their freshman and sophomore years. Analyses of these three cohorts are presented separately in tabular format in Appendices I-K, and provide further insights into the characteristics and progress of additional AISS students in their first two years of college.

Research Question One: What are the characteristics and attributes (background, aspirations, self-concept, and perceptions) of students who enroll in AISS? How do AISS students compare with other science majors on outcome variables measured in the junior year?

The purpose of this research question is to learn about AISS students, beginning in their freshman year and progressing through their senior year. Surveys were designed for each year, based on studies in the literature, results from previous years' surveys, and issues that were of interest as the cohort progressed through college. Results and analysis are reported in chronological order below.

Fall Freshman Survey – Cohort 1 AISS Students (2007-2008)

Demographic Characteristics. Of the 29 freshman students enrolled in AISS in fall 2007, 28 responded to the researcher's questionnaire, for a response rate of 97%, and data are reported below (Table 2). Twenty-four of the respondents were female (83%) and 4 were male. Nineteen students (all female) were from Scripps College, five (4 female, 1 male) were from Claremont McKenna College, and four (1 female, 3 male) were from Pitzer College. Twenty-one students identified themselves as White, four as Asian American, two as Latino, and one as Other/Biracial. Twenty-six of the 28 students who responded to the survey were native English speakers. The high percentage of women in this cohort is worth noting as it may affect certain results in this study.

These students come from families with high educational attainment. Nearly 40% of the students (11 of the 28) are from families in which both the father and mother hold a graduate degree. Sixteen students report fathers with graduate degrees, while 12 students indicate mothers with graduate degrees.

Table 2.

Demographic Characteristics: AISS Cohort 1 Freshmen, Fall 2007 (N=28)

Variable	N	Valid %*
Female	24	85.7
Male	4	14.3
Claremont McKenna College	5	17.9
Pitzer College	4	14.3
Scripps College	19	67.8
Asian American	4	14.3
Latino (not Mexican American)	2	7.1
White/Non-Hispanic	21	75.0
Other/Biracial	1	3.6
Native English speaker	26	92.9
Not Native English speaker	2	7.1
Father with a graduate degree	16	57.1
Mother with a graduate degree	12	42.9
Both parents with graduate degrees	11	39.3

Note. * Valid percent reflects percent of respondents who answered the question

High School Background. The vast majority of students (75%) in this first cohort of AISS attended public high schools, either comprehensive, charter, or magnet in structure (Table 3). Twenty-five percent of the students in the cohort attended private high schools, either parochial or independent. Almost ninety percent of these schools were coeducational and 79% were in suburban settings. These statistics are closely associated with the profile of the general student population of the Claremont Colleges.

In order to be eligible for AISS, students are required to have strong backgrounds in high school mathematics (at least one year of high school Calculus and a score of 700 or higher on the math section of the SAT-I, or a score of 4 or 5 on the Calculus Advanced Placement exam) and science (at least 2 years of upper division science, including Advanced Placement when offered).

Many of the AISS students took Advanced Placement exams in both math and science, as well as in other subjects not directly relevant to their preparation for the sciences, and received passing scores of 3, 4, or 5. Nineteen students took the Advanced Placement Calculus AB exam or received credit for it as a subtest of the Calculus BC exam. Of those, thirteen students (68.4%) scored a 5 and five more (26.3%) scored a 4. Eight students took the Advanced Placement Calculus BC exam and of those, three students (37.5%) earned a 5 and five students (62.5%) scored a 4. Thirteen students took Advanced Placement Biology and all scored either a 4 or 5, with six students (46.2%) earning a 5 and seven students (53.8%) earning a 4. Six students took the Advanced Placement Physics B exam; one student (16.7%) scored a 5 and four others (66.7%) scored a 3. While only two students took the Advanced Placement Physics C exam, both earned a score of 4. Seven students took the Advanced Placement Chemistry exam; two students (28.6%) scored a 5, three students (42.9%) scored a 4, and 1 student (14.3%) earned a 3.

Table 3.

High School Characteristics: AISS Cohort 1 Freshmen, Fall 2007 (N= 28)

Variable	N	Valid %*
Public comprehensive	17	60.7
Public charter	1	3.6
Public STEM magnet	2	7.1
Public non-STEM magnet	1	3.6
Private parochial	3	10.7
Private independent	4	14.3
Coeducational	25	89.3
Single gender	3	10.7
Day	25	89.3
Boarding	3	10.7
Small (less than 500)	5	17.9
Medium (500 – 1000)	5	17.9
Large (more than 1000)	18	64.2
Urban	5	17.9
Suburban	22	78.5
Rural	1	3.6
Advanced Placement Calculus AB	19	67.9
Advanced Placement Calculus BC	8	28.6
Advanced Placement Biology	13	46.4
Advanced Placement Chemistry	7	25.0
Advanced Placement Physics B	6	21.4
Advanced Placement Physics C	2	7.1

Note. *Valid percent reflects percent of respondents who answered the question

The Claremont Colleges accept both the SAT-I and the ACT as standardized tests for admission. While some students took the ACT, the majority of students in this cohort took the SAT-I. The mean scores on the SAT-Math and SAT-Critical Reading sections are reported below (Table 4). It is noteworthy that the average SAT-Math score was comfortably above the threshold of 700 for selection into AISS. Also, it is apparent that the mean scores in the quantitative and verbal sections are well balanced and are above 700.

Only six of the students in this cohort took the ACT rather than the SAT-I. Their mean scores are as follows: Math, M=31.5, SD=.89; English, M=32, SD=2.8; Reading, M=33.3, SD=2.5; Composite, M=32, SD=1.26. According to the websites of both the College Board and the ACT, there is a predictable concordance between SAT-I and ACT scores. An ACT-Composite score of 32 corresponds to a combined SAT-Math + Critical Reading score between 1400 and 1430. These students had standardized test scores—subtests and composite—that were within the range set for selection into AISS.

Table 4.

SAT-I Scores: AISS Cohort 1 Freshmen, Fall 2007

	SAT-Math			SAT-Critical Reading		
	N	Mean	SD	N	Mean	SD
AISS Cohort 1	22	719	39	21*	706	56

Note. *SAT-Critical Reading score for 1 student was not reported

Majors and Degree Aspirations. When asked their probable fields of study, these freshmen students selected 9 of the 17 majors offered by JSD (Table 5). Twelve students indicated Biology-based majors (i.e., Biology, Biochemistry, Molecular Biology, and Organismal Biology). Five students selected interdisciplinary majors (i.e., Neuroscience and Environment, Economics, and Politics). One student selected Environmental Science (renamed Environmental Analysis in 2010) and another selected Art, not a science major, as their probable majors. Only one freshman indicated that she was undecided about a major at the time of the survey.

Physical science majors (i.e., Chemistry and Physics) were listed by eight students. The physical sciences were represented strongly in the early aspirations of this group of students, possibly due to their notably strong mathematical backgrounds. At the time of the first freshman survey (fall 2007), none of the AISS students indicated an intention to double major, either within the sciences or by combining science with a non-science discipline.

Twenty-seven (96.4%) of the AISS freshmen indicated an intention to earn a graduate degree. Five students (17.9%) aspired to earn a Master's degree. Approximately half (46.4%) intended to earn a Ph.D. and about a third of the group (32.1%) intended to earn an M.D. There is some overlap between these two doctoral categories because some students indicated both degrees, but clearly the AISS freshmen hold high aspirations for their terminal degrees. Ten students indicated that they were pre-med and none were pre-dental or pre-vet.

Table 5.

Probable Majors[*] and Degree Aspirations AISS Cohort 1 Freshmen, Fall 2007 (N=28)

Variable	N	Valid %
Biology	3	10.7
Biochemistry**	5	17.9
Chemistry	5	17.9
Environment, Economics, & Politics	1	3.6
Environmental Science	1	3.6
Molecular Biology	3	10.7
Neuroscience	4	14.3
Organismal Biology	1	3.6
Physics	3	10.7
Other (Art)	1	3.6
Undecided/Did not know	1	3.6
Pre-Medicine	10	35.7
Pre-Dental	0	0
Pre-Veterinary	0	0
Degree aspirations—Bachelor's	0	0
Degree aspirations—Master's	5	17.9
Degree aspirations—Ph.D.	13	46.4
Degree aspiration—M.D.	9	32.1
Did not know/undecided	1	3.6

Note. [*] Reflects 9 of the 17 majors offered by JSD
**Biochemistry, named Biology-Chemistry before 2010, is a combination of the two majors that partially meets the requirements of both

Self-Concepts. When asked to rate themselves on selected self-concepts and abilities compared to the average person their age, the AISS freshmen's mean responses fell in the average to above average range on all of the variables. There were no self-concepts on which these students rated themselves (mean score) in the highest ten percent or below average. Ratings were made using a 5-point Likert scale calibrated in the following way: 5=highest 10%, 4=above average, 3=average, 2=below average, and 1=lowest 10%. Results are rank ordered in descending order in Table 6.

AISS freshmen gave themselves highest ratings on the following self-concepts: academic ability, drive to achieve, compassion, mathematical ability, and cooperation. On these five self-concepts the mean rating ranged between 4.04 and 4.21. Students rated themselves nearly as high on critical thinking and problem solving, with mean scores of 3.96 and 3.89, respectively. Intellectual self-confidence received a rating of 3.82. The reasonably close grouping of these self-concepts, most of them directly related to success in an academic setting, is consistent with their strong pre-collegiate performance and their selection for the AISS course. It is somewhat surprising to see compassion and cooperation in this top tier; however, these are both values that are emphasized in the community life on college campuses and in the lecture and laboratory settings in AISS.

AISS freshman rated themselves lowest on the self-concepts of competitiveness, social self-confidence, risk taking, computer skills, and artistic ability. Mean ratings ranged from 3.29 down to 2.96. In contrast to areas in which they indicated more confidence, AISS freshmen rated themselves near average on these five self-concepts. With the exception of competitiveness, these may well be areas in which students have had relatively less experience prior to college. It is possible that competitiveness would be rated relatively low given that cooperation and compassion received considerably higher ratings; this may reflect the high value placed on collaborative group work and study partners in AISS.

In the middle range fall the ratings on self-understanding, leadership, creativity, and spatial ability. Typically, science and math majors do not think of themselves as creative; rather, they tend to view themselves as logical and systematic in their thinking.

This may figure in their average rating on the self-concept of creativity. The average rating for spatial ability may reflect the high proportion of women in this cohort. It is well documented in the literature that girls and women tend to have less experience with spatial reasoning than do their male counterparts, and therefore it seems reasonable to expect them to rate themselves average in this area.

These self-concepts help provide a profile of the students who are attracted to and are selected into AISS. In this cohort, high achieving students indicate quite strong self-concepts overall, with areas of perceived strength and weakness. The apparent modesty of their self-ratings may reflect their interpretation of the survey question, as well as the high percentage of women enrolled in the course, and is discussed in greater detail in Chapter Five.

Table 6.

Selected Self-Concepts: AISS Cohort 1 Freshmen, Fall 2007 (N=28)

	AISS Cohort 1	
Self-Concepts	M*	SD
Academic ability	4.21	.63
Drive to achieve	4.21	.69
Compassion	4.21	.69
Mathematical ability	4.11	.63
Cooperation	4.04	.74
Critical thinking	3.96	.64
Problem solving	3.89	.57
Intellectual self-confidence	3.82	.55
Self understanding	3.75	.80
Leadership	3.68	.72
Creativity	3.64	.73
Spatial ability	3.64	.73
Competitiveness	3.29	.76
Social self-confidence	3.25	.70
Risk taking	3.25	.84
Computer skills	3.04	.96
Artistic ability	2.96	.69

Note. *Likert scale: 5=highest 10%, 4=above average, 3=average, 2=below average, 1=lowest 10%

Preparedness for College-Level Work. AISS students were asked how well they felt their high school programs prepared them in the following areas for college level work. Their responses are indicated in Table 7. Many students felt well prepared by their science (82.1%) and mathematics (71.4%) coursework, as well as by their experience working in groups (75%). Many AISS students had access to Advanced Placement courses in high school, and those who did not took the highest level science and math offered by their school. However, there is a range of exposure to advanced topics and concepts among the students in AISS.

Nearly 2 out of 3 students (64.3%) felt well prepared in their writing skills. In the areas of computer technology and independent research, only about 20% of the class felt they had been well prepared. Only 8 students (28.6%) felt well prepared by their high school laboratory experience.

This response may reflect the fact that high school science classes consist mainly of lectures, and even many advanced laboratory science classes require cookbook-style labs. It may also help explain students' requests in the free response section of the survey for more laboratory periods in AISS. Laboratory experience is both something students feel they lack from their high school preparation and something that they expect in this course.

Table 7.

Preparedness for College-level Work: AISS Cohort 1 Freshmen (N=28)

Variable	N	Valid %*	Mean	SD
Science coursework	23	82.1	2.82	.39
Mathematics coursework	20	71.4	2.71	.46
Working in groups	21	75	2.71	.53
Writing skills	18	64.3	2.57	.63
Laboratory experience	8	28.6	2.14	.65
Computer technology	6	21.4	2.00	.67
Independent research	6	21.4	1.75	.80

Note. * "Well prepared" on a Likert scale: 3=well prepared, 2=somewhat prepared, 1=poorly prepared

Spring Freshman Survey – Cohort 1 AISS Students (2007-2008)

Cohort 1 students were asked to respond to a second questionnaire in May 2008, at the end of their freshman year. The purpose of this survey was to delve into issues and concerns that surfaced during the fall and spring semesters, and specifically to ascertain the freshmen's growth as science students and confidence to move into upper division science courses in all three disciplines. A variety of questions in several domains sought to assess students' aspirations and perceptions of their growth during the year-long AISS course. Specifically, students were asked about their intended majors (and whether they intended to continue as science majors), about their confidence in skills and abilities needed in the science major, and about instructional strategies as they related to their learning in the course.

Probable Majors. Between the fall and spring of freshman year, eight AISS students changed their science major, but none switched out of a major in science (Table 8). Four students expressed interest in a dual major at the end of the freshman year. While it was not clear whether students were interested in the dual majors offered by the JSD or in double majoring in science and another discipline, this finding is noteworthy since one of the goals of the AISS course is to accelerate the major and allow interested students this option. Also, it is worth noting the trend away from intended physical science majors even among these select students with strong mathematical backgrounds; three students who were considering physics or chemistry in the fall had shifted toward biology-related majors, interdisciplinary majors, or had become undecided by spring.

While these are tentative choices (since students are not required to declare a major until the end of sophomore year), it is apparent that students were refining their interests as a result of their early experience with collegiate level coursework. It is well reported in the literature that women tend toward biology-related fields (AAUW, 2010). Since the majority of students in this cohort are female, it is not unexpected to see a preference in this direction.

Four students did not complete the yearlong AISS course. Three female students, all with passing grades, dropped the course after the fall semester, and a third (male) student did not receive a passing grade in the second semester. Their departure from the course led to a first-year retention rate for the first cohort of 86%.

Table 8.

Probable Majors[*]: AISS Cohort 1 Freshmen, Fall 2007 vs. Spring 2008

	Freshmen Fall 2007[**]		Freshmen Spring 2008[**]		
Major	N	Valid %	N	Valid %	D%[†]
Biology	3	11.1	5	19.2	+8.1
Dual Major[††]	0	0	4	15.4	+15.4
Chemistry	5	18.5	3	11.5	-8.0
Molecular Biology	3	11.1	3	11.5	+0.4
Other/Undecided	1	3.7	3	11.5	-7.8
Biochemistry	5	18.5	2	7.7	-10.8
Neuroscience	4	14.8	2	7.7	-7.1
Physics	3	11.1	2	7.7	-3.4
Environmental Science	1	3.7	1	3.8	+0.1
Organismal Biology and Ecology	1	3.7	1	3.8	+0.1
Environment, Economics & Politics	1	3.7	0	0	-3.7

Note. [*]Reflects 10 of the 17 majors offered by JSD
[**] Fall 2007, N=27; Spring 2008, N=26
[†]D% is shown as a negative value when freshmen spring value is less than freshman fall value
[††]Dual majors in STEM and non-STEM fields, including Computer Science (2), Mathematics, and Spanish

Confidence in Content and Skills from AISS. One purpose of the spring survey was to assess students' sense of confidence in their readiness to move from this accelerated introductory course into upper division science courses in their sophomore year, because this might affect their desire to persist in a science major. Students expressed confidence that they had a strong understanding of introductory concepts in all three disciplines (Table 9), in spite of the concerns they expressed in the fall survey and in interviews with the researcher subsequent to that survey.

Sixty-nine percent of the AISS Cohort 1 freshman agreed or strongly agreed that this was true for biology; 62% agreed or strongly agreed that this was true for chemistry; and 85% agreed or strongly agreed that they felt confident in their understanding of introductory physics concepts. That there was a greater expressed sense of confidence in physics content knowledge may be reflective of the greater proportion of time dedicated to this discipline by the course design. More than half of the students agreed or strongly agreed that they felt confident in the laboratory experience gained (54%) and in the laboratory skills acquired (54%) in AISS.

When asked about research skills and abilities deemed important for success in the science major, students near the end of the AISS course responded with just better than average confidence on all of these variables, except confidence that they would publish as undergraduates (19.2%) and confidence in their formal academic writing skills (80.7%). It is possible that the reported low confidence in publishing during college reflects their relative newness to college and the fact that this is not a typical freshman aspiration. That these freshmen are confident of their writing skills is not surprising based on their strong SAT scores. Their reported confidence in the realm of scientific investigation and use of technological equipment corresponds well with their sense of confidence in laboratory experience gained in the first semester of AISS.

Taken together, these findings suggest strong student confidence in the preparation provided by this introductory course. This is important because it indicates that students felt confidence to proceed in a science major at the end of AISS even though they expressed concern earlier in the year that the accelerated pace might lead to abbreviated knowledge and experience. Hewitt and Seymour (1997) found that students who lacked confidence that they could succeed in a science major were likely to switch to another major regardless of level of achievement. Also, Margolis and Fisher (2002) report that women computer science majors who lack confidence in their preparation lose enthusiasm for the major in the early years of college and switch to other fields in which they feel they can succeed.

Table 9.

Confidence in Science Content/Skills: AISS Cohort 1 Freshmen, Spring 2008 (N=26)

Variable	N	Valid %*	Mean	SD
Have a solid understanding of introductory physics concepts	22	84.6	4.35	1.02
In formal academic writing skills	21	80.7	3.96	.72
Have a solid understanding of introductory biology concepts	18	69.2	3.62	.98
In laboratory skills acquired	14	53.9	3.54	1.21
Have a solid understanding of introductory chemistry concepts	16	61.5	3.46	1.24
In laboratory experience gained	14	53.9	3.46	1.17
In ability to ask and investigate an original research question	14	53.9	3.46	1.17
In ability to use high-tech scientific equipment in a laboratory setting	14	53.9	3.31	.92
Will publish as an undergraduate	5	19.2	3.04	.60

Note. * "Agree + strongly agree" on a Likert scale: 5=strongly agree, 4=agree, 3=no opinion, 2=disagree, 1=strongly disagree

Self-Concepts. Students rated themselves on the same self-concepts as in the fall survey. Table 10 below shows the results of both the fall and the spring survey. Self-concept ratings are rank ordered in descending order according to the results of the spring survey. The right column indicates whether there was a change in rating between the fall survey and the spring survey, and if so, the direction of the change.

The self-concept ratings show only slight changes between the fall and spring survey and none of the changes were statistically significant; however, there are trends and subtle shifts that are worth noting. Overall, there was an upward shift in the ratings. The self-concepts with the lowest ratings (competitiveness, risk taking, social self-confidence, computer skills, and artistic ability) still remain at the bottom of the list, but all show a slight increase. Risk taking and competitiveness in the spring survey results can be grouped in the middle band of ratings, those that range from 3.54 to 3.85. This reflects an upward trend compared to the fall survey results.

Self understanding, leadership, creativity, and spatial ability remain in the same relative positions in the spring survey and all except spatial ability show a slight increase. The slight drop in the rating for spatial ability may be due to experiences in the course (perhaps in labs or computer modeling exercises), but because the difference between the fall and spring ratings was not statistically significant, this can only be interpreted as a trend.

The ten self-concepts in the top group—those with ratings from 3.96 to 4.35—remain the same as the fall results although there are some subtle changes in their relative positions. Most notably, critical thinking ranks second in the spring survey, whereas it was considerably lower in the fall survey, and mathematical ability rose slightly in the relative rankings.

Although none of the changes in self-concept ratings between fall and spring were shown to be significantly different using a paired means T-test, they trend in a mostly positive direction, suggesting changes that could be attributable to the college experience and maturation during the freshman year. This has relevance in this first year and will continue to have relevance in the next three years since the literature on college impact and retention is in agreement that persistence toward a degree is largely dependent on the student's experience during college, not on pre-collegiate factors (Astin, 1993; Pascarella & Terenzini, 1991; Tinto, 1993).

Table 10.

Selected Self-Concepts: AISS Cohort 1 Freshmen: Fall 2007 vs. Spring 2008

	AISS Cohort 1* Fall 2007		AISS Cohort 1* Spring 2008		
Self-Concepts	M**	SD	M	SD	D†
Academic ability	4.21	.63	4.35	.56	+.14
Critical thinking	3.96	.64	4.19	.75	+.23
Mathematical ability	4.11	.63	4.08	.48	-.03
Drive to achieve	4.21	.69	4.08	.96	-.13
Cooperation	4.04	.74	4.04	.66	0
Compassion	4.21	.69	4.04	.87	-.17
Intellectual self-confidence	3.82	.55	3.96	.66	+.14
Problem solving	3.89	.57	3.96	.72	+.07
Self understanding	3.75	.80	3.85	.78	+.10
Leadership	3.68	.72	3.84	.78	+.16
Creativity	3.64	.73	3.69	.79	+.05
Spatial ability	3.64	.73	3.54	.95	-.10
Competitiveness	3.29	.76	3.54	.91	+.25
Risk taking	3.25	.84	3.54	.71	+.29
Social self-confidence	3.25	.70	3.39	1.1	+.14
Computer skills	3.04	.96	3.23	.81	+.19
Artistic ability	2.96	.69	3.12	.69	+.16

Note. * AISS Cohort 1 Fall 2009, N=28; AISS Cohort 1 Spring 2010, N=26
** Likert scale: 5=highest 10%, 4=above average, 3=average, 2=below average, 1=lowest 10%
†D is shown as a negative value when freshmen spring value is less than freshman fall value; paired-sample T-test indicated no significant differences, $p < .05$

Early Research Opportunities. Completion of AISS confers eligibility for funded research opportunities in the summer following freshman year. Typically, undergraduate research opportunities are reserved for older students who have completed introductory requirements and are well into upper division coursework. This means that most students are not eligible for research opportunities until after their sophomore year. When asked whether they intended to participate in research and when during college they planned to do this, AISS students indicated strong interest in capitalizing on this early advantage (Table 11).

Nearly 60% of the students planned to participate in summer research opportunities after freshman year, upon completion of AISS. In fact, eleven AISS freshmen secured funding to do research in the summer after freshman year. While most were planning to work on projects with JSD faculty members, several were in the process of arranging research opportunities closer to home or at field stations. Some of the research projects were discipline-specific, but the majority had an interdisciplinary emphasis to reinforce the themes of the AISS course. Most students who wanted to do research stated that they had received stipends in the range of $4,000-$5,000. Because the interest in summer research in this first cohort exceeded the funds allotted by the AISS NSF-STEP grant, the Joint Science Department sought additional monies to allow interested students to participate in this early research opportunity.

Seventy-seven percent of the students indicated the intent to do summer research after the sophomore and junior year. Forty-two percent of this cohort indicated that they plan to do research during every summer while in college! About two-thirds of the students indicated that they intended to do research during the academic year, and a number of these indicated planned to continue research they had begun in the summer. This would be possible because many of the AISS students were placed in research laboratories within the Joint Science Department with JSD faculty as advisors. Students who follow through on these intentions may well be engaged in several research projects during their undergraduate years. Potentially, this would provide them early and repeated access to the scientific community in the Joint Sciences, and to multiple opportunities to attend conferences and possibly publish their research as undergraduates. By the end of junior year, an impressive 36% of the original AISS cohort had done research for two or more summers. Two students did research three summers during college. Another student is already a co-author on one publication and is working on a second publication on which she is the first author.

Table 11.

Intent to Participate in Research: AISS Cohort 1 Freshmen, Spring 2008 (N=26)

Variable	N	Valid %*	Mean	SD
In the summer after sophomore year	20	77.0	4.23	.91
In the summer after junior year	20	77.0	4.19	.90
During future academic/school years	17	65.4	4.04	.96
In the summer after freshman year	15	57.7	3.50	1.7
Every summer during college	11	42.3	3.31	1.4

Note. *"Agree + strongly agree" on a Likert scale: 5=strongly agree, 4=agree, 3=no opinion, 2=disagree, 1=strongly disagree

Sophomore Survey – Cohort 1 AISS Students (2008-2009)

The sophomore survey (Appendix C) assessed AISS students' major and degree aspirations, self-concepts, preparation for upper division expectations, and STEM course taking and achievement. Also, students were asked open-ended questions about AISS and how it affected their sophomore experience. The analysis of that questionnaire is presented below and is organized by major thematic areas.

Fifteen of the 25 Cohort 1 students who completed AISS ("AISS completers") responded to the sophomore survey in fall 2009 for a response rate of 60%. Thirteen of the respondents were female and two were male. Fourteen students indicated the intention to major in science, while one female respondent switched to a non-science major. Ten of the respondents were from Scripps College (all were female), three were from Claremont McKenna College (2 were female, 1 was male), and two were from Pitzer (1 was male, 1 was female).

Majors and Degree Aspirations. By the end of sophomore year, students are required by the Claremont Colleges to declare a major. There was some switching from one science major to another between freshman and sophomore year; however, all but one of 15 respondents who completed AISS as freshmen remained a science major. One student switched to a Classics major after freshman year, even though she continued a deep interest in science. She responded to survey requests by the researcher in the sophomore, junior, and senior years.

Interpretation of the magnitude of switching between majors is influenced by the fact that only 15 AISS sophomores responded to the survey. Comparison between the two surveys, in the spring of freshman year and in the spring of sophomore year, must be made on the basis of the percentage of the cohort that responded, or valid percent. The valid percents indicate a fluctuation in some cases, such as the number of dual majors; however, the number of students with that choice is the same in both surveys. For example, it is important to consider that the same four students who indicated dual majors responded to both surveys and therefore, the increase in valid percent in the sophomore year is actually an artifact of the response rate to that survey. The data below in Table 12 are rank ordered in descending order of valid percent in the sophomore year survey.

The results of the sophomore survey show a migration out of majors in Chemistry, Environmental Science, Neuroscience, Organismal Biology and Ecology and "Undecided/Other," as well as an apparent influx into majors in Biology, Biochemistry, Molecular Biology, Physics and a dual major. Some of this movement between majors within Joint Sciences may be due to the fact that by sophomore year students have learned that the requirements for one major are similar to another major with greater desirability or flexibility. It is striking that between the end of AISS and the end of the sophomore year, only one AISS completer switched from a science major. Not apparent in the sophomore survey, but revealed in the junior year transcript data, is that three AISS completers transferred to other colleges and universities, but remained science majors. Transcript data from the junior and senior years will provide a more complete picture of the course taking and achievement by students within their majors.

The percentage of students who identified as pre-med dropped sharply between the fall freshman survey (42.3%) and the sophomore survey (13.3%), as did the percentage who aspired to an M.D. (from 32.1% to 12.3%). There was a corresponding increase (from 46.4% to 66.7%) in the percentage of students who indicated an intention to earn a Ph.D. The percentage of students who intend to earn a Bachelor's or Master's degree remained low and relatively steady, at 6.7% and 13.3% respectively. It should be noted that questions about degree aspiration did not appear on the spring freshman survey so this comparison shows fall freshmen responses compared to sophomore responses. Due to the moderate response rate on the sophomore survey, this comparison may not provide an accurate snapshot of this cohort over the course of one year, but it does suggest that by sophomore year students have decided they no longer want to be on the pre-medical track. For some, this is the result of freshman year grades and for others, it may reflect changing interests. In terms of persistence, it is noteworthy that so many AISS students remained in a science major, because freshman and sophomore years are crucial departure points for many students (Seymour and Hewitt, 1997; Tobias, 1990).

Table 12.

Majors[*] & Degree Aspirations: AISS Cohort 1 Freshmen vs. Sophomores, Spring 2009

	AISS Cohort 1 Freshmen, Spring 2008[**]		AISS Cohort I Sophomores Spring 2009[**]		
Major	N	Valid %	N	Valid %	D%[†]
Dual Major[††]	4	15.4	4	26.7	+11.3
Biology	5	19.2	3	20.0	+0.8
Biochemistry	2	7.7	2	13.3	+5.6
Molecular Biology	3	11.1	2	13.3	+2.2
Physics	2	7.7	2	13.3	+5.6
Chemistry	3	11.5	1	6.7	-4.8
Other/Undecided	3	11.5	1	6.7	-4.8
Environmental Science	1	3.8	0	0.0	-3.8
Neuroscience	2	7.7	0	0.0	-7.7
Organismal Biology and Ecology	1	3.8	0	0.0	-3.8
Pre-Medicine	11	42.3	2	13.3	-29.0
Pre-Dental	0	0.0	0	0.0	0.0
Pre-Veterinary	0	0.0	0	0.0	0.0
Ph.D. or Ed.D. [†††]	13	46.4	10	66.7	+20.3
M.D., D.O., D.D.S., or D.V.M.	9	32.1	2	13.3	-18.8
Master's	5	17.9	2	13.3	-4.6
Bachelor's	0	0.0	1	6.7	+6.7
Did not know/Undecided	1	3.6	0	0.0	-3.6

Note. *Reflects 9 of the 17 majors offered by JSD
**AISS Cohort I Spring Freshmen, N=26; AISS Cohort I Sophomores, N=15
[†]D% is shown as a negative value when sophomore year value is less than freshman year value
[††]Sophomore dual majors in Molecular Biology/Computer Science, Molecular Biology/Physics, EEP/Computer Science, and Biochemistry/Spanish
[†††]Degree data from AISS Cohort I Fall Freshman survey; was not asked on AISS Cohort I Spring survey

Self-Concepts. The sophomore survey contained most of the same self-concepts as the freshman survey. Several new self-concepts were added based on results of freshman surveys and interviews at the end of freshman year. These are indicated in Table 13 with a double asterisk, and include the ability to reason logically, ability to work hard, determination, writing ability, time management, optimism, persistence, and collaboration. All of these self-concepts were either mentioned by the freshmen as important to their success in AISS or mentioned in the literature as important to success in college (Astin, 1993).

AISS sophomores continue to be relatively modest in their self assessment in that their highest average self ratings remain in the “above average” range in majority of the self-concepts, but on none of the self-concepts did these students rate themselves in the highest 10%. As mentioned in the analysis of the freshman year surveys, it is highly likely that these students are comparing themselves to other students at the Claremont Colleges, including possibly other highly capable students who took the AISS course, and this comparison may result in somewhat depressed self-concept ratings.

The top ranked self-concepts, those above 4.00, were ability to reason logically, ability to work hard, drive to achieve, determination, and critical thinking. Self-concepts that fell to the bottom of the rankings were spatial ability, competitiveness, social self-confidence, collaboration, artistic ability, and risk taking. This is a result similar to that seen in the freshman year surveys, in which competitiveness, spatial ability, artistic ability, and risk taking received the lowest rankings. It is possible that this is a reflection of the gender representation in this cohort, given that 12 of the 15 (80%) sophomore respondents were female, as were 24 of the 28 (86%) original AISS freshmen. The possible effects of the overrepresentation of women in this cohort will be explored further in Chapter 5. The remaining self-concepts fell between ratings of 3.60 and 3.93, all above average.

Table 13.

Selected Self-Concepts: AISS Cohort 1 Sophomores, Spring 2009 (N=15)

	AISS Cohort 1	
Self-Concepts	M*	SD
Ability to reason logically**	4.20	.68
Ability to work hard**	4.20	.68
Drive to achieve	4.07	.70
Determination**	4.07	.70
Critical thinking	4.00	.53
Mathematical ability	3.93	.70
Problem solving	3.93	.59
Writing ability**	3.80	.70
Time management**	3.80	.86
Optimism**	3.80	.94
Creativity	3.73	.89
Compassion	3.67	.90
Persistence**	3.60	.91
Spatial ability	3.53	.64
Competitiveness	3.53	1.13
Social self-confidence	3.33	.90
Collaboration**	3.33	.72
Artistic ability	3.33	.90
Risk taking	3.27	.88

Note. *Likert scale: 5=highest 10%, 4=above average, 3=average, 2=below average, 1=lowest 10%
**Self-concepts that appeared on sophomore survey, but not on freshman surveys

In another analysis, ratings of self-concepts that are common to both the freshman spring survey and on the sophomore survey were compared (Table 14). They are rank ordered in descending order of magnitude on the sophomore survey. Even though there is a slight downward trend in average self-concept rating between freshman and sophomore years, none of these differences are statistically significant, based on paired-sample T-tests. In this comparison, drive to achieve, critical thinking, mathematical ability, and problem solving appear in the top tier of ratings. The self-concepts of spatial ability, competitiveness, social self-confidence, artistic ability, and risk taking still remain at the bottom of the rankings. It is worth noting that the self-concepts held noticeably steady between the end of AISS and the completion of the first three quarters of sophomore year, during which time many AISS students participated in summer research projects, weathered Organic Chemistry, and took a variety of other challenging upper division courses as second-year college students. It is documented in the literature that self-concepts tend to be remarkably enduring throughout the college years, and this documentation of the steadiness of the AISS students' self-concepts can be taken as at least a small indication of the success of the course in preparing first-year students for future academic challenges.

Table 14.

Selected Self-Concepts: AISS Cohort 1, Freshmen vs. Sophomores, Spring 2009

	AISS Cohort 1* Freshmen Spring 2008		AISS Cohort 1* Sophomores Spring 2009		
Self-Concepts	M**	SD	M	SD	D
Drive to achieve	4.08	.96	4.07	.70	-.01
Critical thinking	4.19	.75	4.00	.53	-.19
Mathematical ability	4.08	.48	3.93	.70	-.15
Problem solving	3.96	.72	3.93	.59	-.03
Creativity	3.69	.79	3.73	.89	.04
Compassion	4.04	.87	3.67	.90	-.37
Spatial ability	3.54	.95	3.53	.64	-.01
Competitiveness	3.54	.91	3.53	1.13	-.01
Social self-confidence	3.39	1.1	3.33	.90	-.06
Artistic ability	3.12	.69	3.33	.90	.21
Risk taking	3.54	.71	3.27	.88	-.27

Note. * AISS Cohort I Spring 2010, N=26; AISS Cohort I Sophomores, N=15
**Likert scale: 5=highest 10%, 4=above average, 3=average, 2=below average, 1=lowest 10%
†D is shown as negative value when sophomore year value is less than freshman year value; paired-sample T-test showed no significant differences, $p < .05$

Preparedness for Upper Division Expectations. When asked how well AISS had prepared them for upper division expectations (Table 15), 93% of the Cohort I sophomores indicated that they felt well prepared. Eighty percent indicated that they were well prepared to collaborate with others, make connections between disciplines, and work independently—all skills that were emphasized and practiced in the AISS course. Two-thirds of the respondents said they felt well prepared by AISS to take upper division science courses, while only 40% felt that AISS prepared them well to take upper division math courses in general, and less than 20% felt AISS prepared them well for Calculus II and Calculus III, specifically. This is probably an indication that AISS was a science course that utilized mathematics up to the level of Calculus I, rather than a mathematics course per se. This response also may have reflected the fact that a good number of the AISS students do not need to take Calculus II by virtue of their Advanced Placement credits, and therefore didn't consider AISS as preparation for a course they would not need to take. In spite of this decidedly measured sense of their preparedness to continue in upper division mathematics, these sophomores enrolled in an impressive array of upper division science and mathematics courses, as indicated in the footnote to Table 15. Not only did they enroll in these courses, but also they achieved at a nearly uniformly high level by earning grades in the A/B range in virtually all of these courses. This achievement is discussed in more detail in the next section.

Consistent with their concerns as freshmen about their laboratory skills and experience, only 20% of AISS sophomores indicated that they felt well prepared by AISS for the laboratory portion of Organic Chemistry. In AISS, the labs were less prescribed and more open-ended than in the traditional chemistry courses (Chem 14, 15, and 29). Additionally, they were often integrated into lecture portion of the course rather than being standalone labs that focused on teaching a set of laboratory skills. This left many

AISS students feeling insecure about the quality and quantity of their laboratory experience as compared to their peers, who had more extended and structured laboratory sessions in the traditional introductory pathway.

Table 15.

Preparedness for Upper Division Expectations: AISS Cohort 1 Sophomores, Spring 2009 (N=15)

Variable	N	Valid % *
Other upper division science courses**	10	66.7
Organic Chemistry lecture (Chem 116, 117)	9	60.0
Other upper division math courses†	6	40.0
Organic Chemistry lab (Chem 116L, 117L)	5	33.3
Calculus III (Math 32)	2	20.0
Calculus II (Math 31)	2	13.3
Physical Chemistry lecture (Chem 121, 122)	2††	0
Continuing in a science major	14	93.3
Collaborating with others	12	80
Making connections between disciplines	12	80
Working independently	12	80
Doing summer research	8	53.3
Going to office hours	8	53.3
Studying abroad in future years	6	40

Note. *"Well prepared" on a Likert scale: 3=well prepared, 2=somewhat prepared, 1=poorly prepared
**Includes Genetics (Biol 143), Evolution (Biol 145), Neuroscience II: Systems (Biol 149), Natural Resources Management (Bio 159), Cell & Molecular Neurobiology (Biol 161), Molecular Biology (Biol 170), Molecular Biology Seminar (Biol 173), Organic Chemistry (Chem 116 and 117), Physical Chemistry (Chem 121and 122), Organic Geochemistry (168C), Modern Physics (Phys 35), Computational Physics & Engineering (Phys 100), Intermediate Electricity and Magnetism (Phys 102), Calculus III (Math 32), Discrete Mathematics (Math 35), Introductions to Biostatistics (Math 58), Linear Algebra (Math 60), Differential Equations (Math 102), and Math Analysis (Math 131)
†Includes Discrete Mathematics (Math 55), Introduction to Biostatistics (Math 58), Linear Algebra (Math 60), Differential Equations (Math 102), Math Analysis (Math 131)
††Responded "somewhat prepared"; these students subsequently earned grades in Introduction to Physical Chemistry as sophomores of B+, A- in Chem 121 and B, A- in Chem 122

STEM Course Taking and Achievement. An analysis of AISS sophomore course taking was undertaken in order to learn which courses these students enrolled in after completing the accelerated introductory sequence. AISS students complete the introductory coursework in biology, chemistry, and physics in the freshman year, whereas other intended science majors do not complete all three required introductory courses until the end of the sophomore year. Other aspiring science majors can take only two of the three required introductory courses as freshmen because of breadth or core requirements in the first year of college. Most of these students take introductory biology and chemistry as freshmen, in order to be eligible for Organic Chemistry as sophomores, and virtually all who need physics for their major take introductory physics as sophomores. Additionally, many of the students not in AISS take Calculus I or II as freshmen, whereas most AISS students place into either Calculus II or III (or even Linear Algebra, the next course in the mathematics sequence) because of credit received for the Advanced Placement Calculus AB or BC exam. As a result of the acceleration of the introductory coursework in science and advanced placement credit in mathematics, AISS students are able to enroll in more upper division requirements in science and mathematics as sophomores. In many cases, AISS sophomores are a full year ahead of their peers in the Joint Sciences.

For example, AISS sophomores may take Modern Physics, Calculus III, Linear Algebra (all advanced upper division courses), while their peers who complete introductory chemistry and biology as freshmen may enroll in Organic Chemistry as sophomores, but must still take introductory level physics and prerequisite mathematics as sophomores. Some JSD majors (such as Biology, Human Biology, Organismal Biology, Science and Management, and Environment, Economics, and Politics) require only Calculus I or Statistics. All of the remaining majors (such as Biochemistry and Chemistry) require mathematics through Calculus II, and some (such as Physics and Economics-Engineering) require mathematics through Differential Equations. Non-AISS students often fulfill this mathematics requirement in sophomore and junior year. AISS students, many of whom scored a 4 or 5 on the Advanced Placement exam in Calculus, receive credit for Calculus I and II. Others take Calculus III and beyond as sophomores.

Table 16 below shows the AISS students' broad enrollment in thirty science, mathematics, computer science, and engineering courses. Twenty-two of these courses are upper division requirements and require introductory-level courses as prerequisites. In some courses only a small number of AISS students—sometimes only a single student—are enrolled and the average grade is calculated from a small N. Nevertheless, the strong achievement of these students is clear across the disciplines.

Table 16.

STEM Course Taking and Achievement[*]: AISS Cohort 1 Sophomores, Spring 2009

Course Number	Course Name	N	Mean Grade
Biol 082	Topics in Infectious Disease	1	C+
Biol 133L	Introduction to Math. Physiology[†]	1	A
Biol 138L	Applied Ecology and Conservation[†]	1	A
Biol 143	Genetics[†]	5	A
Biol 145	Evolution[†]	4	A-
Biol 159	Natural Resource Management[†]	1	A
Biol 161L	Neuroscience 1: Cell, Molecular	1	A-
Biol 173L	Introductory Biology Seminar w/ Lab[†]	6	A
Biol 199	Independent Study in Biology[†]	1	A
Chem 116L	Organic Chemistry[†]	19	B
Chem 117L	Organic Chemistry[†]	18	B
Chem 121	Principles of Physical Chemistry[†]	2	A-
Chem 122	Principles of Physical Chemistry[†]	2	A-
Chem 168	Organic Geochemistry[†/††]	1	B+
Phys 35	Modern Physics[†]	4	B+
Phys 100	Computational Physics & Engineering[†]	3	A-
Phys 102	Intermediate Electricity & Magnetism[†]	3	B
Neur 95	Principles of Neuroscience	1	A-
Math 30	Calculus I	1	A
Math 31	Calculus II	3	A-
Math 32	Calculus III[†]	3	B+
Math 55	Discrete Mathematics[†]	1	B
Math 58	Introduction to Biostatistics w/ Lab[†]	1	B
Math 60	Linear Algebra[†]	3	A
Math 102	Differential Equations[†]	2	A
Math 131	Math Analysis I[†]	1	A-
CSci 51	Introduction to Computer Science	3	B+
CSci 52	Fundamentals of Computer Science [†]	1	B[F]
CSci 60	Principles of Computer Science[†]	2	B
Engr 04	Introduction to Engineering	1	B

Note. [*]Calculated from sophomore transcript data, using 12-point grading scale in which A= 12 points
[†]Upper division courses that have introductory science and/or mathematics as prerequisites
[††] Upper division courses offered at Harvey-Mudd College; have introductory science and/or mathematics as prerequisites

Organic Chemistry, Chem 116 and Chem 117, is a two-semester gateway course to many of the majors (e.g., Chemistry, Biochemistry, Biology, Molecular Biology, Science and Management) in the Joint Sciences. Many students who intend to major in science take Organic Chemistry as sophomores. AISS sophomores are eligible and so are students who took the traditional introductory pathway and completed the introductory chemistry course (Chem 14 and Chem 15, or the one-semester Chem 29 for students who Advanced Placement credit). Nineteen of the 25 students who completed AISS took Chem 116, and eighteen continued on into Chem 117. The average grade for these AISS sophomores in each semester (Chem 116 and Chem 117) was a B—9.3 for Chem 116 and 9.0 for Chem 117. The Joint Science Department uses a 12-point scale in which an A is awarded 12 points.

In the junior year, a group of 30 science majors who took the traditional introductory science coursework (who will be referred to as Other Science Majors throughout this dissertation) were surveyed along with the AISS juniors. From the transcripts of these students, it was possible to see how many enrolled in Chem 116 and 117 and to document their achievement in those courses. Seventeen of the Other Science Majors took Chem 116 and earned an average grade of B (GPA 8.6). Sixteen continued on to Chem 117 and earned an average grade of B (GPA 9.0). This comparison indicates that AISS sophomores and sophomores who took the traditional Chem 14, 15 and 29 performed comparably in a rigorous upper division chemistry course. It is an important early indicator that AISS successfully prepares students, at least as well as traditional introductory chemistry courses, to succeed in rigorous upper division chemistry coursework.

Further, in all of the STEM courses taken by AISS sophomores, except one, the average grade was B or better. In sixteen courses, AISS sophomores earned average grades in the A/A- range. In twelve other courses, the average grade was in the B/B+ range. One AISS sophomore who took an elective in biology that required no prerequisites earned a C+.

A more extensive comparison between AISS students and other science majors was performed using junior year transcripts and the junior year surveys to learn more about course taking trends and achievement.

Qualitative Description of Open-ended Survey Questions. The sophomore year survey included several open-ended questions about important aspects of the AISS course and experience. Students' responses are summarized and discussed in the following section.

Question #1: If you did summer research after your freshman year, please describe how that experience impacted you as a science student.

AISS students were unanimously positive in their comments about the summer research experience. They described the opportunity to do early research in college as "transformational," "irreplaceable," "a unique experience in science and in college that I wouldn't trade," and an experience that "confirmed that research is what I want to do and I will do research again this upcoming summer as a result of this summer's work." They described their summer research opportunities as helping them clarify their goals and solidify their interests. One student stated that summer research exposed her to "the realities of a science career and helped me realize that I love research and want to be a research scientist," while for another student the experience "helped me decide to change from biology major because I realized that the biomedical lab is not the environment I want to work in as a career." A number of students describe research as something that made science real for them and allowed them to "take abstract concepts learned in my classes and apply them to real data and real situations." Students appreciated the chance to "to see science used in the real world." One student said that "summer research made me realize my interests more intensely." Students clearly valued the chance to be in laboratory and field settings and enjoyed the camaraderie of their research groups. They "worked hard, got a lot of work done, went to conferences, and heard scientists present their findings." They realized that they were gaining valuable experience from these opportunities. One student commented, "It launched me into the scientific community, and fostered my independent research." Another said that it was a "great introduction to the academic community and how research is done and presented." Students also made the connection between the interdisciplinary approach to science they experienced in AISS and how research is actually done, as shown by comments like, "It made me realize how interdependent and collaborative research is" and "I actually used some of the interdisciplinary thinking I learned in AISS to solve a problem in my lab." The enthusiasm of these students is obvious from their comments and it is easy to see why the students who were able to do summer research felt so strongly influenced by the experience. It was impressive that three of the students indicated that they were participating in research opportunities during their sophomore year. The importance of research in the undergraduate science experience is well documented in the literature (NRC, 2003a; Lopatto, 2009) and its early placement in the undergraduate experience is one of the most powerful features of the AISS course.

Question #2: Looking back on the AISS course, how do you think it most benefited you?

The goal of the question was to try to gain a clearer understanding of what students saw the benefit of AISS to be. The course was designed to meet institutional goals, such as increasing the number of science majors, and instructional goals, such as emphasizing in the first college course the deep integration of the scientific disciplines. An important goal of the three liberal arts colleges that compose the Joint Science Department is to allow students to broaden their education through study abroad. An important albeit secondary goal of AISS is to facilitate students to major in a science *and* study abroad. Science major programs in the Joint Sciences are course intensive, and account in some cases for half of a student's four-year course load. When combined with each college's general education requirements and the hierarchical nature of the science curricula, the effect is to severely restrict students who select science majors from studying abroad. By accelerating the introductory course work and allowing students do complete upper division requirements for the science major earlier, AISS removes this barrier.

Students' responses indicated that they saw the practical benefits associated with AISS as well the deeper developmental benefits of the course. Students commented that AISS "saved me time and freed up my schedule for studying abroad and fitting in the classes I have to take and those I want to take" and "it set me up really well for finishing my major and being pre-med" and "I've gotten to take upper division courses as a sophomore and I can study abroad either in science or not."

They also realized that AISS helped them develop as students, as shown by comments such as, “it prepared me for the work load of college, for taking initiative, and for taking advantage of office hours” and “it taught me how to manage large volumes of work; every other course I’ve taken seems easy by comparison.” Several students described psychosocial benefits to the year in AISS in comment such as “it was an intense experience with people who became some of my closest friends” and “AISS helped foster close faculty relationships and made me comfortable approaching professors for help” and “it caused a general rise in my self-esteem.”

Recognizing the unique educational value of the course, students wrote comments such as, “it taught me to learn subjects by connecting them with related subjects, like taking what I learned in linear algebra and connecting it to my computational physics class” and “it was helpful in preparing me for the intensity and depth of analysis that my other physics classes have required” and “it helped me see the connections, for example in organic chemistry I’ve applied physics to help me better understand certain concepts.” One student stated that “AISS allowed me to see concepts in a different light and more holistically when presented in an interdisciplinary manner.”

Question #3: If given the chance to roll back time, would you choose the AISS course or the traditional introductory science pathway?

AISS sophomores were divided in their responses to this question. Many described the course as a “baptism by fire introduction to the science major” and indicated that if they could survive the pace of the course and volume of material they had to learn, they could survive anything. Students recognized that AISS provided them with unique opportunities that weren’t available to other science majors: “Even though it was extremely difficult, AISS prepared me for success and failure as a science major and opened up many doors early for me" and "I'm glad I was able to condense the introductory courses into only the most vital part; for me, the traditional pathway would have been very redundant and I want to get on with it." Students wanted to dispel the myth that AISS catered to students interested in biology; one commented, "AISS isn't just for biochem people. I'm strictly physics and learning the other two strands definitely put me a step ahead." Students recognized "that three professors were completely dedicated to that course and its students" and were impressed that "all three of them came to class every day even when it wasn't their lecture."

However, two students indicated that they would not choose AISS if they could roll back the clock. One student stated, "I think I could have learned these subjects more deeply if I took them separately" and the other student "wanted flexibility to explore other majors, but AISS completely dominated my life all freshman year." Although this was the minority opinion, it is worth paying attention to the reasons why capable students would not opt into the course if given another chance. In both cases, these students' opinions were at odds with what the professors and the published information about the AISS tells incoming students to expect; however, that might be an indication that more effort is needed to explain the demands of this accelerated, double credit course, especially for freshmen new to the college experience.

Junior Surveys – AISS Cohort 1 Students and Other Science Majors (2009-2010)

In the junior year, AISS juniors and other junior science majors were surveyed on measures of self-concept and academic development, factors that influenced their decision to major in a science, plans after college, career aspirations, and perceptions of the effect of AISS or the traditional introductory science pathway on their undergraduate experience. The survey developed for AISS juniors is included in Appendix D and the survey developed for the other junior science majors is included in Appendix E. The analyses of those surveys are presented below and are organized by the major thematic areas.

Eighteen of the 25 Cohort 1 students who completed AISS responded to the junior survey in spring 2010 for a response rate of 72%. Sixteen of the respondents were female and two were male. Three of these students (all female) had transferred from the Claremont Colleges after sophomore year, were attending other institutions at the time of the survey, and were continuing to major in a STEM field at the institutions to which they transferred. Fourteen students were declared science majors in the Joint Science Department at the time of the survey; one student switched to a Classics major after freshman year. Ten of the students were from Scripps College (all were female), four were from Claremont McKenna College (3 were female, 1 was male), and the one Pitzer student was a male.

A comparison group of 30 other junior science majors was created by surveying science majors in upper division courses in the Joint Science Department. The researcher was granted permission from five professors to invite juniors to take the Other Science Majors Survey at the end of a class period in spring 2010. This survey was developed specifically for science majors who did not take AISS to fulfill the introductory coursework for their majors. It contains many of the same questions as the AISS Junior Survey, as well as questions uniquely designed to learn how most students who major in science experience the Joint Science Department.

Majors and Degree Aspirations. It was of interest to first compare the probable majors selected by AISS students as freshmen to their declared majors in the junior year. Nine AISS students selected their majors as freshmen and did not change. Four students settled on the major as sophomores and five declared their major in the junior year. Joint Science professors encourage students to delay deciding on a major until they had taken courses in several disciplines so that the college experience rather than the high school experience informed their ultimate choice. While half of the respondents to the junior survey indicated that they had not fully decided on their major in the freshman year, the other half arrived at college with this decision already made. Since AISS integrates biology, chemistry and physics in the freshman year, the seemingly early selection of a major may be the result of early exposure to all three major disciplines. The two students who indicated physics as a major in the freshman year reported to the researcher that their experience in AISS directly influenced this decision.

Table 17 indicates that between freshman and junior year the number of biology-related majors selected by AISS students showed a slight increase and remained predictably higher than the number of physical science majors. About 20% of AISS juniors who took this survey opted for a major in chemistry or physics. In addition, it should be noted that the three dual majors selected by AISS juniors involved a physical science and mathematics. This relatively strong representation of the physical sciences among the major choices of the group may be in part a reflection of the strong mathematical inclination and background of students selected for AISS. Interdisciplinary majors, such as Neuroscience and Organismal Biology and Ecology, were chosen in greater number by AISS students as freshman than as juniors. Even for students who did not select an interdisciplinary major, data on senior research thesis topics presented later in this chapter demonstrate their enduring interest in interdisciplinary work.

Table 17.

Probable and Declared Majors[†]: AISS Cohort 1 as Freshmen vs. Juniors, Spring 2010

	AISS Freshmen Spring 2008 [††]		AISS Juniors Spring 2010[††]		
Major	N	Valid %	N	Valid %	D%[††]
Biology	5	19.2	4	22.2	+3.0
Biochemistry	2	7.7	1	5.6	-2.1
Chemistry	3	11.5	3	16.7	+5.2
Dual Major	4[*]	15.4	3[**]	16.7	+1.3
Molecular Biology	3	11.5	3	16.7	+5.2
Environmental Science	1	3.8	1	5.6	+1.8
Neuroscience	2	7.7	1	5.6	-2.1
Other/Undecided[***]	3	11.5	1	5.6	-5.9
Physics	2	7.7	1	5.6	-2.1
Organismal Biology and Ecology	1	3.8	0	0	-3.8

Note. [†]Reflects 9 of the 17 majors offered by JSD
[††] D% is shown as a negative value when junior year value is less than freshman year value
[†††] Spring 2008, N=26; Spring 2010, N=18
*Dual majors as freshmen: Chemistry/Computer Science, Chemistry/Mathematics (2), and Biology/Spanish
**Dual majors as juniors: Chemistry/Mathematics (2), Physics/Media Studies
*** Undecided, 3 freshmen; Other, 1 junior who switched to Classics major after AISS freshman year

When AISS juniors and Other Science Majors are compared on their declared choice of major (Table 18), a number of trends emerge. There are more biology-based majors (i.e., Biology, Human Biology, Biology-Chemistry, Molecular Biology, and Organismal Biology and Ecology) in the group of students who took the traditional pathway through the science major than in the AISS group. Sixty percent of these students selected biology-based majors compared to 45% of the AISS juniors. The percentage of students in both groups who selected physical science majors (Physics or Chemistry) is very similar, 22.3% in the AISS group and 23.4% in the Other Science

Majors group. Interdisciplinary majors (Biology-Chemistry; Environment, Economics, and Politics; and Neuroscience) were selected by 11.2% of AISS juniors compared to 13.4% of Other Science Majors.

The most notable difference in majors between these two groups of students is in the percentage who selected a dual major. In the AISS group, 16.7% of the juniors surveyed are dual majoring compared to none in the Other Science Majors group. This difference is at least in part due to the fact that AISS students complete introductory science coursework as freshmen and are therefore more able to take more upper-division science and math courses in subsequent years than are their peers, thus making it possible to fulfill the major requirements in more than one field of study.

A higher percentage of Other Science Majors were pre-professional than were AISS juniors. Forty percent of the Other Science Majors selected a pre-professional track, with 33.3% choosing pre-med and 6.7% choosing pre-dental. Of the AISS juniors, 27.8% were pre-med and none were pre-dental. Many incoming students, especially those who are pre-professional, consider AISS a "risky" first-year course because of its accelerated pace, because they are not sure what to make of the integrated format, and because it carries a double-course credit on the college transcript. For this reason, students who are concerned about having a competitive grade point average tend to take their introductory science courses at a slower pace in the traditional course sequence.

It follows that there are more students in the Other Science Majors group (40%) who aspire to an M.D. or a D.D.S as their terminal degree than in the AISS group (27.8%) in the group of students who took traditional introductory coursework. On the other hand, 56% of the AISS juniors aspire to a Ph.D., compared to 43% of the Other

Science majors. Just over 80% of students in both the AISS and the comparison group aspire to a doctoral degree, while 11.1% of AISS students and 6.7% of the comparison group aspire to a Master's degree. Only a small percentage in each group indicated an interest in pursuing a J.D., 6.7% in the AISS group and 3.3% in the Other Science Majors group.

Table 18.

Declared Majors[†] & Degree Aspirations: AISS Cohort 1 Juniors vs. Other Science Majors, Spring 2010

	AISS Cohort 1 Juniors[*]		Other Science Majors Juniors[*]		
Major	N	Valid %	N	Valid %	D%[††]
Biology	4	22.2	10	33.3	-11.1
Human Biology	0	0	1	3.3	-3.3
Biochemistry	1	5.6	2	6.7	-1.1
Chemistry	3	16.7	5	16.7	0
3/2 Engineering Option	0	0	1	3.3	-3.3
Environment, Economics & Politics	0	0	2	6.7	-6.7
Environmental Science	1	5.6	2	6.7	-1.1
Molecular Biology	3	16.7	4	13.3	+3.4
Neuroscience	1	5.6	0	0	+5.6
Organismal Biology and Ecology	0	0	1	3.3	-3.3
Physics	1	5.6	2	6.7	-1.2
Dual Major**	3	16.7	0	0	+16.7
Other	1	5.6	0	0	+5.6
Pre-Medicine	5	27.8	10	33.3	-5.5
Pre-Dental	0	0	2	6.7	-6.7
Pre-Veterinary	0	0	0	0	0
Bachelor's	0	0	2	6.7	-6.7
Master's	2	11.1	2	6.7	+4.4
Ph.D. or Ed.D.	10	55.6	13	43.3	+12.3
M.D., D.O., D.D.S	5	27.8	12	40.0	-12.2
J.D.	1	5.6	1	3.3	+2.3

Note. [†]Reflects 12 of the 17 majors offered by JSD; AISS Seniors selected 8 majors, OSM selected 12 majors
[††]D% is shown as negative value when AISS is less than Other Science Majors
*AISS Juniors, N=18, Other Junior Science Majors, N=30
**Dual majors in Chemistry/Mathematics (2) and Physics/Media Studies (1)

Preparedness for Upper Division Course Work. Juniors who took the traditional introductory course pathway were asked how well it prepared them for upper division course work. These same questions were included in the Other Science Majors survey, but not the AISS Junior year survey because AISS students were asked these questions in their sophomore year, after they had completed AISS and were enrolled in their first upper division courses. Most Other Science Majors completed the three year-long introductory courses as sophomores, with the majority taking biology and chemistry as freshmen, and physics as sophomores. Like AISS students in the second semester of sophomore year, many of the Other Science Major juniors had a semester of Organic Chemistry behind them at the time they took the survey. Although these students were a year older than were the AISS sophomores when they responded to these questions, they were at a comparable place in their progress in the major. For this reason, comparing the responses of these two groups is justifiable even though the comparison is not a direct one. These results are shown in Table 19 and analyzed below.

Sixty percent of AISS sophomores indicated that they felt well prepared for the lecture portion of Organic Chemistry (Chem 116, 117) as compared to 36.7% of the Other Science Major juniors. By contrast, a higher percentage of Other Science Majors juniors (46.6%) indicated that they felt well prepared for the laboratory portion of Organic Chemistry as compared to 33.3% of the AISS sophomores. AISS students had also indicated as freshmen that they felt underprepared in their laboratory experience. Regardless of their concerns about lack of laboratory experience, they earned the same average B grade in both semester of the Organic Chemistry as did the Other Science Majors who took the traditional introductory lecture and laboratory courses (Table 28).

None of the AISS sophomores gave a "well prepared" rating for how AISS prepared them for the next upper division course in the Chemistry sequence, Physical Chemistry. Two students responded "somewhat prepared" yet these students went on to earn grades in the B+/A- range in both semesters of Physical Chemistry. Six Other Science Major juniors indicated that they felt well prepared by their introductory coursework for AISS and subsequently earned mean grades in the A-/B+ range. It is possible that having just completed a year of introductory physics as sophomores gave the Other Science Majors more confidence going into Physical Chemistry than AISS students felt at the end of their year of integrated introductory coursework. In both groups, 66.7% felt well prepared for other upper division science courses.

Thirteen percent of AISS sophomores felt AISS prepared them well for Calculus II as compared to 33.3% of Other Science Majors. Twenty percent in both groups felt their introductory science coursework prepared them well for Calculus III. When asked how prepared they felt for other upper division mathematics coursework, 40% of the AISS sophomores indicated “well prepared” as compared to 6.7% of the Other Science Major juniors. This may be because the AISS students were selected for the high pre-collegiate math achievement and are in general confident of their math ability. In addition, AISS required them to use Calculus frequently and this could have added to their sense of preparedness coming out of that course.

Eighty percent of AISS sophomores and 66.7% of Other Science Major juniors responded that they felt well prepared to both collaborate with others and to work independently. The two groups felt equally well prepared (53.3%) to go to office hours.

In two areas emphasized by AISS, there were marked differences between AISS sophomores and Other Science Major juniors. Eighty percent of AISS students indicated they felt well prepared to make connections between disciplines as compared to only 43.3% of the Other Science Major juniors. This strongly suggests the impact of the early interdisciplinary emphasis on the AISS students. Fifty-three percent of AISS sophomores felt well prepared for doing summer research as compared to 30% of the Other Science Major juniors. This is another area that AISS emphasized and assisted interested students in pursuing in the summer following the course. AISS students are given first priority for NSF-STEP grants for summer interdisciplinary research.

More than 90% of AISS students (93.3%) felt well prepared to continue in a science major compared to 76.6% of the Other Science Major juniors. That such a high percentage of AISS students felt well prepared to continue as STEM majors is a tribute to the course. What is surprising is that only 3 out of 4 Other Science Majors felt their introductory coursework prepared them well to continue. This may be a reflection of how students feel after three year-long introductory courses, particularly if their major (e.g., Biology, Physics, Engineering) does not require any more coursework in the other disciplines.

Table 19.

Preparedness for Upper Division: AISS Cohort 1 Sophomores vs. Other Science Major Juniors

	AISS Cohort I Sophomores* Spring 2009		Other Science Majors* Spring 2010		
Variable	N	Valid %**	N	Valid %	D%†
Organic Chemistry lecture (Chem 116, 117)	9	60.0	11	36.7	+23.3
Organic Chemistry lab (Chem 116, 117)	5	33.3	14	46.6	-13.3
Physical Chemistry lecture (Chem 121, 122)	2**	0	6	20	-20
Calculus II (Math 31)	2	13.3	10	33.3	-20
Calculus III (Math 32)	2	20.0	6	20.0	0.0
Other upper division math courses	6	40.0	2	6.7	+33.3
Other upper division science courses††	10	66.7	20	66.7	0.0
Collaborating with others	12	80	20	66.7	+13.3
Working independently	12	80	20	66.7	+13.3
Doing summer research	8	53.3	9	30.0	+23.3
Going to office hours	8	53.3	16	53.3	0.0
Making connections between disciplines	12	80	13	43.3	+36.7
Continuing in a science major	14	93.3	23	76.6	+16.7
Studying abroad in future years	6	40	10	33.3	+6.7

Note. *AISS Cohort I Sophomores, N=15; Other Science Major Juniors, N=30
**"Well prepared" on a Likert scale: 3=well prepared, 2=somewhat prepared, 1=poorly prepared
†D% is shown as negative value when AISS is less than Other Science Majors
††Responded "somewhat prepared"; these students subsequently earned grades in the two semesters of Physical Chemistry as sophomores of B+ and A- in Chem 121 and B and A- in Chem 122

Self-Concepts. AISS juniors and Other Science Majors were asked to rate themselves on selected self-concepts using a 5-point Likert scale. These results are reported below in Table 20. Both groups rate themselves highest on developing a personal code of ethics and values, on their compassion, and on their drive to achieve. On these three outcome variables, students rate themselves solidly in the above average range. In the areas of academic ability, intellectual flexibility, and problem solving, students rate themselves nearly as high with self-ratings of mathematical ability, self-confidence, and spatial ability slightly lower but also still in the above average range.

Only in the areas of creativity and risk taking do these students rate themselves in the low average range.

It was surprising that science majors in highly selective colleges such as the Claremont College reported such modest self-concepts when asked to compare themselves to the average undergraduate in their junior year. Two phenomena may be at work here. The first is "relative deprivation," a type of social referencing in which individuals or groups subjectively perceive themselves as disadvantaged over others perceived as having similar attributes. Drew and Astin (1972) found that highly capable students downgrade themselves when comparing themselves to other students they see as equally or more capable. The second consideration has to do with the high percentage of women in this cohort and how their responses may skew self-concept reports downward. It is well documented that female college students tend to underrate their abilities on self-concept measures as compared to male college students (Sax & Harper, 2007; AAUW, 1998; Astin, 1993).

Table 20.

Selected Self-Concepts: AISS Cohort 1 Juniors vs. Other Science Majors, Spring 2010

	AISS Cohort 1*		Other Science Majors*		
Self-Concepts**	M**	SD	M	SD	D†
Developing values/ethics	4.22	.94	4.13	.86	+.08
Drive to achieve	4.11	.58	4.17	.70	-.12
Compassion	4.11	.68	4.07	.79	+.11
Academic ability	3.89	.68	3.90	.76	-.01
Intellectual flexibility	3.83	.71	3.93	.58	-.13
Problem solving	3.83	.62	3.97	.68	-.06
Mathematical ability	3.78	.81	3.57	.77	+.04
Self-confidence	3.56	.70	3.77	.90	-.20
Spatial ability	3.50	.92	3.57	.73	-.19
Creativity	3.44	.98	3.63	.56	-.42
Risk taking	3.06	.80	3.33	.84	-.04

Note. * AISS Juniors, N=18; Other Science Majors, N=30
**Likert scale: 5=highest 10%, 4=above average, 3=average, 2=below average, 1=lowest 10%
†D is shown as negative value when AISS is less than Other Science Majors; independent-means T-test showed no significant differences between the two groups, $p < .05$

Academic Skills. When asked about academic skills relevant to the science major, AISS juniors and Other Science Majors rated themselves above average on virtually every skill with one exception (Table 21). AISS juniors gave themselves only an average rating on their lab skills and techniques. By contrast, AISS juniors rated themselves slightly higher in the above average range than did the Other Science Majors in their ability to write clearly and effectively, in their ability to think critically, in the quality of their scientific reasoning, in their ability to engage in academic discussions, and in managing a heavy academic load. Other science majors rate themselves slightly higher, but again still in the about average range, on the following academic skills: lab skills and techniques, working comfortably in a college lab, asking and answering a scientific question, understanding systematic inquiry, learning effectively on their own, moving beyond memorization and regurgitation. None of the differences between the two groups on any of these academic skills were statistically significant using a T-test for independent means, suggesting that these two groups of students share many similar skills relevant to the science major. This further reinforces the notion that AISS students and other science majors in the Joint Science Department share common characteristics even though they differ markedly in their introductory science experience.

Table 21.

Academic Skills: AISS Cohort I Juniors vs. Other Science Majors, Spring 2010

	AISS Cohort 1*		Other Science Majors*		
Skills	M**	SD	M	SD	D†
Thinking critically and analytically	4.11	.68	3.83	.75	+.28
Quality of reasoning you bring to a problem	4.00	.77	3.83	.65	+.17
Engaging in academic discussions	3.89	.83	3.73	.78	+.16
Working comfortably in a college lab	3.78	.94	3.93	.78	-.15
Moving beyond memorization/regurgitation	3.78	.73	3.90	.76	-.12
Managing a heavy academic load	3.78	.87	3.70	.84	+.18
Learning effectively on your own	3.72	.73	3.97	.69	-.25
Asking and answering a scientific question	3.67	.59	3.93	.78	-.26
Writing clearly and effectively	3.67	.84	3.63	.76	+.04
Understanding systematic inquiry	3.61	.70	3.67	.71	-.06
Lab skills and techniques	3.44	.86	3.73	.65	-.29

Note. *AISS Juniors, N=18; Other Science Majors, N=30
**Likert scale: 5=highest 10%, 4=above average, 3=average, 2=below average, 1=lowest 10%
†D is shown as negative value when AISS is less than Other Science Majors; independent-means T-test shows no significant differences between the two groups, $p < .05$

Extracurricular Science. The responses from the AISS juniors and Other Science Majors about their involvement in science outside of the coursework reveal low participation in extracurricular science activities (Table 22). The survey questioned students about activities ranging from more self-focused activities such as attending research seminars to more other-focused activities such as helping with science projects for younger students. There was a significant difference between these two groups of juniors on only one variable: AISS juniors taught a science class to younger students significantly more often, $t(46) = 2.0213$, $p < .05$, than did their peers. In this one activity, AISS students indicated a higher involvement than their peers. Further communications with AISS personnel revealed one AISS professor who sponsored a science outreach program for school-age children, and some AISS students participated in this program.

The goal of this set of questions was to ascertain whether students in the junior year were participating in science beyond the classroom. These results indicate that both AISS students and Other Science Major peers are participating at a low level in the variety of activities suggested. On all of these variables, students in both groups reported relatively low engagement (1-3 times) during their undergraduate years. This may reflect the demands of a science major, including courses with laboratories as well as lectures, rather than non-interest in extracurricular science activities. Also, in the junior year students in the Joint Sciences are required to conduct research for their senior thesis and this places extra demands on their time. It also may be possible that students are not aware that lunch conferences and seminars are considered extra-curricular because they participate in them with classmates and professors. Joint Science Department personnel believe students participate in activities with them at a greater rate than they indicated on the junior year survey.

Table 22.

Extracurricular Science Activities: AISS Cohort I Juniors vs. Other Science Majors, Spring 2010

	AISS Cohort 1*		Other Science Majors*		
Activity	M**	SD	M	SD	D†
Gone to hear a scientific speaker	2.33	.77	2.10	.66	+.23
Attended a scientific research seminar	2.11	.75	2.03	.81	+.08
Done an out-of-class scientific research project	1.78	.88	2.17	.87	-.39
Taught a science class to younger students	1.72	.90	1.27	.64	+.45††
Assisted with a science activity for younger students	1.67	.77	1.57	.77	+.10
Attended a scientific conference	1.44	.62	1.40	.72	+.04
Participated in science lunch discussions	1.44	.62	1.53	.73	-.09
Presented at a scientific conference	1.39	.70	1.13	.43	+.26
Published scientific research	1.33	.49	1.17	.46	+.16
Helped with a science fair or science fair project	1.17	.51	1.27	.64	-.10

Note. * AISS Juniors, N=18; Other Science Majors, N=30
**Likert scale: 4=very often (7+ times); 3=often (4-6 times), 2=sometimes (1-3 times), 1=never (0 times)
†D is shown as negative value when AISS is less than Other Science Majors
††Independent-means T-test shows significant difference, $p < .05$

STEM Course Taking and Achievement. An analysis of the transcripts of the AISS junior and the Other Science Majors was performed and the results are shown in Table 23 and Table 24. The upper division courses, which require science and/or math prerequisites (denoted with a superscript †), taken by these students are listed for the freshman, sophomore, and junior year in Table 23. In addition, the introductory-level AISS course and the introductory-level biology (Bio 43 and 44), chemistry (Chem 14 and

15 or Chem 29), and physics courses (Phys 30 and 31 or Phys 33 and 34) are shown in italics and denoted with superscript [I]. The number of AISS student enrolled in each course is indicated in normal text in each yearly column. Other Science Major totals in each course are contained within brackets to the right of the AISS numbers, in the following manner: AISS [Other Science Majors]. Table 24 shows the mean grade earned by AISS students and Other Science Majors (in brackets) in each of the courses listed in Table 23.

Students who completed AISS fulfilled their introductory requirements in biology, chemistry, and physics in the freshman year. As sophomores they were eligible to enroll in upper division science courses, all of which have science and math prerequisites. In addition, because of their strong high school math backgrounds and Advanced Placement credits, many were granted placement in the second and third Calculus courses (Calculus II or III) in the three-course Calculus sequence. Seven AISS students enrolled in Calculus II as freshmen, and six others enrolled in Calculus III or Linear Algebra in their first year of college. By contrast, most of the Other Science Majors were in enrolled in introductory biology and chemistry and Calculus I and II as freshmen, and introductory physics as sophomores. Only two students in this group took Calculus III as freshmen, compared to five students in the AISS cohort. A few of the Other Science Majors came into the major late or transferred from other schools and took their introductory coursework later than their peers. In the sophomore year, Other Science Majors who had taken introductory chemistry and biology as freshmen were eligible to enroll in upper division courses in these two disciplines, but still were in introductory-level physics. As sophomores, AISS students were enrolled in 18 upper division science courses and 4 upper division math courses beyond the Calculus series. As sophomores, Other Science Majors enrolled in 5 upper division science courses and 2 upper division math courses beyond the Calculus series. These tallies indicate clearly that AISS students' progress in the science major (including the co-requisite mathematics requirements) was accelerated in comparison to students who took the traditional introductory course pathway.

When a tally of students enrolled in all upper division courses in the sophomore year was done, there were 81 AISS "enrollments" (total students enrolled in all science and math courses in a given year) compared to only 54 Other Science Majors enrollments. In the junior year, there were 53 AISS enrollments compared to 23 Other Science Majors enrollments. There is a striking difference in the sophomore year, with AISS students enrolled in more upper division courses, including those 2-3 courses into the major requirements.

By the end of junior year, science and math enrollments by the Other Science Majors nearly equaled that of the AISS students at the end of *sophomore* year—77 for the Other Science Majors as juniors compared to 81 for the AISS students as sophomores. AISS students' enrollment in science and math courses in junior year was 53 compared to 23 for the Other Science Majors in the junior year.

This comparison must be interpreted carefully because different majors in the Joint Sciences have different requirements in terms of the number and breadth of upper division science and math courses students must take. For example, Human Biology, Environment, Economics & Politics, Organismal Biology and Ecology require fewer math courses and chemistry courses than do the Chemistry, Physics, and Molecular

Biology. When you compare the number of AISS and Other Science Majors in the various majors they selected as juniors (see Table 18), 53.7% of Other Science Majors (compared to 34.5% AISS students) selected science majors that require fewer upper division science and math courses. Biology; Human Biology Environment, Economics, and Politics; Environmental Science and Organismal Biology and Ecology account for 53.7 % of the Other Science Majors' choices compared to 34.5% of AISS juniors who chose these majors and Neuroscience. By contrast, 61.3% of AISS students selected majors in Biochemistry, Chemistry, Molecular Biology, Physics, and dual majors in Chemistry-Mathematics (2 students) and Physics-Media Studies—all of which require upper division chemistry and biology and some of which require upper division math and physics. Only 46.7% of the Other Science Majors selected these majors and the 3/2 Engineering Major.

By the junior year, more AISS students appear to have decided on more challenging science majors (those requiring more advanced mathematics and science) and taken more upper divisions math and science courses required by these programs than their peers in the comparison sample in this study. All of these students have another year of college in which to complete their majors and it is possible that the Other Science Major group will load their senior schedules with science and math requirements and "catch up" to the AISS students. It is equally likely that AISS students will continue to take more advanced courses in their majors, so that by the time they graduate AISS students will have a substantially stronger undergraduate transcript by virtue of the acceleration provided them by their first-year science course. Some AISS students were taking courses beyond what was required to fulfill the requirements of a single science major because they were double majoring or adding a minor. In this regard, AISS students demonstrate broader and deeper involvement in science and mathematics than do their peers. Senior year transcript data, analyzed later in this chapter, will show that AISS students do indeed outpace their peers in STEM course taking by the end of college.

Table 23.

STEM Course Taking: AISS and Other Science Majors, AISS [Other Science Majors]

Course Number	Course Name	(‘07-‘08) Freshman Year	(‘08-‘09) Sophomore Year	(‘09-‘10) Junior Year
AISS 001L	*AISS* [1]	*28*		
AISS 002L	*AISS* [1]	*25*		
Biol 43L	*Introductory Biology* [1]	*[14]*	*[7]*	
Biol 44L	*Introductory Biology* [1]	*[13]*	*[4]*	
Biol 82**	Topics in Infectious Disease †		1	
Biol 126**	Biology of Prokaryotes†			1
Biol 128L**	Prokaryotes Lab†			1
Biol 132L	Comparative Physiology†		1	1
Biol 143	Genetics†		5[7]	3[4]
Biol 145	Evolution†		4[1]	
Biol 146L	Ecology†			[1]
Biol 149	Neuroscience 2: Systems†		1	
Biol 154	Animal Behavior†			1
Biol 157L	Cell Biology†			1
Biol 159	Natural Resource Management†		1	1
Biol 161L	Cell & Molecular Neurobiology†		1	
Biol 170L	Molecular Biology†		1	6
Biol 173L	Molecular Biology Seminar†		5[2]	
Biol 177	Biochemistry†			5
Biol 188L	Senior Research in Biology†			
Biol 190L	Senior Exptl Thesis†			
Biol 191	Senior Library Thesis in Biology†			
Chem 14L	*Basic Principles of Chemistry* [1]	*[17]*		[1]
Chem15L	*Basic Principles of Chemistry* [1]	*[17]*	*[1]*	
Chem 29L	*Accelerated General Chemistry* [1]	*[2]*	*[1]*	
Chem 104**	Inorganic Chemistry†			1
Chem 116L	Organic Chemistry†		19[17]	1[2]
Chem 117L	Organic Chemistry†		18[16]	1[1]
Chem 121	Principles of Phys Chemistry†		2	5[4]
Chem 122	Principles of Phys Chemistry†		3	2
Chem 123L	Advanced Organic Chemistry†			
Chem 124	Bioanalytical Chemistry†			

Chem 126L	Advanced Lab in Chemistry†			3[3]
Chem 127L	Advanced Lab in Chemistry†			5
Chem 128	Inorganic Chemistry†			
Chem 168C**	Organic Geochemistry†		1	
Chem 177	Biochemistry†			5[1]
Chem 188L	Senior Research in Chemistry†			
Chem 190L	Senior Experimental Thesis†			
Phys 30L	*General Physics* [I]		*[11]*	
Phys 31L	*General Physics* [I]		*[13]*	
Phys 33L	*Principles of Physics* [I]		*[6]*	
Phys 34L	*Principles of Physics* [I]		*[5]*	
Phys 35	Modern Physics†		3	[2]
Phys 100	Comput Physics & Engineering†		3	[1]
Phys 101	Intermediate Mechanics†			2
Phys 102	Intermediate Elect & Magnetism†		3	
Phys 105	Comput Partial Diff Equations†			1
Phys 115	Statistical Mechanics†			3
Phys 170	Quantum Mechanics†			
Phys 175*	Thermodynamics/Statistic M†			1
Phys 188	Senior Research in Physics†			
Phys 190L	Senior Exptl Thesis†			
Math 31	Calculus II†	7[12]	3[5]	1[1]
Math 32	Calculus III†	5[2]	3[2]	[1]
Math 55	Discrete Mathematics†		1	
Math 60	Linear Algebra†	1	2[1]	1
Math 102**	Differential Equations†		2[1]	4[1]
Math 131	Math Analysis†		1	
Math 151	Probability†			1
Math 153	Monte Carlo Methods†			
Math 171	Abstract Algebra 1†			
CSCI 52	Fundamntls of Comp. Science†	1		
CSCI 60	Principles of Comp. Science†		1	
CSCI 70	Data Structures/Program Dev†			1
Engr112	Engineering Clinic II†			
XGOV191	Senior Thesis: EEP†			

Note. [I] *Introductory courses in italics*
† Upper division course that requires science and/or math prerequisites
*Differential Equations= Math 102 at Scripps=Math 111 at CMC
**at Harvey Mudd

Table 24 shows the average grade earned by the AISS students (normal text) and the Other Science Majors [bracketed text] enrolled in each course. This table corresponds to Table 23, which can be referenced in order to see the number of students enrolled in each of these courses. In assessing the achievement of AISS and Other

Science Majors, only courses in which the average grade was A or A- were tallied. This was not an arbitrary cut-off point, but rather one that was made in order to compare the highest achievement in both groups of students.

During the sophomore year, AISS students earned an average grade of A/A- in 14 of the 23 science and mathematics courses in which they were enrolled; Other Science Majors earned an average grade of A/A- in 5 of the 17 introductory and upper division science and mathematics courses in which they were enrolled. For the AISS group, 60.9% of the science and mathematics grades earned were in the A/A- range compared to 29.4% for the Other Science Majors group. It should be noted that Other Science Majors did not earn an average grade higher than B+ in any of the introductory level science courses (Biol 43 and 44; Chem 15 and 29; Physics 30, 31, 33, or 34) or in Calculus II in which they were broadly enrolled as sophomores. For that matter, AISS students also earned an average grade of B+ in that introductory course the previous year, which indicates a wider range of achievement in the introductory-level courses by both groups of students. When only upper division courses taken by Other Science Major sophomores were considered, there were 5 courses out of 9 (55.6%) in which the average course grade was A/A-. This shows clearly that AISS sophomores were enrolled in more upper division courses *and* achieving higher grades in upper division courses than their Other Science Major peers.

During the junior year, AISS students earned an average grade of A/A- in 10 out of the 26 (38.5%) upper division courses in which they were enrolled. Other Science Majors earned an average grade of A/A- in 6 out of 13 (46.2%) upper division courses in which they were enrolled. For both groups, about half of the enrollments consisted of a single student; therefore the "average grade" of A/A- reflected one student's performance. AISS students were enrolled in twice as many upper division courses as were the Other Science Majors (26 compared to 13) and were, in many cases, taking courses that were more difficult because they were a year further into their major requirements. This may account in part for the decrease in the number of earned average A/A- grade in the AISS group.

Another way to compare the achievement of the AISS students and the Other Science Majors is to look at courses required for most of the majors offered by the Joint Sciences (except Environmental Analysis and Environment, Economics and Politics). Organic Chemistry, Genetics, and Calculus II are three courses that meet this criterion. Two semesters of Organic Chemistry (Chem 116 and Chem 117) are required of all Biology, Chemistry, Biochemistry, and Molecular Biology majors. Nineteen AISS students took Chem 116 as first-semester sophomores and earned an average grade of B; seventeen Other Science Majors took the same course at the same time and earned the same average grade. Eighteen AISS students and sixteen Other Science Majors took Chem 117 the following semester and the average grade earned by both groups was a B. Among the students who took these courses in the junior year, AISS students averaged B grades while Other Science Majors averaged C grades.

In the sophomore year, 5 AISS students and 7 Other Science Majors were enrolled in Genetics (Biol 143). The average grade for the AISS students was A; for the Other Science Majors it was C+. During junior year 3 AISS students and 4 Other Science Majors took Genetics. The average grade for AISS juniors was A-, while for the Other Science Majors it was A.

Calculus II was taken by 7 AISS students and 12 Other Science Majors as freshmen. The average grade for the AISS students was B+ and for the Other Science Majors it was B. During sophomore year, 5 AISS students and 7 Other Science Majors took this course. The average grade for the AISS group was A- and for the Other Science Majors it was B+. In the junior year, one AISS student took Calculus II and earned a D, while the one Other Science Major in the same course earned a B.

The small number of students enrolled in some of these courses makes drawing conclusive generalizations about their achievement problematic; however, it appears that the average grades achieved by AISS students in these three courses required of most science majors—therefore a broadly inclusive indicator—is slightly higher. The difference is not striking, but the argument can be made that the AISS cohort shows slightly stronger mean achievement as they progress through junior year than does the comparison group who took the traditional introductory pathway.

Table 24.

STEM Achievement: AISS Cohort 1 Juniors vs. Other Science Majors, Spring 2010

Course Number	Course Name	Freshman Year	Sophomore Year	Junior Year
AISS 001L	*AISS* [1]	*B+*		
AISS 002L	*AISS*[1]	*B*		
Biol 43L	*Introductory Biology* [1]	*[B+]*	*[B]*	
Biol 44L	*Introductory Biology* [1]	*[B+]*	*[B+]*	
Biol 82**	Topics in Infectious Disease [†]		C+	
Biol 126**	Biology of Prokaryotes[†]			B
Biol 128L**	Prokaryotes Lab[†]			A-
Biol 132L	Comparative Physiology[†]		A-	A-
Biol 143	Genetics[†]		A[C+]	A-[A]
Biol 145	Evolution[†]		A-[A]	
Biol 146L	Ecology[†]			[A]
Biol 149	Neuroscience 2: Systems[†]		A	
Biol 154	Animal Behavior[†]			A-
Biol 157L	Cell Biology[†]			A
Biol 159	Natural Resource Management[†]		A	A
Biol 161L	Cell & Molecular Neurobiology[†]		A-	
Biol 170L	Molecular Biology[†]		A-	B+
Biol 173L	Molecular Biology Seminar[†]		A[A-]	
Biol 177	Biochemistry[†]			B
Biol 188L	Senior Research in Biology[†]			
Biol 190L	Senior Exptl Thesis[†]			
Biol 191	Senior Library Thesis in Biology[†]			
Chem 14L	*Basic Principles of Chemistry*[1]	*[B+]*		[A]
Chem15L	*Basic Principles of Chemistry*[1]	*[B+]*	*[C]*	
Chem 29L	*Accelerated General Chemistry*[1]	*[B]*	*[B]*	
Chem 104**	Inorganic Chemistry[†]			B+
Chem 116L	Organic Chemistry[†]		B[B]	B+[C]
Chem 117L	Organic Chemistry[†]		B[B]	B[C-]
Chem 121	Principles of Phys Chemistry[†]		A-	A[A-]
Chem 122	Principles of Phys Chemistry[†]		B+	B+
Chem 123L	Advanced Organic Chemistry[†]			
Chem 124	Bioanalytical Chemistry[†]			
Chem 126L	Advanced Lab in Chemistry[†]			A-[B]
Chem 127L	Advanced Lab in Chemistry[†]			B+
Chem 128	Inorganic Chemistry[†]			
Chem 168C**	Organic Geochemistry[†]		B+	
Chem 177	Biochemistry[†]			B[B-]
Chem 188L	Senior Research in Chemistry[†]			
Chem 190L	Senior Experimental Thesis[†]			
Phys 30L	*General Physics*[1]		*[B+]*	
Phys 31L	*General Physics*[1]		*[B]*	
Phys 33L	*Principles of Physics*[1]		*[B+]*	

Phys 34L	*Principles of Physics*[I]		*[B+]*	
Phys 35	Modern Physics†		B+	[A-]
Phys 100	Comput Physics & Engineering†		A-	[A]
Phys 101	Intermediate Mechanics†			B+
Phys 102	Intermediate Electr & Magnetism†		B-	
Phys 105	Computl Partial Diff Equations†			A-
Phys 115	Statistical Mechanics†			B+
Phys 170	Quantum Mechanics†			
Phys 175*	Thermodynamics/Statistic M†			B
Phys 188	Senior Research in Physics†			
Phys 190L	Senior Exptl Thesis†			
Math 31	Calculus II†	B+[B]	A-[B+]	D[B]
Math 32	Calculus III†	B[B]	B+[A-]	[C]
Math 55	Discrete Mathematics†		B	
Math 60	Linear Algebra†	B+	A-[A-]	A
Math 102*	Differential Equations†		A[A]	B-[B]
Math 131	Math Analysis†		A-	
Math 151	Probability†			B+
Math 153	Monte Carlo Methods†			
Math 171	Abstract Algebra 1†			
CSCI 52	Fundamntls of Comp. Science†	B		
CSCI 60	Principles of Comp. Science†		B	
CSCI 70	Data Structures/Program Dev†			B-
Engr112	Engineering Clinic II†			
XGOV191	Senior Thesis: EEP†			

Note. Mean achievement shown as average grade of enrolled students, using 12-point grade scale
[I] Introductory courses in italics
*Differential Equations= Math 102 at Scripps=Math 111 at CMC
**at Harvey Mudd
† Upper division course that requires science and/or math prerequisites

Plans After College. AISS Juniors and their Other Science Major peers were asked about their post-collegiate plans and their responses are shown in Table 25. One-third of both groups of juniors indicated that they intend to go to graduate school right after college. About the same percentage said they intend to work for a year of two before applying to graduate school. Less than 20% of both groups (16.7% of AISS juniors and 13.3% of Other Science Majors) said they plan to enter the work force immediately after college. This corresponds with high percentage of students who indicated an intention to earn at least a Master's degree, and in many cases, a doctoral degree. Students indicated several reasons for deferring graduate school: financial need, the desire to gain work experience or experience outside of academia, and the desire to take a break before they commit to a graduate program and a career.

The relatively high percentage of students from both groups who indicated that they are undecided about their plans after college is somewhat surprising. Spring of the junior year may be too early for students to have a clear plan for the future. For most of these juniors, their focus has been on completing research for and writing their senior thesis. For some, they have spent a semester or two studying abroad. While many have the goal of earning a higher degree, it appears they haven't yet decided how they will go about realizing those goals. Alternatively, it may be that these students are not sure that they want to go to graduate school right away or that they will be accepted straight out of college or they that they can afford graduate (or medical) school.

Whereas half of the Other Science Majors are undecided about whether they want to enter the workforce right after graduating, the same percentage of AISS juniors are sure they don't want to enter the workforce with just a Bachelor's degree. In both groups of students, there is a portion that knows they will go immediately to graduate (or medical) school. There is a larger portion that is not certain when they will go to graduate school so they responded that they would work for a couple of years and they apply. There is a small percentage of both groups that indicated they intend to start working right out of college; these are likely the same students that indicated they wanted to earn only a Bachelor's degree.

Table 25.

Plans After College: AISS Cohort I Juniors vs. Other Science Majors, Spring 2010

	*AISS Cohort I [Other Science Majors]		
	Yes	No	Undecided
Attend graduate program right after college	**33.3 [33.3]	27.8 [43.3]	38.9 [20.0]
Work for 1-2 years; apply to graduate program	33.3 [30.0]	27.8 [26.7]	33.3 [40.0]
Enter work force right after college	16.7 [13.3]	33.3 [50.0]	50.0 [36.7]

Note. * AISS Juniors, N=18; Other Science Majors, N=30
**Valid %; rounded, therefore may not total 100%

Career Aspirations. AISS junior and other science majors in the junior year were asked to indicate career fields and options they were likely to pursue (Table 26). AISS juniors' and Other Science Majors' aspirations were not significantly different except that AISS students indicated a higher likelihood to choose Pharmacy and Pharmaceutical Research and enter a space science field. This difference may be related to choice of major and mathematical background, since there is a higher percentage of Molecular Biology majors in the AISS group. It is more likely that this difference reflects AISS students' greater interest in pursuing a Ph.D.; without experience beyond college, these career fields may be proxies for careers in research.

Both groups of juniors indicated the greatest likelihood of pursuing university faculty careers and careers in basic research, research and development, and industry. This corresponds with the high percentage in both groups intending to earn doctoral degrees that provide entrée into these careers. Students in both groups indicated that they were least likely to choose careers in sales and marketing, computer programming, and consulting. These results may be indicative of their awareness that careers in sales and marketing do not generally require the terminal degrees they desire, the fact that none of these students are computer science majors, and their awareness of their inexperience outside academia.

Both groups of students indicated a high interest in interdisciplinary or multi-disciplinary careers, which is not surprising given that they did their undergraduate science majors in an interdisciplinary department. The relatively high ranking of the biological and physical science fields probably reflects the nature of the majors offered by the Joint Sciences and selected by these students. It is surprising that space science is ranked between biological and physical science, but this may reflect the broader interests of students in the physical sciences.

Table 26.

Career Aspirations: AISS Cohort I Juniors and Other Science Majors, Spring 2010

	AISS Cohort 1*		Other Science Majors*		
	M**	SD	M	SD	D†
Careers					
Basic Research	2.00	.84	1.90	.71	+.10
Pharmacy/Pharm. Research	2.00	.84	1.40	.73	+.60††
University Faculty Position	1.78	.65	1.43	.63	+.35
Research & Development	1.78	.94	1.89	.77	-.11
Industry	1.78	.81	1.60	.77	+.18
Medicine (physician, dentist)	1.67	.91	1.77	.94	-.10
Medicine (nurse, PT, technician)	1.56	.70	1.53	.78	+.03
Management	1.50	.71	1.43	.63	+.07
K-12 Teacher (science/math)	1.39	.61	1.27	.53	+.12
Consulting	1.06	.24	1.27	.58	-.21
Sales/Marketing	1.00	.00	1.10	.31	-.10
Programming/Analyst	1.00	.00	1.23	.54	-.23
Fields					
Multi/Interdisciplinary	2.00	.77	1.77	.73	+.23
Biology/Life Sciences	1.77	.81	1.83	.75	-.06
Space Science	1.77	.51	1.20	.48	+.57††
Physical Sciences	1.39	.61	1.47	.68	-.08
Environmental Science/Ecology	1.39	.70	1.77	.82	-.38
Neuroscience	1.33	.69	1.27	.52	+.06
Computer & Information Science	1.22	.65	1.13	.43	+.09
Earth Science	1.22	.55	1.33	.61	-.11
Engineering	1.22	.55	1.27	.58	-.05

Note. *AISS Juniors, N=18; Other Science Majors, N=30
**Likert scale: 3=very likely, 2=somewhat likely, 1=not likely
†D is shown as negative value when AISS is less than Other Science Majors
†† Independent-means T-test showed significant differences, $p < .05$

Senior Survey – Cohort 1 AISS Students (2010-2011)

The senior survey (Appendix F) asked AISS students about their degree and career aspirations, self-concepts, academic skills related to the science major, extra-curricular science experiences, senior thesis research, plans after graduation, and career aspirations. The analysis of this survey is presented below and is organized by the major thematic areas.

Fifteen of the 22 students who completed AISS and were enrolled as seniors at the Claremont Colleges responded to the survey, for a response rate of 68%. Fourteen students were science majors in the Joint Science Department at the time of the survey; one student switched to a Classics major after freshman year. Eleven of the students were from Scripps College (all were female), two were from Claremont McKenna College (1 female and 1 male), and two students were from Pitzer (1 female and 1 male).

By senior year, 22 of the 25 students who completed AISS as freshman remained at the Claremont Colleges. Of these, eighteen had persisted in a science major; four had switched from science majors to non-science majors. The 4-year retention rate (N=29 at the start of the course, fall 2007 through senior year) in this cohort, for students remaining at the Claremont Colleges in a science major, was 62%. When this rate was calculated using the number of students who completed AISS (N=25), the retention rate in a science major was 72%.

Majors and Degree Aspirations. Between freshman and senior years, AISS students' majors shifted considerably, as would be expected (Table 27). Their interests consolidated from eight probable majors in the fall of freshman year to six declared majors in the senior year, and there was considerable movement between science major options.

The percentage of students with a Biology-based major increased from 21.5% in the freshman year to 46.6% in the senior year—an increase of 25%, accounting for nearly half of the senior respondents. Given the overwhelming female composition of this cohort, this is not surprising and it corresponds to the literature reports that women tend toward majors in the life sciences (AAUW, 2009; Seymour & Hewitt, 1997). This percentage matches nearly identically the profile of science majors reported by the Joint Science Department in 2009, midway through this study. Nearly 36% of the students selected Chemistry-based majors as freshman, but this decreased to 20% by senior year. Mild interest in Environmental Science and Neuroscience majors in the freshman year dropped to zero by senior year. While it appeared that a similar negative trend occurred with interest in the Physics major, this was not the case. Dual majors accounted for 26.7% of the senior respondents' major choices and three of the four dual majors pursued by AISS seniors involved Physics as one of the major fields. It is noteworthy that just over a quarter of the senior respondents in this cohort double majored, that 3 of the 4 double majors involved Physics, and that 3 of the 4 were double majors involving two STEM fields. This is strong evidence that highly capable and motivated students, when accelerated into upper division courses early in their college careers, can and do take full advantage of offerings of the Joint Science Department, including taking courses in excess of the requirements of a single major field. These students are extremely well prepared and situated for acceptance into top-rate science graduate programs!

By senior year, nearly half of the senior respondents aspire to a Ph.D., and another quarter of them want to become medical doctors. Thirteen percent want to earn a Master's degree and one student (6.7% of the respondents) wants to earn a Bachelor's degree. The initially high degree aspirations of this cohort remained consistent throughout their four years of college.

Table 27.

Majors & Degree Aspirations: AISS Cohort 1 Freshmen vs. Seniors

	AISS Cohort 1 Freshmen Fall 2007*		AISS Cohort 1 Seniors Fall 2010*		
Major	N	Valid %	N	Valid %	%D
Biology	3	10.7	5	33.3	+22.6
Chemistry	5	17.9	2	13.3	-4.6
Dual Major**	0	0.0	4	26.7	+26.7
Molecular Biology	3	10.7	2	13.3	+2.6
Biochemistry	5	17.9	1	6.7	-11.2
Physics**	3	10.7	0	0.0	-10.7
Environmental Science	1	3.6	0	0.0	-3.6
Neuroscience	4	14.3	0	0.0	-14.3
Other†	1	3.6	1	6.7	+3.2
Pre-Medicine	10	35.7	4	26.7	-9.0
Pre-Dental	0	0.0	0	0.0	0.0
Pre-Veterinary	0	0.0	0	0.0	0.0
Bachelor's	0	0.0	1	6.7	+6.7
Master's	5	17.9	2	13.3	-4.6
Ph.D. or Ed.D.	13	46.4	7	46.7	+0.3
M.D. or D.O.	9	32.1	4	26.7	-5.4
J.D.	0	0.0	1	6.7	+6.7
Undecided	1	3.6	0	0.0	-3.6

Note. *AISS Fall Freshmen, N=28, AISS Seniors, N=15
**Dual majors in Molecular Biology/Physics, Chemistry/Physics Chemistry/Mathematics, Physics/Media Engineering
†Other: 1student who was undecided as a freshman; 1 AISS senior who switched to Classics major after freshman year

Self-Concepts. By senior year, the self-concepts of this cohort had climbed to their highest point in four years. Across the board, all self-concepts that appeared on both the freshman and senior surveys showed an increase (Table 28). Three self-concepts—critical thinking, $t(14) = 3.162$, $p < .05$; self-understanding, $t(14) = 3.228$, $p < .05$; and social self-confidence, $t(14) = 3.154$, $p < .05$—showed a statistically significant increase over four years. One of these self-concepts, critical thinking, is an academic self-concept; its increase over four years of predominantly science and mathematics course work required of science majors is anticipated. The other two self-concepts, self-understanding and social self-confidence, are psychosocial self-concepts. Their significant increase during the four years of college may be the result of maturation as well as involvement with the challenges and opportunities provided by the collegiate environment.

Table 28.

Selected Self-Concepts: AISS Cohort 1 Fall Freshmen vs. Seniors

	AISS Cohort 1 Freshmen Fall 2007*		AISS Cohort 1 Seniors Fall 2010*		
Self-Concepts	M**	SD	M	SD	D†
Thinking critically	3.96	.64	4.54	.52	+.58††
Drive to achieve	4.21	.69	4.36	.74	+.15
Academic ability	4.21	.63	4.36	.59	+.15
Self understanding	3.75	.80	4.35	.74	+.60††
Mathematical ability	4.11	.63	4.29	.61	+.16
Developing values/ethics	--	--	4.29	.91	--
Compassion	4.21	.69	4.21	.89	0
Intellectual flexibility	--	--	4.14	.77	--
Problem solving	3.89	.57	4.00	.39	+.11
Social self-confidence	3.25	.70	3.93	.62	+.68††
Spatial ability	3.64	.73	3.79	.70	+.15
Creativity	3.63	.73	3.71	.83	+.08
Risk taking	3.25	.84	3.29	.85	+.04

Note. *AISS Fall Freshmen, N=28; AISS Seniors, N=14
**Likert scale: 5=highest 10%, 4=above average, 3=average, 2=below average, 1=lowest 10%
†D is shown as negative value when senior year value is less than freshman year value
††Significant difference between freshman and senior years; paired-sample T-test, $p < .05$

Academic Skills. AISS students gave uniformly higher reports of academic skills in the senior year than they did as juniors. These questions were not asked of freshmen, so that comparison could not be made; however, it is remarkable to see such a consistent increase in students' academic self-ratings over the course of one year. Between junior and senior year, a number of things converge that might contribute to this phenomenon. Students, and this is particularly true for AISS students, complete or come close to completing their major requirements and continue taking upper-division courses of their choosing. Students who chose to study abroad have done so and returned to campus. Science majors conduct independent research for their senior thesis and complete that capstone project with a major paper and poster session. By senior year, students are increasingly confident that they will graduate college.

AISS seniors rated themselves above average on all academic skills surveyed, except writing skills. Skills that are cognitive in nature (i.e., engaging in academic discussions, asking and answering a scientific question, thinking critically and analytically, understanding systematic inquiry, and reasoning) received the highest ratings, ranging from 4.21 to 4.36 on a 5-point Likert scale (Table 29).

Learning and study skills, such as moving beyond memorization, learning independently, and managing a heavy work load, grouped together with ratings between 4.00 and 4.14. Students' ratings of their laboratory skills and techniques increase from 3.44 to 4.00, showing one of the highest gains. This is worth noting because these students have been concerned about their laboratory skills since freshman year when they worried that AISS had not prepared them in this area as well as the traditional introductory courses might have.

The lowest rating, and the rating that also showed the least improvement, was for writing skills. These students, like many science- and mathematics-oriented students, are more confident of their quantitative abilities than their written expressive abilities. This self rating remained one of the most intransigent to the environmental effects of college.

In his major study of the impact of college, Astin (1993) found that self-rated writing skills are negatively associated with the number of science courses taken and the number of math or numerical courses taken (and majoring in engineering). Self-rated writing skills are enhanced by taking courses that emphasize writing and are diminished by taking courses in science and math.

Table 29.

Academic Skills: AISS Cohort I as Juniors vs. Seniors

	AISS Cohort 1* Juniors		AISS Cohort 1* Seniors		
Skills	M**	SD	M	SD	D†
Engaging in academic discussions	3.89	.83	4.36	.63	+.47
Asking and answering a scientific question	3.67	.59	4.36	.63	+.69††
Working comfortably in a college lab	3.78	.94	4.36	.74	+.58
Thinking critically and analytically	4.11	.68	4.29	.47	+.18
Understanding systematic inquiry	3.61	.70	4.29	.61	+.68††
Quality of reasoning you bring to a problem	4.00	.77	4.21	.58	+.21
Moving beyond memorization/regurgitation	3.78	.73	4.14	.66	+.36
Learning effectively on your own	3.72	.73	4.07	.73	+.35
Lab skills and techniques	3.44	.86	4.00	.55	+.56
Managing a heavy academic load	3.78	.87	4.00	.78	+.12
Writing clearly and effectively	3.67	.84	3.71	.99	+.04

Note. *AISS Juniors, N=18; AISS Seniors, N=14
**Likert scale: 5=highest 10%, 4=above average, 3=average, 2=below average, 1=lowest 10%
†D is shown as negative value when senior year value is less than junior year value
††Significant difference between junior and senior years; paired sample T-test, $p < .05$

Extracurricular Science. Between junior and senior year AISS students reported increased involvement in extracurricular science activities (Table 30). The three areas that showed the greatest increase, and in fact a statistically significant increase, were going to listen to a scientific speaker, $t(10) = 4.67$, $p < .05$; attending a scientific research seminar, $t(10) = 3.99$, $p < .05$; and participating in science lunch discussions, $t(10) = 5.24$, $p < .05$. Increases in these three related activities may have been due in part to students' involvement in their senior thesis research and a heightened awareness of research related activities in the Joint Science Department and on their respective campuses.

Seniors reported less involvement in three other areas: attending a scientific conference, presenting at a scientific conference, and publishing scientific research. All of these activities appear to be beyond the experiences of these undergraduates and suggest that even though AISS students become involved in research, both during the summer and for their senior thesis projects, they do not venture outside of campus to attend professional meetings. Their experience with extracurricular science appears to be limited to events presented at the colleges.

Table 30.

Extracurricular Science Activities: AISS Cohort I as Juniors vs. Seniors

	AISS Cohort 1* Juniors Spring 2010		AISS Cohort 1* Seniors Fall 2010		
Activity	M**	SD	M	SD	D†
Gone to hear a scientific speaker	2.33	.77	3.69	.63	+1.36††
Attended a scientific research seminar	2.11	.75	3.38	.77	+1.27††
Participated in science lunch discussions	1.44	.62	2.54	.97	+1.10††
Done an out-of-class scientific research project	1.78	.88	2.46	.97	+.68
Attended a scientific conference	1.44	.62	1.38	.51	-.06
Presented at a scientific conference	1.39	.70	1.31	.48	-.08
Assisted with a science activity for younger students	1.67	.77	--	--	--
Taught a science class to younger students	1.72	.90	--	--	--
Helped with a science fair or science fair project	1.17	.51	--	--	--
Published scientific research	1.33	.49	1.08	.28	-.25

Note. *AISS Juniors, N=18; AISS Seniors, N=14
**Likert scale: 4=very often (7+ times); 3=often (4-6 times), 2=sometimes (1-3 times), 1=never (0 times)
†D is shown as negative value when senior year value is less than junior year value
††Significant difference between junior and senior year, paired sample T-test, $p<.05$

STEM Course Taking and Achievement. When a tally of students enrolled in all upper division courses in the first semester of senior year was done, there were 42 AISS enrollments compared to 64 Other Science Majors enrollments (Table 31). As predicted, Other Science Majors were using senior year to complete their requirements and were taking more upper division science and math courses than were AISS seniors. By contrast, the lower number of AISS student enrollments in upper division science and mathematics requirements suggest that they had completed these requirements earlier.

A comparison of AISS students and Other Science Majors during sophomore, junior, and senior years shows the yearly patterns and overall total enrollments. AISS students had 81 enrollments in the sophomore year, 53 in the junior year, and 42 in the senior year—for a total of 176 enrollments. Other Science Majors had 54 enrollments in the sophomore year, 23 in the junior year, and 64 in the senior year—for a total of 141 enrollments. AISS enrollments in upper division science and math courses over the last three years of college were 25% greater.

During the senior year, AISS students earned an average grade of A/A- in 19 out of the 42 (45.2%) upper division courses in which they were enrolled (Table 32). Other Science Majors earned an average grade of A/A- in 14 out of 64 (21.8%) upper division courses in which they were enrolled. Even though AISS students had fewer enrollments in the senior year, they continued to have higher achievement than the Other Science Majors. The percentage of mean A/A- grades in the AISS group was double that in the Other Science Majors group.

A comparison of achievement in upper division science and math courses during sophomore, junior, and senior years shows a three-year trend of higher achievement by the AISS cohort. AISS students had mean grade of A/A- in 14 upper division science and mathematics courses as sophomores, 10 courses as juniors, and 19 courses as seniors—for a total of 47 courses. Other Science Majors had mean A/A- grades in 5 upper division science and mathematics courses as sophomores, 6 courses as juniors, and 14 courses as seniors—for a total of 35 courses. Over the course of these three years, AISS students had a mean grade of A/A- in 34% more courses than did the Other Science Majors.

Table 31.

STEM Course Taking: AISS and Other Science Majors (AISS [OSM])

Course Number	Course Name	Freshman Year	Soph. Year	Junior Year	Senior Year Fall††
AISS 001L	*AISS* [1]	*28*			
AISS 002L	*AISS*[1]	*25*			
Biol 43L	*Introductory Biology* [1]	*[14]*	*[7]*		
Biol 44L	*Introductory Biology*[1]	*[13]*	*[4]*		
Biol 82**	Topics in Infectious Disease †		1		
Biol 126**	Biology of Prokaryotes†			1	
Biol 128L**	Prokaryotes Lab†			1	[1]
Biol 132L	Comparative Physiology†		1	1	4
Biol 133L	Introduction to Math. Physiology†				[1]
Biol 143	Genetics†		5[7]	3[4]	1[2]
Biol 145	Evolution†		4[1]		1[3]
Biol 146L	Ecology†			[1]	1[2]
Biol 149	Neuroscience 2: Systems†		1		
Biol 154	Animal Behavior†			1	
Biol 157L	Cell Biology†			1	4[3]
Biol 159	Natural Resource Management†		1	1	[1]
Biol 161L	Cell & Molecular Neurobiology†		1		[3]
Biol 166	Animal Physiological Ecology				[2]
Biol 169	Marine Ecology				[2]
Biol 170L	Molecular Biology†		1	6	[2]
Biol 173L	Molecular Biology Seminar†		5[2]		[1]
Biol 177	Biochemistry†			5[1]	1
Biol 188L	Senior Research in Biology†				6[8]
Biol 190L	Senior Exptl Thesis†				1[5]
Biol 191	Senior Library Thesis in Biology†				1[1]
Chem 14L	*Basic Principles of Chemistry*[1]	*[17]*		*[1]*	[3]
Chem15L	*Basic Principles of Chemistry*[1]	*[17]*	*[1]*		
Chem 29L	*Accelerated General Chemistry*[1]	*[2]*	*[1]*		
Chem 104**	Inorganic Chemistry†			1	
Chem 116L	Organic Chemistry†		19[17]	1[2]	
Chem 117L	Organic Chemistry†		18[16]	1[1]	
Chem 121	Principles of Phys Chemistry†		2	5[4]	
Chem 122	Principles of Phys Chemistry†		3	2	[2]
Chem 123L	Advanced Organic Chemistry†				2[2]
Chem 124	Bioanalytical Chemistry†				3[2]
Chem 126L	Advanced Lab in Chemistry†			3[3]	1[1]
Chem 127L	Advanced Lab in Chemistry†			5	
Chem 128	Inorganic Chemistry†				3[3]
Chem 168**	Organic Geochemistry†		1		
Chem 177	Biochemistry†			5[1]	1[2]

Chem188L	Senior Research in Chemistry†				2[2]
Chem190L	Senior Experimental Thesis†				3[3]
Chem 199	IS: Bio-Molecule Synthesis				[1]
Phys 30L	*General Physics*[1]		*[11]*		[1]
Phys 31L	*General Physics*[1]		*[13]*		
Phys 33L	*Principles of Physics*[1]		*[6]*		
Phys 34L	*Principles of Physics*[1]		*[5]*		
Phys 35	Modern Physics†		3	[2]	[1]
Phys 100	Computational Physics & Engineering†		3	[1]	
Phys 101	Intermediate Mechanics†			2	
Phys 102	Intermediate Electricity & Magnetism†		3		
Phys 105	Comput Partial Diff Equations†			1	
Phys 115	Statistical Mechanics†			3	
Phys 165	Introduction to Fluid Dynamics				[1]
Phys 170	Quantum Mechanics†				3[1]
Phys 175*	Thermodynamics/Statistic M†			1	
Phys 188	Senior Research in Physics†				1
Phys 190L	Senior Exptl Thesis†				1
Math 31	Calculus II†	7[12]	3[5]	1[1]	
Math 32	Calculus III†	5[2]	3[2]	[1]	
Math 55	Discrete Mathematics†		1		
Math 60	Linear Algebra†	1	2[1]	1	
Math 102*	Differential Equations†		2[1]	4[1]	
Math 131	Math Analysis†		1		
Math 143	Differential Geometry				[1]
Math 151	Probability†			1	
Math 153	Monte Carlo Methods†				1[1]
Math 171	Abstract Algebra 1†				1
CSCI 52	Fundamntls of Comp. Science†	1			
CSCI 60	Principles of Comp. Science†		1		
CSCI 70	Data Structures/Program Dev†			1	
Engr112	Engineering Clinic II†				1
XGOV191	Senior Thesis: EEP†				1

Note. [1] *Introductory courses in italics*
*Differential Equations= Math 102 at Scripps=Math 111 at CMC
**at Harvey Mudd
† Upper division course that requires science and/or math prerequisites
††Senior year transcripts for Other Science Majors not available

Table 32.

STEM Achievement: AISS and Other Science Majors (AISS [OSM])

Course Number	Course Name	Freshman Year	Soph. Year	Junior Year	Senior Year Fall[††]
AISS 001L	*AISS* [I]	B+			
AISS 002L	*AISS*[I]	B			
Biol 43L	*Introductory Biology* [I]	[B+]	[B]		
Biol 44L	*Introductory Biology*[I]	[B+]	[B+]		
Biol 82[**]	Topics in Infectious Disease [†]		C+		
Biol 126[**]	Biology of Prokaryotes[†]			B	
Biol 128L[**]	Prokaryotes Lab[†]			A-	[B+]
Biol 132L	Comparative Physiology[†]		A-	A-	A-
Biol 133L	Introduction to Math. Physiology[†]				A
Biol 143	Genetics[†]		A[C+]	A-[A]	C[C+]
Biol 145	Evolution[†]		A-[A]		A[B+]
Biol 146L	Ecology[†]			[A]	A-[A]
Biol 149	Neuroscience 2: Systems[†]		A		
Biol 154	Animal Behavior[†]			A-	
Biol 157L	Cell Biology[†]			A	A-[A]
Biol 159	Natural Resource Management[†]		A	A	A
Biol 161L	Cell & Molecular Neurobiology[†]		A-		[A-]
Biol 166	Animal Physiological Ecology				[B-]
Biol 169	Marine Ecology				[A]
Biol 170L	Molecular Biology[†]		A-	B+	[A-]
Biol 173L	Molecular Biology Seminar[†]		A[A-]		[B+]
Biol 177	Biochemistry[†]			B[B-]	A-[A-]
Biol 188L	Senior Research in Biology[†]				A[A]
Biol 190L	Senior Exptl Thesis[†]				A[A]
Biol 191	Senior Library Thesis in Biology[†]				A-[B+]
Chem 14L	*Basic Principles of Chemistry*[I]	[B+]		[A]	[C+]
Chem15L	*Basic Principles of Chemistry*[I]	[B+]	[C]		
Chem 29L	*Accelerated General Chemistry*[I]	[B]	[B]		
Chem 104[**]	Inorganic Chemistry[†]			B+	
Chem 116L	Organic Chemistry[†]		B[B]	B+[C]	
Chem 117L	Organic Chemistry[†]		B[B]	B[C-]	
Chem 121	Principles of Phys Chemistry[†]		A-	A[A-]	
Chem 122	Principles of Phys Chemistry[†]		B+	B+	[B]
Chem 123L	Advanced Organic Chemistry[†]				A-[B]
Chem 124	Bioanalytical Chemistry[†]				A[B+]
Chem 126L	Advanced Lab in Chemistry[†]			A-[B]	B+[A-]
Chem 127L	Advanced Lab in Chemistry[†]			B+[C]	
Chem 128	Inorganic Chemistry[†]				A-[B+]
Chem 168C[**]	Organic Geochemistry[†]		B+		

Chem 177	Biochemistry†			B+[B-]	A-[A]
Chem 188L	Senior Research in Chemistry†				A[A]
Chem 190L	Senior Experimental Thesis†				A[A]
Chem 199	IS: Bio-Molecule Synthesis				[A]
Phys 30L	*General Physics*[I]		[B+]		[B-]
Phys 31L	*General Physics*[I]		[B]		
Phys 33L	*Principles of Physics*[I]		[B+]		
Phys 34L	*Principles of Physics*[I]		[B+]		
Phys 35	Modern Physics†		B+	[A-]	[A]
Phys 100	Computational Physics & Engineering†		A-	[A]	
Phys 101	Intermediate Mechanics†			B+	
Phys 102	Intermediate Electricity & Magnetism†		B-		
Phys 105	Computl Partial Diff Equations†			A-	
Phys 115	Statistical Mechanics†			B+	
Phys 165	Introduction to Fluid Dynamics				[B+]
Phys 170	Quantum Mechanics†				B[B+]
Phys 175*	Thermodynamics/Statistic M†			B	
Phys 188	Senior Research in Physics†				A
Phys 190L	Senior Exptl Thesis†				A
Math 31	Calculus II†	B+[B]	A-[B+]	D[B]	
Math 32	Calculus III†	B[B]	B+[A-]	[C]	
Math 55	Discrete Mathematics†		B		
Math 60	Linear Algebra†	B+	A-[A-]	A	
Math 102*	Differential Equations†		A[A]	B-[B]	
Math 131	Math Analysis†		A-		
Math 143	Differential Geometry				[B]
Math 151	Probability†			B+	
Math 153	Monte Carlo Methods†				A[C]
Math 171	Abstract Algebra 1†				C+
CSCI 52	Fundamntls of Comp. Science†	B			
CSCI 60	Principles of Comp. Science†		B		
CSCI 70	Data Structures/Program Dev†			B-	
Engr112	Engineering Clinic II†				A-
XGOV191	Senior Thesis: EEP†				A

Note. Mean achievement shown as average grade of enrolled students, using 12-point grade scale

[I] Introductory courses in italics

*Differential Equations is Math 102 at Scripps and Math 111 at CMC

**at Harvey Mudd

† Upper division course that requires science and/or math prerequisites

††Senior year transcripts for Other Science Majors not available

Senior Thesis Research. Seven of the fourteen AISS senior survey respondents (50%) chose an interdisciplinary senior thesis topic. All of them indicated that AISS was an early and enduring influence on this decision. This is an important finding because students in the Joint Science Department spend two semesters, usually in the junior year, selecting a research topic, doing a literature review, conducting independent research on that topic (whether it involves library, field, or laboratory work), writing a thesis paper, and preparing a poster for presentation. This capstone project might be considered as a kind of proxy for their commitment to thinking and working across the boundaries of the science and mathematics disciplines. In a sense, it can also be interpreted as one sign of the success of AISS in encouraging and guiding students with an interest in an interdisciplinary orientation.

Plans for After College. AISS seniors were clearer about their plans after college than they were as juniors (Table 33). The percentage that planned to attend graduate school right after college had decreased from 33.3% to only 13.3% in this final year of college. The percentage of students who were certain they didn't want to go to graduate school right away had more than doubled, from 27.8% to 60%. About a quarter of this cohort were undecided about graduate school immediately after college. Sixty percent stated they wanted to work for a year or two, and then apply. One student (6.7% of the cohort) planned to earn a Bachelor's degree and enter the work force straight out of college. Two-thirds knew that they did not want to join the work force right after college, and about a quarter of the group was still undecided about their plans following college.

The senior survey was given to students in the first semester when most had not yet taken the GREs or the MCAT. This factored into their lack of certainty about their plans after college. The percentage of students who were undecided in their responses to all three questions ranged from 33.3% to 50%. These students may simply not know yet whether they will be able to do what they want, therefore "undecided" may represent a holding pattern while they wait for final semester grades, test results, and notification from graduate schools and post-baccalaureate programs. It will be important for the Joint Science Department to follow AISS students paths after graduation, in order to learn how many enter and complete STEM graduate programs, and how many begin STEM careers.

Table 33.

Plans After College: AISS Cohort I as Juniors vs. Seniors

	AISS Cohort I Seniors [AISS Cohort I Juniors]*		
	Yes	No	Undecided
Attend graduate program right after college	**13.3 [33.3]	60.0 [27.8]	26.7 [38.9]
Work for 1-2 years; apply to graduate program	60.0 [33.3]	13.3 [27.8]	26.6 [33.3]
Enter work force right after college	6.7 [16.7]	66.7 [33.3]	26.7 [50.0]

Note. *AISS Juniors, N=18; AISS Seniors, N=15
**Valid %; rounded, therefore may not total 100%

Career Aspirations. AISS seniors aspire to the same top five careers they did as juniors, although in a slightly different order. Basic research, research and development, industry, university faculty position, and pharmacy/pharmacy research were all rated as somewhat likely careers, and for all of these careers except pharmacy/pharmacy research there was a slight increase in interest. Careers in K-12 education and medicine were ranked as somewhat likely, although not as strongly as the top five career choices.

Consulting, management, nursing/medical technician, programming, and sales were deemed as unlikely career choices for these seniors, basically consistent with their junior year ratings. None of the differences between junior and senior year were statistically significant.

AISS seniors' career aspirations were consistent with their degree aspirations. Nearly half of the cohort aspired to a Ph.D. and another quarter aspired to earn an M.D. Throughout the four years of college, the science majors in this cohort maintained their aspirations for high educational attainment and expressed interest in careers that for the most part require and utilize graduate training in STEM fields (Table 34).

Table 34.

Career Aspirations: AISS Cohort I as Juniors vs. Seniors

	AISS Cohort 1* Juniors Spring 2010		AISS Cohort 1* Seniors Fall 2010		
	M**	SD	M	SD	D†
Careers					
Basic Research	2.00	.84	2.14	.77	+.14
Research & Development	1.78	.94	2.14	.77	+.36
Industry	1.78	.81	1.93	.99	+.15
University Faculty Position	1.78	.65	1.86	.77	+.08
Pharmacy/Pharm. Research	2.00	.84	1.71	.83	-.29
K-12 Teacher (science/math)	1.39	.61	1.57	.65	+.18
Medicine (physician, dentist)	1.67	.91	1.57	.85	-.10
Consulting	1.06	.24	1.36	.50	+.30
Management	1.50	.71	1.36	.50	-.14
Medicine (nurse, PT, technician)	1.56	.70	1.36	.50	-.20
Programming/Analyst	1.00	.00	1.36	.63	+.36
Sales/Marketing	1.00	.00	1.07	.27	+.07
Fields					
Biology/Life Sciences	1.77	.81	2.10	.83	+.33
Multi/Interdisciplinary	2.00	.77	1.79	.70	-.21
Physical Sciences	1.39	.61	1.64	.74	+.25
Computer & Information Science	1.22	.65	1.29	.61	+.07
Engineering	1.22	.55	1.29	.47	+.07
Environmental Science/Ecology	1.39	.70	1.21	.58	-.18
Earth Science	1.22	.55	1.14	.36	-.08
Neuroscience	1.33	.69	1.00	0	-.33
Space Science	1.77	.51	1.00	0	-.77

Note. *AISS Juniors, N=18; AISS Seniors, N=14
**Likert scale: 3=very likely, 2=somewhat likely, 1=not likely
†D is shown as negative value when senior year value is less than junior year value; paired-sample T-test showed no significant differences

<u>Research Question Two</u>: What are the strongest predictors of achievement in AISS?

It was of interest to identify the variables that predicted success in the fall semester and the spring semester of the AISS course. Multiple regression techniques were utilized to identify these variables and the strength of their influence on achievement.

Fall Freshman Survey — Cohort 1 AISS Students (2007-2008)

A multivariate regression using a stepwise algorithm and mean replacement of missing data was conducted to predict first semester grades with the following variables: student self-concept ratings, degree aspiration, parent educational attainment, and SAT scores. Because SAT scores were critical for correlation (Table 35) and regression analysis, any student who did not report both SAT Math and SAT Critical Reading scores was removed from the analysis. Two variables emerged as the strongest predictors of achievement: SAT-I Critical Reading score and self-confidence in math ability (Table 36). Together, these variables predicted 51.6% of the variability in the first semester course grade. The strongest predictor of success was the student's SAT-I Critical Reading score (β-value=.721), followed by self-confidence in math ability (β-value=.427). This result points out that strong critical reading skills, in addition to strong quantitative competencies, are important for success in AISS. Students in the course are expected to read advanced textbooks and research articles at an accelerated pace. Students' self-confidence in their math ability is directly related to their demonstrated competency on the SAT and AP exams prior to college.

Table 35.

Pearson Product-Moment Correlation Matrix: Key Achievement Variables, Fall 2007

	Fall 2007 Grade	SAT I – Critical Reading Score	Self-Confidence in Math Ability
Fall 2007 Grade	1.00	.630	.273
SAT I – Critical Reading Score	.630	1.00	-.213
Self-Confidence in Math Ability	.273	-.213	1.00

Table 36.

Predictors of Student Achievement: AISS Cohort 1 Freshmen, Fall 2007

	Standardized β-Coefficients	t	Sig t
SAT I – Critical Reading	.721	4.296	.001
Self-Confidence in Math Ability	.427	2.542	.022

Note. Final Model = Model 2; R = .755; R^2 = .570; Adjusted R^2 = .516; F = 10.613; Sig F = .001; N =19

Spring Freshman Survey — Cohort 1 AISS Students (2007-2008)

The spring freshman survey data were analyzed with a multivariate regression using a stepwise algorithm and mean replacement of missing data. The analysis was conducted to predict the spring semester grade with the following variables: the fall grade, student self-concept ratings, plans in science, and SAT scores. Two variables emerged as the strongest predictors of achievement in the spring semester: the fall grade and plans to do summer research in the junior summer (Table 38). Collectively, these variables predicted 78% of the variability in the spring semester grade. The strongest predictor of success was the student's fall grade (β-value=.873), followed by plans to do research in the junior summer (β-value=-.248). The finding that the first semester grade in a science course is predictive of the second semester grade is not particularly surprising especially since the course is yearlong; however, it does provide a benchmark against which future achievement can be compared. The fall survey results indicated the importance of SAT-Critical Reading as a predictor of success, but this variable did not enter in this regression. Instead, waiting until the summer after junior year to do research emerged with a β-value of -.248. Planning to delay summer research until after the third year of college predicted lower achievement in the spring semester of AISS.

Table 37.

Pearson Product-Moment Correlation Matrix: Key Achievement Variables, Spring 2008

	Spring 2008 Grade	Fall 2007 Grade	Scientific Research Junior Summer
Spring 2008 Grade	1.00	.862	-.209
Fall 2007 Grade	.862	1.00	.045
Scientific Research Junior Summer	-.209	.045	1.00

Table 38.

Predictors of Student Achievement: AISS Cohort 1 Freshmen, Spring 2008

	Standardized β-Coefficients	t	Sig t
Fall 2007 Grade	.873	7.887	.000
Scientific Research Junior Summer	-.248	-2.241	.040

Note. Final Model = Model 2; R = .897; R^2 = .804; Adjusted R^2 = .780; F = 32.886; Sig F < .001; N =19

<u>Research Question Three</u>: What aspects of the student experience in the Joint Science Department most strongly influenced the decision to persist in a science major?

The quality of teaching and the climate within the department both have been cited in the literature as important factors that influence whether students persist in the science major. This research question seeks to determine which factors within the Joint Science Department influenced students' decision to persist as science majors in college.

On the junior year surveys of AISS students and Other Science Majors questions were designed in the following areas: faculty and advisors, interest in science and mathematics, achievement in science and mathematics, whether majoring in science was questioned, and research experiences. Respondents were asked to indicate whether factors within the areas were a strong, moderate or weak influence on their decision to major in science. These data are shown in Table 39 and discussed in the following section.

Table 39.

Influences on Persistence: AISS Cohort I Juniors and Other Science Majors, Spring 2010

	AISS Cohort 1 [Other Science Majors]*			
	Strong Influence	Moderate Influence	Weak Influence	Did Not Experience/ Does Not Apply†
JSD Faculty/Advisors				
Provide academic and career advice	27 [7]	50 [20]	11 [30]	23 [7]
Provide accurate info on courses & sequencing	28 [27]	56 [43]	22 [23]	0 [7]
Provide out-of-class academic/personal help	39 [40]	44 [27]	11 [27]	0 [6]
Provide quality learning experiences & teaching	50 [55]	28 [28]	17 [10]	7 [3]
Interest				
Intrinsic interest in science	83 [87]	11 [20]	0 [3]	6 [0]
Intrinsic interest in mathematics	33 [30]	44 [20]	17 [37]	6 [14]
Achievement				
High achievement in science classes	39 [87]	39 [10]	17 [3]	6 [0]
Low achievement in science classes	50 [7]	11 [7]	22 [30]	6 [57]
High achievement in math classes	22 [27]	22 [27]	39 [23]	23 [3]
Low achievement in math classes	50 [3]	11 [0]	22 [27]	17 [70]
High achievement in non-science classes	6 [30]	44 [17]	44 [40]	17 [13]
Low achievement in non-science classes	0 [7]	6 [3]	28 [17]	67 [70]
Question Science Major				
Lack or loss of interest in college science	6 [0]	0 [13]	22 [17]	72 [70]
Questioned science major and lifestyle	17 [7]	11 [30]	22 [17]	50 [47]
Science career not worth the effort	0 [7]	11 [10]	22 [17]	67 [67]
Discovered non-science/math aptitude	0 [7]	11 [13]	50 [33]	39 [47]
Prefer non-science/math teaching approaches	0 [3]	11 [7]	6 [27]	73 [53]
Non-science major offers better education	6 [3]	6 [7]	17 [30]	72 [70]
Morale undermined by competition in science	6 [10]	17 [13]	28 [13]	50 [63]
Morale undermined by strict grading systems	6 [7]	22 [29]	28 [17]	45 [57]
Research Experiences				
Participation in summer science/math research	28 [40]	17 [10]	17 [13]	39 [11]
Participation in science/math research during school year	17 [23]	11 [23]	11 [10]	61 [43]

Note. *AISS Juniors, N=18; Other Science Majors, N=30
**Valid %; rounded, therefore may not total 100%
†These two response categories were conflated

Role of the Faculty. Faculty and advisors had a moderate to strong influence on students interested in majoring in science in both the AISS cohort and the comparison group of Other Science Majors in all of the categories of survey questions. At least fifty percent of both groups indicated that quality teaching and learning experiences provided by JSD faculty were a strong influence on their decision to persist in a science major. Nearly forty percent in both groups indicated that out-of-class academic and personal help strongly influenced them to stay in the sciences and nearly another third or more of the both groups cited this factor as a moderate influence. This is supported by students' responses on open-ended questions indicating that faculty members are readily available to them during office hours and for help sessions.

Both groups indicated that JSD faculty's career and academic advising, as well as advice on scheduling classes were a moderate influence. Half of the AISS students indicated that academic and career advice moderately influenced them, whereas only 20% of the other science majors cited this as a moderate influence. More of the other science majors (30%) stated that this type of advice had only a weak influence on them. This difference may be a result of the time AISS professors and students spent together in the AISS course during freshman year. Twelve AISS juniors chose AISS professors to be their academic advisors, and even those who didn't may have done summer research or taken at least one upper division course with these same professors. The small class size in AISS and the intensity of their first year immersion in the sciences provided AISS students additional opportunities to get to know their professors. It should be pointed out that two of these professors, a biologist and a chemist, were women and ten AISS students, all women, selected them as advisors. This is noteworthy because the literature cites female professors, mentors, and role models as critical to the persistence of women in STEM majors (Seymour & Hewitt, 1997; Margolis & Fisher, 1995; AAUW, 2009).

In spite of difference between the groups, it is obvious that faculty and their interactions with students interested in majoring is at least a moderate, and in some cases a strong, influence. Joint Sciences is a relatively small department that is housed in a single building. Size, close contact between personnel in the department, and the fact that nurturing strong student-professor relationships is a high priority for this department all contribute to the influence faculty have on their potential and declared majors.

Interest and Achievement in Science and Mathematics. Eighty-three percent of the AISS juniors and 87% of the comparison group indicated intrinsic interest in science as a strong influence on their decision to pursue a science major. To a lesser extent, intrinsic interest in mathematics influenced the decision, with about a third of each group citing it as a strong influence. Forty-four percent of the AISS juniors indicated that math interest was a moderate influence and 37% of the Other Science Majors stated that it was a weak influence on their major decision. AISS juniors' indication of intrinsic math interest as a strong factor may also be a reflection of their demonstrated achievement and confidence in math.

Nearly 90% of Other Science Majors indicated that achievement in science courses was a strong influence on the decision to major in science. By comparison, only 39% AISS juniors stated that science achievement was a strong influence; however, an additional 39% indicated that it was a moderate influence, suggesting that achievement in their intended major was important to both groups of students. Fifty percent of the AISS Juniors indicated that low achievement in both science and mathematics strongly influenced their decision to pursue a science major. Since 22 out of the 26 students who completed AISS persisted as science majors through junior year, these responses can be interpreted to mean that AISS students tended to decide on which science major was the best fit based on whether they had earned low grades in that discipline or in the mathematics courses required for those majors. Students often choose between science majors or switch out of a science major, as was the case for four AISS completers, based on achievement as well as on interest.

High mathematics achievement was a moderate to strong influence for both groups of students, as was indicated by 44% of AISS and 54% of Other Science Majors. Other Science Majors differed from AISS juniors in their response to low math achievement. Whereas half of the AISS juniors indicated that it had a strong effect (probably in a negative direction), 70% of the Other Science Majors answered that it wasn't an influence because either it didn't apply to them or they didn't experience it. Perhaps one reason AISS juniors indicated the strong effect is because they have very high expectations of themselves in math because of their high SAT-Math scores coming into college. These are students who expect to do well in math so a low grade might have a stronger negative impact for them than for other students.

Achievement in non-science course had relatively little effect on their decision to major in science. Eighty-eight percent of AISS junior stated that high achievement in non-science course was a weak to moderate influence on their decision to major in science, while 57% of Other Science Majors indicated the same. Nearly 70% of both groups indicated that low achievement in non-science courses either did not apply to them or that they didn't experience it.

Questioned a STEM Major. AISS junior and Other Science Majors by and large did not experience many of the factors that draw students away from the science major. Approximately 70% of both groups indicated that they had not experienced a loss of interest in science nor had they felt that a science major was not worth the effort or that a non-science major offered a better education. Roughly half of both groups responded that they had not questioned the lifestyle of the science major and that their morale had not been undermined by competition or strict grading policies. This may indicate that students felt grading policies were fair and were not strongly affected by competitiveness in their courses. It may also indicate that they were committed to majoring in science and took these conditions in stride.

Research Experiences. About half of the students in both groups indicated that participation in summer science or math research had a moderate to strong effect on their decision to major in a science. Thirty-nine percent of AISS juniors compared to only 11% of Other Science Majors reported that summer research did not apply to them or that they did not experience it. It is interesting that nearly 40% of the AISS juniors did not do summer research or found summer research not to be a factor affecting their decision to major in science. This may indicate that these students were committed to major in science regardless of whether they did research. A number of AISS students indicated on the freshman survey that they needed to work during the summer or that they wanted a break from science during the summer. The junior year survey did not ask students to specify whether or not they received funding for summer research, nor did it ask whether they has conducted research in the Joint Science Department or elsewhere. These data have been collected by the department for AISS students, but not for Other Science

Majors. Regardless of where they did research or whether it was funded, these students reported that its influenced their decision to persist as science majors.

Results from the junior year years of AISS and Other Science Majors who took the traditional two-year introductory science sequence as freshmen and sophomores indicate that faculty interaction and advising as well as students' intrinsic interest in science and their achievement in science classes were the strongest influences on the decision to persist in a science major. The nearly 30-40% of students in both groups who participated in summer STEM research ranked that experience as strongly influential on their decision to persist in science**.** Initially, it was surprising to see how important summer research was to the Other Science Majors, especially considering the attention and funding resources the AISS students receive. The survey did not ask whether or not all students who did summer research all received funding; however, some students indicated that they chose to work in laboratory and field settings during the summer in order to gain experience so it can be assumed that at least some of these students were unfunded or minimally funded compared to the generous grants allotted by the NSF grant that funded AISS in its first four years. Nearly 50% of the Other Science Majors indicated that research during the academic year was a moderate to strong influence on their decision to persist in science. This suggests that these students are gaining their research experience differently than AISS students—part-time during the academic year rather than full-time on a summer grant.

<u>Research Question Four</u>: How do AISS faculty members perceive AISS, its influence on students' development in the major, and its influence on them as science educators?

In order to answer the fifth research question, "How do AISS faculty members perceive AISS, its influence students' development in the major, and its influence on them as science educators?" AISS faculty members were asked to participate in a focus group led by the researcher and her advisor. The IRB-approved questions (Appendix H) were emailed to the professors several days prior to the focus group. Four of the seven professors who have taught the course during the past four years participated. One other professor submitted responses by email. All three science disciplines—biology, chemistry, physics—were represented by those present. Questions were developed in two overlapping domains: student-related and instructor-related. This section describes emergent themes in these two domains and provides insight into the thoughts and perceptions of the professors.

Impact on Student Development in the Major. Without a doubt, AISS is a rich and rigorous introduction to college-level science. Professors were aware that the structure of AISS, as a double-credit, honors-level course, requires students' nearly full commitment. In addition to the twelve hours of required lectures, seminars, and labs, students are strongly encouraged to attend help sessions and office hours. All of the professors agreed that those students who utilize this extra help benefit not only academically, but also learn how to develop supportive faculty-peer and peer-peer relationships. Within these relationships, students build shared understandings of the concepts and principles of the course, as well as foster a network of support and care.

AISS faculty are committed to their students and the students acknowledge the importance of the extra time and help they receive from professors. More than half of the first cohort of students did summer research with these professors, many in collaborative lab groups involving several students.

AISS professors are aware that AISS completers move into upper-division courses earlier than most of their peers. When they are not part of the AISS teaching team, some of these professors taught AISS students in advanced courses in their fields. They describe them as better able to make connections between disciplines than other students, and attribute this difference largely to the AISS experience. Because AISS students have strong mathematical abilities, professors described being able to teach concepts in greater depth and from a quantitative perspective, not just a qualitative perspective as is done in most introductory courses. They feel this gives AISS students an early advantage because they can describe phenomena in its complexity rather than having to simplify it. Professors feel students leave AISS well prepared for upper division course work in biology, chemistry and physics, even as they acknowledge that they are exposed to basic material in very different manner than are students in the traditional introductory courses sequence. For some professors and students, covering less material in greater depth remains a challenge.

Integration of Science Disciplines. When asked to reflect on the AISS experience, the professors unanimously agreed that presenting the fundamentals of biology, chemistry, and physics at the introductory level was the most powerful aspect of the course. At no other point in their undergraduate experience will students be so intentionally and intensively exposed to principles, concepts, and processes from an interdisciplinary perspective. For biology, it is particularly useful to be able to draw on chemistry and physics to explain what is occurring. However, the down side of this is that every problem is more complex and more difficult because it is "decorated with baggage from chemistry and physics" which complicates student learning. They are asked to give harder explanations and to think more deeply about problems and with a broader range of application than they can in a regular course.

One professor gave an example of a situation that arose in the current AISS course. He was able to ask why DNA would come apart if it was placed in a strongly ionic solution. Because AISS students were taught about relative bond strengths in the context of learning about DNA (i.e., the chemistry was presented along with the biology), they were able to answer the question. According to this professor, such a question would never have come up in a regular introductory level biology course. Another professor gave the example of being able to quantify the Gibbs free energy in oxidation-reduction reactions (in the electron transport chain of cellular respiration, for example) rather than merely mentioning that energy is required or released during the process. Because they are able to delve more deeply into how the biological process and the chemical process that underlies it, the professors believe that students gain deeper and fuller understanding than when they are taught as either the biological process or the chemical reaction separately, often in two completely different and unrelated courses. In this regard, AISS makes explicit to students how chemistry and biology are related ways to examine and explain natural processes. Introductory-level biology does not ordinarily quantify processes because often students haven't yet taken the necessary chemistry or physics. Instead, introductory biology courses usually describe and students must wait until they encounter the same biological processes in upper division courses to get the full explanation.

Although the professors were generally in agreement that chemistry and physics laid the foundation for teaching biology, they didn't agree that the converse was true. Students are taught to analyze new phenomena by breaking them into the core physical principles; however, the physics professor felt that this is difficult for beginning college students because they are generally less familiar with physical principles than biological principles. To help students become comfortable with this kind of analysis, especially since they had widely different physical science preparation coming out of high school, the instructors begin the course with an intensive review of fundamental physics. The AISS professors were unanimous in their opinion that AISS validates the physical sciences, which are often avoided or dreaded by many students, because the course tries to present new phenomena (especially biological phenomena) through the lens of core physical principles.

Accelerated Pace. AISS accelerates three one-year courses, usually taken in the freshman and sophomore years, into a single double-credit course in the freshman year. When asked to discuss the effect of accelerating as compared to that of integrating the course material, professors agreed that integration of the three disciplines was the more successful endeavor for several reasons. Because AISS essentially compresses three courses into two, it attracts certain students—those with strong high school preparation in both mathematics and science who know they want to study science in college and who are willing and able to work extremely hard in order to master the quantity of material presented. These are students with strong high school science and mathematics backgrounds, demonstrated competency on SAT and Advanced Placement examinations, and an expressed interest in the course's interdisciplinary perspective. Even these highly capable students struggle with the work load that results from the accelerated pace. The professors pointed out that AISS doesn't necessarily attract students to science during admissions, but once they are enrolled it does make a science more attractive as a major. Because AISS accelerates the introductory coursework, students can enroll earlier in upper division courses and some can complete the requirements for the science major by the end of junior year. This allows them latitude in their schedules for double majoring or studying abroad, options that generally are not possible for most science majors wanting to graduate in four years.

The professors agreed that one of the positive effects of the accelerated nature of the course is that students learn that they can handle the heavy work load of AISS. This is a valuable lesson for incoming freshmen and shows them that they have the capacity to understand greater volumes of difficult material than they previously thought. Also, the early exposure to physics as well as chemistry and biology (taken by freshmen in the traditional introductory pathway) gives them greater confidence and room in their schedules as sophomores and junior to pursue a broader range of majors.

The accelerated nature of the AISS course presents several challenges. It "narrows the funnel" as to which students are admitted into the course and which succeed. While the professors agree that integration of disciplines is "very valuable," there is concern that the course aspires to cover too much material and in so doing fails to serve as many potential science majors as it might. More capable freshmen, including those who want to major in science but did not score above 700 on the SAT-Math exam, might be attracted to an integrated approach were it not also accelerated.

The lived reality for students and professors in this double-credit course is its unrelenting pace. The course meets twelve hours a week for lecture and lab, with lecture and lab both meeting several days a week. In addition there are office hours, help sessions, and preparation for the course for both students and professors.

Early Research Readiness. Upon completion of the two semesters of AISS students are prepared to participate in summer research opportunities. Most other students interested in majoring in science must wait until the following summer (after sophomore year) to pursue research because they must complete their introductory science coursework during sophomore year. The professors agreed that early entrée into research provides AISS students with distinct advantages. All of them had advised interdisciplinary research projects with AISS students during summer research. Some had AISS students in their laboratories for more than one summer. One professor was co-author with an AISS senior on an article that resulted from her freshman summer research. As a senior this student was working on a second article, on which she would be first author. All of the professors agreed that serving as mentors to students was a critically important role for them, and they all take that responsibility very seriously. They are aware of and cite Seymour & Hewitt's work on the role of faculty in student persistence in STEM majors.

Impact on Pedagogy. All of the professors indicated that they lecture less in AISS than in other courses they teach. They described a shift away from a pedagogy with which they were comfortable and toward one that was less familiar but better suited to the goals and structure of AISS. In AISS, there is more back and forth interaction between instructors and students. This is encouraged by the professors and is well received by the students. These professors described spending hours every week co-planning lectures and discussion section with each other. While time consuming, all reported that it was invigorating to look at topics they had taught before through an interdisciplinary lens, and to try to find examples of research in the literature that helped students see how natural phenomena can be examined from the perspectives of several disciplines. These professors also mentioned that they gave more formative assessments, in the form of problem sets and quizzes, to check for student learning. These smaller and more frequent assessments helped them see where students had gaps in their understanding. Professors also encouraged students to come to office hours to discuss problems they were having, to get help sooner rather than later, and to get to know them and fellow students better. Through their many interactions, professors and students in AISS built a culture of support, collaboration, and mutual respect.

Sustainability of AISS. Professors expressed concern that, in spite of its benefit to students and its high profile as a curricular innovation, the AISS course is costly in terms of human and financial capital. The course requires three full-time professors from three disciplines. This puts staffing pressures on these disciplines to cover other course offerings. Also, because AISS requires a novel approach to professors' own disciplines, it is extremely labor intensive. The course is team taught with all three professors present for all lectures and labs, which are created anew or modified each year. Significant time each week is spent planning integrative lectures and creating or refining simulations and lab exercises. Not all Joint Science Department personnel fully support AISS, on philosophical and pedagogical grounds and because its collaborative nature is so demanding compared to teaching alone. Some professors do not feel their discipline receives adequate coverage in the integrated format. Even though the AISS faculty report that they have grown tremendously from the experience of interdisciplinary teaching, there are members of their departments with little buy-in to this way of teaching and learning. This makes recruiting and training new AISS instructors a greater challenge.

During the past four years, four cohorts of students have participated (or are currently participating) in AISS. In that time, the instructional team has changed three times. This first cohort was taught by a female biologist, a female chemist, and a male physicist. The second cohort was taught by the same biologist and physicist, and a female chemist new to the team. The third and fourth cohorts were taught by an all-male team of professors. Initially, there was some concern about the lack of female role models on the AISS team, especially given the high enrollment in the course of female students and the widely-known importance of same gender role models in persistence in the science major (Seymour & Hewitt, 1997; Margolis & Fisher, 2002). However, the faculty of the Joint Science Department is composed of 37% full-time female faculty and students have access to them as advisors and as professors in upper division courses.

Suggestions have been made to integrate two disciplines (such as biology and chemistry or chemistry and physics) rather than all three, as a way to make discipline integration and the amount of material to be taught more manageable. This modification would still provide an integrated approach and, by decreasing the volume of content, allow a slower pace that might be attractive to more students and more professors.

Concern was expressed that students would be more attracted to biology and chemistry and less inclined to pursue physics in this kind of two-subject integration.

AISS is unique among efforts to integrate the major strands of science. Other colleges and universities have designed courses that integrate two subjects or that are directed to non-majors or are taught by post-doctoral fellows, but none have committed the resources and senior personnel to the extent that the Joint Science Department at the Claremont Colleges has. No other college or university fully integrates the lecture and laboratory sections, based on topics and themes, to the extent done in AISS. The challenge, as expressed by these professors, will be to sustain the course beyond the original NSF funding and to secure it a permanent place in the course offerings of the JSD. Reconfiguring AISS to accommodate the budget, facilities, and personnel limitations, or securing long-term funding and building departmental capacity will be key to successfully meeting this challenge.

This study characterized the students in the first four AISS cohorts and a comparison group of Other Science Majors as juniors. It described their pre-college backgrounds, their aspirations, their self-concepts, their involvement with science beyond the classroom, and their perceptions about their experiences as science majors. It identified variables that most strongly predict achievement in both semesters of AISS. Also, this study revealed factors in the Joint Science Department that most influenced students' persistence in a science major. Finally, this study described AISS professors' perceptions of the course, its impact on science majors, and how the experience of teaching on an interdisciplinary team changed their pedagogy as science educators.

Chapter Five will present a summary and discussion of the findings, and will make recommendations for future practice and future research.

CHAPTER 5 – DISCUSSION

This chapter presents the summary, conclusions, and discussion of the findings of this study. A brief review of the purpose, significance, research questions, and methodology will be presented, followed by an interpretation of the findings and conclusions. This section also will present a discussion of the implications of the study results as they relate to science education research and practice, and will conclude with recommendations for practice and further research.

Summary of the Study

Purpose

One purpose of this study was to examine the characteristics and backgrounds of college students attracted to studying interdisciplinary science in a newly developed accelerated and integrated introductory science sequence (AISS), and to determine the influence of that course on students' experiences and development in the science major during the subsequent three years. Another goal of the study was to determine how AISS students differed in the junior year from their peers in the Joint Science Department who took the traditional introductory coursework. A third goal of this study was to identify the variables that predict success in the course. Finally, this study aimed to explore the experience of the faculty who developed and taught the course, their perceptions of how AISS impacts student in the major, and the ways in which participation in AISS shaped their attitudes and pedagogy as undergraduate science educators.

This research builds on the existing scholarship in K-12 and undergraduate science education and college student development. The literature on reforms in K-12 science education indicates the need to institute commensurate reforms in undergraduate science education. Especially important is the need to improve the quality of undergraduate science education, particularly at the introductory level, in order to attract talented high school students into science in college, and then retain them in science majors as undergraduates.

Significance

Numerous studies cite a poor introductory science experience as a major reason why many interested and qualified students choose not to continue in a science major (NRC, 1999; Seymour & Hewitt, 1997; Oakes, 1990). Additionally, the length of time required to complete a science major deters students from pursuing an undergraduate science degree. Other factors, such as traditional "weed out" processes and the practice of reserving undergraduate research opportunities for upper division students, further discourage capable freshmen from forming an affinity to the undergraduate science experience. AISS presents a new interdisciplinary approach to introductory coursework that accelerates entry into upper division coursework, encourages a collaborative learning environment, creates a strong affinity to science faculty in the Joint Science Department, and offers early opportunities for funded undergraduate research. These are all factors that have been found to contribute to the persistence of students, including women and underrepresented minorities, in STEM majors (Bonsangue & Drew, 1992; Seymour & Hewitt, 1997; Margolis & Fisher, 2002).

This study is important for several reasons. It describes how an interdisciplinary curriculum innovation for teaching introductory undergraduate science at highly selective liberal arts colleges attracts capable students and launches them into a science major. More scientists, particularly those with diverse perspectives and interdisciplinary training, are needed in order for the U.S. to be competitive in the global economy, to maintain our pre-eminence in the scientific community, and to engage the real-world problems of the 21st century. Students who graduate from their undergraduate programs with significant exposure to rigorous coursework that emphasizes connections between the sciences, mathematics, engineering, and computer science and with substantial research experience are likely to be successful in graduate training programs (NRC, 2003a). This new introductory-level course combines components known to be effective in attracting talented students and strengthening their commitment to major in a science—an interdisciplinary approach, an accelerated pathway through the major, rich faculty-student interactions, and early undergraduate research experiences. Therefore, there is value in learning about the students who enroll in the course, the ways in which the course impacts their development as science majors, and the faculty's opinions about the course's strengths and weaknesses and how teaching it affected their pedagogy as science educators.

Research Questions

The following research questions guided this study:

1) What are the characteristics and attributes (background, aspirations, self concept, perceptions) of students who enroll in AISS? How do AISS students compare with other science majors on outcome variables measures in the junior year?

2) What are the strongest predictors of achievement in AISS?

3) Which aspects of the student experience most strongly influenced the decision to persist in a science major?

4) How do faculty members perceive AISS, its influence on students' development in the major, and its influence on them as science educators?

Methodology

This study consists of the analysis of four cohorts of students who took AISS to fulfill the introductory coursework in biology, chemistry, and physics. The first AISS cohort, Cohort 1, was the main focus of this research and was studied throughout their four years of college. They were surveyed twice in the freshman year and again in the sophomore, junior and senior years. Subsequent cohorts, Cohorts 2 – 4, were administered surveys on this same schedule. The analyses of data collected on Cohort 1, seniors at the time of this dissertation, are presented in Chapter 4. Survey data on Cohorts 2 – 4 are presented in the Appendix. The decision to include these data was made because although Cohort 1 was the primary focus of this dissertation, there is important information and knowledge to be gained from the students who took AISS in the following three years which can add to the depth of our understanding of the impact and effectiveness of AISS.

The analysis of the data followed the order of the four research questions. To answer Research Question One, the analysis used univariate descriptive statistics. Frequency distribution tables were compiled for the survey questions that were identified as most relevant to the research questions. T-tests were used to compare results and to test for significant differences between and within groups. To answer Research Question Two and discern the strongest predictors of achievement in AISS, multiple regression analysis, using a stepwise algorithm was used. To answer Research Questions Three, descriptive statistics and T-tests for samples with independent means and paired means were used. To answer Research Question Four, the responses of the faculty who participated in a focus group were analyzed, organized by emergent themes, and then elaborated using rich textual description.

Summary of the Findings

This four-year longitudinal study described and analyzed the characteristics and background of students attracted to interdisciplinary science. Next, it identified variables that predicted successful achievement in AISS. Because AISS students have a very different introduction to science than do students in the traditional introductory pathway, this study also looked at how the AISS juniors and Other Science Majors in the junior year perceived their experiences in the Joint Sciences Department, in an effort to determine the long-term impact of AISS on student attitudes, experiences, persistence, and involvement with science outside the classroom. The final aspect of this study examined faculty attitudes about AISS, its impact on science majors, and its effect on their teaching and pedagogy.

The first research question asks about the characteristics (background, aspirations, self concepts, and perceptions) of students who enroll in AISS and compares AISS students and Other Science Majors on certain outcome variables in the junior year. The analyses showed that in Cohort 1, the modal student who enrolled in AISS was a native English speaking, White female; with at least one parent with a graduate degree; who attended a large, suburban, coeducational pubic high school; who took and passed more than two science and mathematics Advanced Placement exams; who scored above 700 on the Math SAT-1 and nearly that high on the Critical Reading SAT-1; and who intended (as a freshman) to pursue a Biochemistry or Chemistry major and obtain a Ph.D.

By the first semester of senior year, when the final survey for this study was administered, eighteen of the 29 students who had enrolled in AISS as freshmen remained science majors. Fifteen of these were women. They had narrowed their choices of majors to Biology, Molecular Biology, Chemistry, Biochemistry, and dual majors involving Physics, Chemistry, Mathematics, and Media Studies. While biology-based majors predominate in the preferences of AISS students and Other Science Majors, more AISS students pursued majors that were more challenging (required more upper division science and math courses) than the Other Science Majors. The acceleration of introductory requirements provided by AISS allowed AISS-completers to begin taking upper division STEM courses while the Other Science Majors were still completing introductory courses.

By senior year, AISS students had outpaced the Other Science Majors in STEM course taking and had earned higher achievement in STEM courses than these peers. Students who completed AISS participated strongly in funded summer research—40% after freshman summer (8 women, 2 males) and 50% for more than one summer during college (10 women, 1 male). Seven AISS seniors chose interdisciplinary senior thesis topics, and indicated that AISS was an early and enduring influence on this decision. Nearly half of the cohort aspired to a Ph.D. and another quarter of the AISS students aspire to earn an M.D. Their top four most likely career fields—basic research, research and development, industry, and academia—reflected their interest and experience in research. By comparison, when the Other Science Majors were surveyed in the junior year, they had selected more biology-based majors (60% versus 45% for AISS juniors) and more were pre-med and pre-dental (40% versus 27.8% for AISS juniors). Forty percent of the Other Science Majors aspired to an M.D. or a D.D.S compared to 27.8% for AISS juniors, and 46% aspired to a Ph.D. compared to 56% of AISS juniors. Careers with a research component were among the top choices for both groups of juniors.

AISS students had mean self-concept ratings in the average to above average range throughout all four years of college. Self-rated academic ability, mathematical ability, drive to achieve, and critical thinking consistently outranked spatial ability, creativity, and risk taking. Self-rated spatial ability was the lowest ranking all four years, except during the sophomore year when it was still in the bottom third of the ratings. The mean self-concept ratings of the Other Science Major juniors followed this same trend; however, their self-ratings were slightly (but not significantly) higher overall than the AISS juniors. For the AISS students, virtually every mean self-concept rating showed at least a slight increase between freshman and senior year, suggesting the kind of growth in self-concept that Astin's Involvement Theory predicts. It was striking that the relative ranking of the mean self-ratings remained basically unaltered throughout college, indicating that these students grew modestly more confident in all self-concepts, but the profile of their self-ratings did not change.

The second research question examines the strongest predictors of student achievement in AISS. Multiple regression analysis was conducted to predict the first semester grade with the following variables: student self-concept ratings, degree aspirations, parent educational attainment, and SAT scores. Two variables emerged as the strongest predictors of achievement: the SAT-I Critical Reading score and self-confidence in math ability. Together, the same independent variables predicted 51.6% of the variability in the first semester grade. The stronger predictor of success was the student's SAT-I Critical Reading score (β-value=.721), followed by self-confidence in math ability (β-value=.427). This result indicates that strong critical reading skills, in addition to strong quantitative competencies, are important for success in AISS.

A similar multiple regression, using the same variables as above and the fall semester grade, was conducted to learn which variables predicted success in the spring semester. Two variables emerged as the strongest predictors of achievement: the fall grade and plans to do summer research in the summer after junior year. Collectively, these variables predicted 78% of the variability in the spring semester grade, but as discussed below, the causal chain may be reversed. The strongest predictor of the spring semester grade was the student's fall semester grade (β-value=.873), followed by plans to do research in the junior summer (β-value=-.248), a weaker and negative predictor of success. Planning to delay summer research until after the third year of college predicted lower achievement in the spring semester of AISS

The third research question asks which aspects of the student experience in the Joint Science Department most strongly influence the decision to persist in the science major. Both AISS students and Other Science Majors cited quality teaching, out-of-class academic and personal help, and career advice given by the Joint Sciences faculty as strong influences in their decision to major in science. More than 80% of both AISS students and Other Science Majors cited an intrinsic interest in science as a strong influence on their decision to major in science. Achievement in both science and mathematics were moderate to strong influences on choosing to persist in a science major, although science achievement was more influential than mathematics achievement. By and large, students in this study were not discouraged by factors such as losing interest in science, low morale due to competitive grading policies, or preferring the teaching style in non-science and mathematics courses. Both groups were moderately to strongly influenced by a summer research experience.

The fourth research question examines how faculty members perceive AISS, its influence on students' development in the major, and its influence on them as science educators. Professors unanimously agreed that AISS was a successful and rigorous first-year course that required students to commit significant time and effort. All agreed that the experience was a tremendous benefit to most students. The unique presentation of the contents of introductory biology, chemistry, and physics in one comprehensive course helped students think across traditional disciplinary boundaries. Students built collaborative networks of support with each other and with their professors to help them weather the demands of the accelerated pace of the course. Forty percent of the students who completed AISS worked with AISS professors and other professors in the Joint Sciences on summer research projects that all agreed provided the students entrée into the way science is actually done.

In terms of AISS' impact on their teaching pedagogy, all of the professors indicated that they had made a shift from a lecture-dominant style to one that was more interactive and allowed for more questioning and discussion to take place. These professors agreed that it was a challenge to share the stage with other disciplines and they struggled to make certain they covered what they considered to be the most essential concepts from their individual fields in the interdisciplinary format. All reported that this process was challenging and invigorating at the same time. They expressed concerns about expanding the cadre of faculty who could teach AISS, and agreed that recruitment and professional development would be important elements in this expansion. Because AISS was funded for its first four years by a NSF-STEP grant, these professors were concerned that more permanent funding needed to be secured in order to institutionalize this curricular innovation.

Discussion and Conclusions

Research Question One

AISS allowed students to progress through sophomore, junior and senior year taking full advantage of the wealth of upper division courses offered by the Joint Sciences. AISS students often took science, math, and computer science courses beyond the requirements for their majors. AISS students who chose to do so were able to fulfill the requirements for two majors, thereby completing a double major. Four of the fourteen Cohort 1 students who participated in the senior survey completed double majors, and two of them double majored in two STEM fields. In terms of development during the college years, students who double majored involved themselves *most* fully in the STEM offerings within the Joint Science Department. In general, AISS students selected more challenging majors than the Other Science Majors so even those students took more science and mathematics courses than many of their peers.

Astin's Involvement Theory gives the institutional environment a critical role in college student development in that it provides students a great number and variety of opportunities. Change in college students occurs to the extent to which they become involved in the encounters provided by the environment, and it is the quality of their effort or involvement that determines the extent of their growth. As an introductory course sequence, AISS launches students into the array of opportunities offered by the

Joint Science Department at an accelerated pace. As a cohort, this group of AISS students took full advantage of this acceleration and parlayed it into rich involvement, resulting in a retention rate in the science major (of students who remained at the Claremont Colleges for four years) of nearly 90%, nearly 20% of students electing to double major, more STEM course taking and higher STEM achievement than other science major peers, and repeated participation in summer research by half of the cohort. Additionally, the fact that half of the AISS senior survey respondents chose an interdisciplinary topic for their capstone senior thesis research can be considered a kind of proxy for their commitment to thinking across discipline boundaries and a signal of the success of early interdisciplinary exposure to college-level science.

It must be noted that 22 out of 25 (88%) of the students in this first AISS cohort were women. Fifteen of the 18 (83%) who remained at the Claremont Colleges all four years and persisted in a science major were women. One of the three colleges in the Joint Science Department is Scripps College, a women's college; therefore, it was likely and indeed turned out to be the case, that the majority of students in this cohort and subsequent cohorts in AISS were women. Although AISS was not conceived specifically as a course to attract women, it has the added value of attracting women into science and offering them the opportunities known to increase persistence in the science major. As more students participate in AISS, the capacity of women science majors within the Joint Science Department will grow. This is important advancement for the Joint Science Department not only because of the general increase in women in science, but also because AISS encourages a wide variety of majors and facilitates double majoring. Two of the four AISS seniors with dual majors were women who double majored in two STEM fields!

The finding that nearly 40% of the first AISS cohort did summer research two or more summers by the end of junior year and that almost 10% of the cohort did summer research every year of college is significant. The benefits of undergraduate research are complex and range from learning to read primary literature to mastering lab techniques to enduring setbacks and possibly, to making new contributions to scientific knowledge. Done well, undergraduate research engages multiple dimensions of a student's cognitive, behavioral, and attitudinal skills (Lopatto, 2009). These experiences in the laboratory or in the field can build self-confidence and independence that helps shape the student's vision of his or her future. They provide opportunities for undergraduates to rule in and rule out certain disciplines and research areas, and to both broaden and narrow their areas of interest. Not to be understated for students interested in advanced degrees, undergraduate research has the benefit of adding to a student's credentials for being admitted to graduate school. Hence, undergraduate research has value in enhancing student's career trajectory as well in addition to broadening their college experience. Lopatto (2009) reported a majority of students said that their research experience helped them be better students. The presence of undergraduate researchers in a science course after they have had a research experience may elevate the course. This may in part explain the high average achievement seen in the AISS cohort in their upper division STEM course taking. The support for early and repeated research experiences is one of the strongest value-added factors of the AISS initiative.

Research Question Two

The findings that emerged from this research question can help professors better select and support students in AISS. If AISS faculty members know the student variables that most strongly predict success in the first semester of the course, they can take them into consideration when selecting applicants. Selection criteria include a score of 700 or higher on the SAT-Math exam and a strong background in high school science and math; therefore, when the SAT-Critical Reading score emerged as a predictor of success it was initially somewhat surprising, given the quantitative nature of science courses. Upon reflection, this finding becomes less surprising and quite helpful, especially when considering the volume and technical difficulty of the readings, in textbooks and primary sources, in this course.

High self-confidence in math ability and academic ability also emerged as predictors of success in AISS and this is supported by the considerable research that indicates that student self-efficacy and self-concept are important determinants of aspirations toward a STEM career. The additional knowledge that students with unbalanced quantitative and verbal scores may struggle in the course is useful to consider when reviewing student applications and selecting those most likely to benefit from and succeed in this first college course.

Also, with regard to self concept and its role in academic achievement in AISS, it is noteworthy that there were no criteria on which AISS students rated themselves (mean score) in the highest ten percent when comparing themselves to the average person their age. While it is understood that these students attend highly selective colleges, it was surprising to see the reported self concepts of these talented science students so modulated. All of these students were selected into the AISS course by virtue of their high SAT scores, their performance on Advanced Placement examinations, and their high school math and science course taking and grades.

This modest self-assessment may reflect a sociological phenomenon known as "relative deprivation," in which people tend to decide how well-off or deprived they are not from any absolute standard, but by comparing themselves with other people. In research relevant to this study, Drew & Astin (1972) found that highly capable students downgrade themselves when comparing themselves to other students they see as equally or more capable. It is likely that the reference group AISS students were considering when answering these questions consisted of other students at the Claremont Colleges, including those in the AISS course. Many of the AISS students were among the top achievers in their high schools and in AISS, they are surrounded by others like themselves. If the AISS freshmen considered their AISS classmates and college peers as the "average person" to whom they compared themselves, then this may account, at least in part, for their relatively modest self concept ratings. This finding, of consistently lower than expected self-ratings by capable students, along with the predictive role of academic self concept and mathematical self concept in first-semester achievement in the course, provides AISS faculty with more insight into the students who enroll in the course.

The finding that the first semester grade in AISS is strongly predictive of the second semester grade is important because it provides a benchmark against which future achievement can be compared. Also, it can serve as an indicator to AISS faculty of the importance of close monitoring and support of students in the first semester of this demanding double-credit course. Early intervention with capable science students who are struggling may make the difference as to whether or not they continue in the course and continue as science majors. This finding is particularly relevant given the high enrollment of women in this course, because it is well documented in the literature that girls and women tend to rate their performance more critically than do their male peers, and attribute lack of success to personal failings rather than external factors (AAUW, 2010; Eccles, 1994). Mindfulness on the part of AISS faculty of female students' tendency to blame themselves for poor performance will help professors better support students through difficult assignments and lower than expected grades on assessments, especially early in the course. This awareness will help not only women in the course, but also men who may become discouraged early on if their college grades are not as high as they are used to.

The fall freshman survey results indicated the importance of SAT-Critical Reading as a predictor of success, but this variable did not enter in this regression in the spring survey. However, waiting until the summer after junior year to do research emerged as a moderately weak predictor of achievement in the spring semester. Because this variable has a β-value of -.248, we can understand that planning to delay summer research until after the third year of college predicted lower achievement in the spring semester of AISS. This finding may reflect both a cause and an effect, in that students who are not achieving academically at a high level may lack the confidence to see themselves as capable scientists outside the classroom, and at the same time, students with low interest in pursuing research opportunities (known to be important growth experiences and useful for graduate school admission) may be less committed to a science major. While there may also be other factors at play in a student's decision not to engage in summer research early in college, such as a student's need to work, family demands, and homesickness, AISS professors who are aware of this finding can better advise students of the value of doing early research and find ways to support and encourage reluctant students.

Research Question Three

The major finding from this research question—the strong influence of the quality of the teaching by, and interactions with, faculty members on persistence in a science major—can be taken as an affirmation that the Joint Science Department has created an environment in which students are welcomed and respected by the faculty, and in which undergraduate teaching is valued. This is important for the persistence all students, but especially important for the women students who make up a large percentage of the science students in the Joint Sciences. Seymour and Hewitt (1997) found that failing to engage faculty in a personal pedagogical relationship was a major contributor to women's decisions to leave SME majors, so a departmental culture that engenders strong faculty-student interaction is one that encourages persistence. Using Tinto's conceptual framework, in contrast to experiencing negative interactions that tend to reduce integration, these students report strong connections with faculty as teachers and as advisors, suggesting strong integration of AISS students and Other Science Majors into the community of the Joint Science Department.

Clearly, science majors in the Joint Science Department value the close relationships they have with faculty members of both genders. AISS has been taught by mixed-gender faculty teams two of the four years it has been in existence; in the past two years, the AISS professors all have been male. In the Joint Science Department, nearly 45% of the full-time faculty members are women, so students are likely have both men and women as instructors in upper-division courses as well as in introductory courses. For women science majors, the presence and visibility of women professors is particularly important. Several studies have shown that women faculty members, who advise and mentor women students, positively impact their persistence. Women students in STEM departments with no female faculty often experience difficulty feeling that they belong, but the presence of female professors helps make the participation of women in STEM disciplines appear and feel normal (Margolis & Fisher, 2002; Seymour & Hewitt, 1997). In this regard, the relatively high percentage of women faculty, and female representation in two of the three disciplines (chemistry and biology, but not physics), indicate that the Joint Science Department's faculty is well calibrated to serve its largely female student population. A gender-balanced faculty helps all students feel that they belong in and can succeed in STEM fields.

A "chilly" departmental culture, replete with weed-out courses and competitive grading practices, is often cited as a reason why capable students leave STEM majors. The findings of this study indicated a positive and supportive culture within the Joint Science Department. This was reflected in the responses of AISS students and Other Science Majors; therefore, it can be presumed to be characteristic of the department as a whole and not just of the culture of the AISS course. This study found that students who come to college with a strong intrinsic interest in science are supported intellectually and socially within the environment of the Joint Science Department.

Research Question Four

The fourth research question examines how faculty members perceive AISS, its influence on students' development in the major, and its influence on them as science educators. AISS faculty have worked hard for the past four years designing, launching, and sustaining this new interdisciplinary introductory course. Initially, months of collaborative planning were invested to create the integration of biology, chemistry, and physics topics into a cohesive module of seminars and laboratories. During the course of this study, the researcher observed the professors on the various AISS teaching teams at work in classrooms and labs, actively supporting each other in delivering lectures, leading discussions, and supervising laboratory exercises. Not surprisingly, students also recognized their professors' dedication to the course.

Innovation requires vision, energy, and time; this highly collaborative teaching requires much more investment from professors than individual teaching. The AISS professors were willing to step beyond the traditional boundaries of their disciplines and venture into uncharted territory in their own teaching and pedagogy. They remarked more about the accelerated pace of this double-credit course than the complexity of its interdisciplinary design, yet both factors combine to make AISS a rigorous teaching assignment. The need to renew the AISS teaching force every couple of years is very real, because professors cannot sustain the pace and demands for much longer than that. Teaching AISS means time away from other courses, often upper division courses, that professors want and need to teach, as well as from their own career advancement. Therefore, rotating new faculty through the course on a regular basis is both desirable and imperative. The benefit to the Joint Science Department is that the interdisciplinary capacity of the department is increased, laying the foundation for more interdisciplinary offerings further up the curriculum.

Faculty described seeing AISS' benefits for students during and after the course. In terms of interdisciplinary science content, the integrated laboratories allowed students to connect theoretical physical principles to applications in biology and chemistry and vice versa. The ability to see practical applications of theoretical principles was very useful for the students (Purvis-Roberts, et. al, 2009). In terms of acceleration, faculty recognized that AISS students would be able to take upper division courses earlier than there peers, and this study found that AISS students were indeed doing this and achieving higher mean grades in these courses than their peers. Many AISS students selected majors that required more upper division science and math courses than their peers, and four were able to double major. AISS professors sponsored summer research projects for AISS students (as well as Other Science Majors), some for multiple summers, and saw the effects of early research experience as increased integration into the community of scientists within the Joint Science Department. This is one of the greatest successes of the course, to give freshman students enough grounding in the three disciplines to be able to competently enter research settings after their first year in college.

When faculty described the impact of AISS on their pedagogy, they mentioned the challenges and rewards of reframing their disciplines through an interdisciplinary lens. They reported that the move away from a lecture-style presentation of course material to a more interactive discussion-style presentation was a significant pedagogical shift. They described feeling challenged to come up with new examples of phenomena that they could use to demonstrate interdisciplinary connections. Even as they taught the course, they were creating new material for it. For seasoned educators, this kind of challenge can be invigorating and can serve as a pump to prime faculty interest and productivity.

Recommendations

The significance of this study is its contribution to our understanding of what constitutes effective undergraduate science education. Today's undergraduate students have experienced many of the reforms that have improved K-12 science education, including more interaction between teachers and students, greater incorporation of technology, and a variety of instructional strategies beyond the traditional lecture-lab format. They are preparing to enter scientific workplaces that will require them to work collaboratively, to possess myriad technological competencies, to adapt to rapidly changing conditions, and to work across boundaries that traditionally separate areas of scientific knowledge to solve complex problems in existing and emerging fields. The Accelerated Integrated Science Sequence is a forward-looking curricular model for introducing students to science as it will be practiced in the 21st century, by grounding their undergraduate experience in rigorous interdisciplinary coursework and transformative undergraduate research opportunities. Following are several recommendations that have emerged from this research study.

Recommendations for Practice

Recruit and train more faculty members who could teach AISS.

AISS requires not only a large time commitment, but also specific training in how to teach one's discipline through an interdisciplinary lens and in coordination with other instructors. Those who have taught the course during the past four years report great satisfaction and growth from the experience; however, they all agree that two years of teaching AISS should be the limit. For this reason, if AISS is to continue to be offered as an introductory sequence, more professors in biology, chemistry, and physics must be brought on board and trained. In order to overcome resistance on the part of some faculty members, it may be advisable to offer incentives such as release time or additional compensation.

Extend interdisciplinary teaching up the curriculum.

After their first year, AISS students found themselves in traditional courses at the second level of the curriculum. Comprehensive interdisciplinary innovation had not been extended up the curriculum. While not all advanced courses, especially those at the intermediate level because of the volume of the canon in each discipline, lend themselves to integration of disciplines, the Joint Science Department might be able to find opportunities to continue its interdisciplinary innovations in some advanced seminars, and in so doing, increase the capacity of interdisciplinary teaching and research and become known as a national leader in interdisciplinary science pedagogy.

Secure future funding for AISS and other interdisciplinary courses.

The National Science Foundation generously funded the start-up of AISS through the Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP) that seeks to increase the number of students (U.S. citizens or permanent residents) receiving associate or baccalaureate degrees in established or emerging STEM fields. In order for this course to continue and potentially expand, a more permanent funding source will be necessary. External, as well as institutional, funding for an innovation such as AISS that attract students to the Claremont Colleges and puts the Joint

Science Department on the map as a leader in undergraduate science education should be a priority for the Joint Science Department and the participating colleges.

Be mindful of importance of female faculty role models.

The Joint Science Department should work hard to recruit one or more females on to the AISS teaching team or, at least, be certain to have female faculty sign up to sponsor summer research with AISS students after freshman year. Also, it is important that all students in the Joint Science Department see women represented in physics department; therefore, it should be a priority to recruit and hire women into this currently all-male department. This would be especially important for recruiting women and underrepresented minorities students who might be alienated if they wanted to pursue certain majors but didn't find role models in those disciplines in the Joint Science Department.

Leverage AISS' potential to attract underrepresented minorities.

This study has shown that AISS is a successful mechanism by which to attract students into STEM majors. Because of the high percentage of students from Scripps College, AISS is particularly successful in attracting female students. If a goal of the Claremont Colleges is to increase the diversity of the students, then AISS could serve as recruitment tool for attracting traditionally underrepresented minorities, both male and female, to the colleges and into science majors in the Joint Science Department.

Recommendations for Future Research

Science majors in the Joint Science Department hold high educational aspirations. It would be of interest to conduct a long-term follow-up of these students after they graduate to learn what types of graduate programs and careers they pursue, in an effort to find out how AISS graduates differ from other Joint Science Department graduates in their research interests and career choices.

Because the students in this study apply for and are accepted into AISS on the basis of their pre-college achievement (specifically, SAT-Math scores, Advanced Placement science and mathematics scores, and high school science and mathematics coursework), it was necessary to control for (or minimize) selection effects. These are high-achieving students with an expressed interest in studying college-level science in an interdisciplinary manner. There are other science students in the Joint Science Department to whom AISS students could be systematically compared. For example, students in Chemistry 29-Advanced General Chemistry, another selective introductory course in the Joint Sciences could be compared to AISS students on measures of achievement (e.g., course taking and achievement, American Chemical Society standardized examination results, research experiences). Students who applied to AISS, but were not accepted, could provide a comparison group of students with an expressed interest in interdisciplinary science. Other comparison groups would provide an indication of whether the AISS sample, in the freshman and subsequent years, contains an unintended bias. Also, it would be useful to survey AISS student and students in comparison groups at more than one time point.

This study is based on self-reports of students who applied to AISS because they were predisposed toward interdisciplinary science. After taking AISS, they strongly believe that they are seeing interdisciplinary connections as they continue their STEM studies. It would be interesting to design an assessment that could be administered to students at the end their introductory coursework that could help ascertain whether AISS students can demonstrate interdisciplinary thinking as they believe they do. An objective expert would need to evaluate the assessment using designated criteria and without knowledge of which introductory pathway the students had followed. This type of objective assessment would yield information about student learning and could indicate whether students can make interdisciplinary connections in novel situations. Results could inform revisions to the existing AISS curriculum as well as other interdisciplinary aspirations in the Joint Science Department.

Conclusion

This study analyzed the Accelerated Integrated Science Sequence, the first cohorts of students to complete the course, and the professors who brought it to life. It provides useful knowledge and insights about how we can re-envision effective undergraduate science education at the introductory level. AISS presents a forward-looking model for curriculum innovation that integrates the principles and concepts of biology, chemistry, and physics; confers early eligibility for research opportunities; and accelerates students' STEM course taking. It offers exportable elements to other institutions anxious to present an interdisciplinary introduction to college science that is rich in the skills scientists will need in order to creatively approach the challenges they will encounter in the 21st century. Colleges and universities that develop and adopt curricular models like AISS will move to the forefront of undergraduate science education. They will better position themselves to attract the diverse pool of today's talented young people and have a pivotal role in transforming them into scientists of the future.

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Appendix A

Institutional Review Board Approvals

Claremont
GRADUATE UNIVERSITY

Institutional Review Board

January 30, 2008

RE: IRB# 951
Evaluation of Accelerated Integrated Science Sequence

Dear Lisa:

Thank you for submitting your research protocol to the IRB at Claremont Graduate University. Your protocol has been approved as indicated on the coversheet that you provided when you submitted the protocol. Your signed cover sheet is being returned with this letter. **Please note your protocol has been approved to conduct surveys at CMC and Scripps College. No research may be conducted at Pitzer College until we receive Pitzer IRB approval. Furthermore, please submit a CGU IRB amendment form to submit a Spring survey.**

Your protocol is approved for a period of one year from the date on this letter. At that time you must send a brief report on your progress-to-date to the IRB and have your protocol renewed if necessary. Be sure to submit your report in time for a renewal to be issued before this one expires. Include in your report any changes that should be made to the originally approved protocol for the renewal.

If your research is completed before this protocol expires you must notify the IRB that your research has been completed and identify any problems encountered that will assist the Board in approving future research of the type you conducted.

If any injuries or unanticipated problems are encountered in the conduct of your research that are related to risks to participants or others it is your responsibility to notify the Chair of the IRB and the Office of Research and Sponsored Programs as soon as practical but in no more than five days of the occurrence (phone: 909-607-9406 or via email to irb@cgu.edu).

If, during the conduct of your research, you discover changes that should be made to the procedures in the approved protocol you must promptly report the proposed changes to the IRB. The proposed changes must not be implemented without IRB approval except where necessary to eliminate immediate hazards to participants.

The entire Institutional Review Board of Claremont Graduate University wishes you well in the conduct of your research project.

Sincerely,

Catharine Grier Carlson

Catharine Grier Carlson, Associate Chair
Institutional Review Board

APPROVED
JAN 30 2008
CLAREMONT GRADUATE
UNIVERSITY
IRB

Harper Hall 152 • 150 East Tenth Street • Claremont, California 91711-6160
Tel: 909.607.9406 • Fax: 909.607.9655

Claremont
GRADUATE UNIVERSITY

Institutional Review Board

February 11, 2009

RE: Renewal of IRB# 951
Title of Study: Evaluation of Accelerated Integrated Science Sequence

Dear Lisa:

Thank you for submitting your application for renewal entitled "Evaluation of Accelerated Integrated Science Sequence."

The IRB approval for your protocol has been renewed for a period of one year from the date on this letter. At that time you must send a brief report on your progress-to-date to the IRB and have your protocol renewed if necessary (use "Project Update and Closure Form"). Be sure to submit your report in time for a renewal to be issued before this one expires. Include in your report any changes that should be made to the originally approved protocol for the renewal.

If your research is completed before this protocol expires you must notify the IRB that your research has been completed and identify any problems encountered that will assist the Board in approving future research of the type you conducted.

If any injuries or unanticipated problems are encountered in the conduct of your research that are related to risks to participants or others it is your responsibility to notify the Chair of the IRB and the Office of Research and Sponsored Programs as soon as practical but in no more than five days of the occurrence (phone: 909-607-9406 or via email to irb@cgu.edu).

If, during the conduct of your research, you discover changes that should be made to the procedures in the approved protocol you must promptly report the proposed changes to the IRB. The proposed changes must not be implemented without IRB approval except where necessary to eliminate immediate hazards to participants.

The entire Institutional Review Board of Claremont Graduate University wishes you well in the conduct of your research project.

Sincerely,

Catharine Grier Carlson, Associate Chair
Institutional Review Board

APPROVED

FEB 11 2009

Harper Hall 152 • 150 East Tenth Street • Claremont, California 91711-6160
Tel: 909.607.9406 • Fax: 909.607.9655

Claremont
GRADUATE UNIVERSITY

Institutional Review Board

February 9, 2010

RE: Renewal of IRB #951
Title: Evaluation of Accelerated Integrated Science Sequence

Dear Lisa:

Thank you for submitting your application for renewal entitled, "Evaluation of Accelerated Integrated Science Sequence." The IRB approval for your protocol has been renewed for a period of one year from the date on this letter. At that time you must send a brief report on your progress-to-date to the IRB and have your protocol renewed if necessary (use "Project Update and Closure Form"). Be sure to submit your report in time for a renewal to be issued before this one expires. Include in your report any changes that should be made to the originally approved protocol for the renewal.

If your research is completed before this protocol expires you must notify the IRB that your research has been completed and identify any problems encountered that will assist the Board in approving future research of the type you conducted.

If any injuries or unanticipated problems are encountered in the conduct of your research that are related to risks to participants or others it is your responsibility to notify the Chair of the IRB and the Office of Research and Sponsored Programs as soon as practical but in no more than five days of the occurrence (phone: 909-607-9406 or via email to irb@cgu.edu).

If, during the conduct of your research, you discover changes that should be made to the procedures in the approved protocol you must promptly report the proposed changes to the IRB. The proposed changes must not be implemented without IRB approval except where necessary to eliminate immediate hazards to participants.

The entire Institutional Review Board of Claremont Graduate University wishes you well in the conduct of your research project.

Sincerely,

Catharine Grier Carlson

Catharine Grier Carlson, Associate Chair
Institutional Review Board

APPROVED

Harper Hall 152 • 150 East Tenth Street • Claremont, California 91711-6160
Tel: 909.607.9406 • Fax: 909.607.9655

Claremont
GRADUATE UNIVERSITY

Institutional Review Board

February 21, 2011

RE: Expedited Renewal of IRB #951
Title: Evaluation of Accelerated Integrated Science Sequence

Dear Lisa:

Thank you for submitting your application for renewal entitled, "Evaluation of Accelerated Integrated Science Sequence." The IRB approval for your protocol has been renewed for a period of one year from the date on this letter. At that time you must send a brief report on your progress-to-date to the IRB and have your protocol renewed if necessary (use "Project Update and Closure Form"). Be sure to submit your report in time for a renewal to be issued before this one expires. Include in your report any changes that should be made to the originally approved protocol for the renewal.

If your research is completed before this protocol expires you must notify the IRB that your research has been completed and identify any problems encountered that will assist the Board in approving future research of the type you conducted.

If any injuries or unanticipated problems are encountered in the conduct of your research that are related to risks to participants or others it is your responsibility to notify the Chair of the IRB and the Office of Research and Sponsored Programs as soon as practical but in no more than five days of the occurrence (phone: 909-607-9406 or via email to irb@cgu.edu).

If, during the conduct of your research, you discover changes that should be made to the procedures in the approved protocol you must promptly report the proposed changes to the IRB. The proposed changes must not be implemented without IRB approval except where necessary to eliminate immediate hazards to participants.

The entire Institutional Review Board of Claremont Graduate University wishes you well in the conduct of your research project.

Sincerely,

Karl Haushalter

Karl Haushalter, IRB Representative
Institutional Review Board

APPROVED

FEB 2 1 2011

CLAREMONT GRADUATE UNIVERSITY IRB

Harper Hall 152 • 150 East Tenth Street • Claremont, California 91711-6160
Tel: 909.607.9406 • Fax: 909.607.9655

Appendix B

AISS Freshman Fall Survey
AISS Freshman Spring Survey
Informed Consent Form
Minor Informed Assent Form
Parental Informed Consent Forms

Number____________

Joint Science Department
Accelerated Integrated Science Sequence (AISS)
Freshman Survey – Fall

1. **From what kind of high school did you graduate?** (Mark one)

- ❑ Public school (not charter or magnet)
- ❑ Public charter school
- ❑ Public math/science magnet school
- ❑ Other public magnet school
- ❑ Private religious/parochial school
- ❑ Private independent college-prep school
- ❑ Home school

2. **Was that high school . . . ?** (Mark all that apply)

- ❑ Coeducational
- ❑ Single gender
- ❑ A day school
- ❑ A boarding school
- ❑ Small (less than 500 students)
- ❑ Medium (between 500 and 1000 students)
- ❑ Large (more than 1000 students)
- ❑ Urban
- ❑ Suburban
- ❑ Rural

3. **What is the highest academic degree you intend to obtain?**

- ❑ None
- ❑ Bachelor’s degree (B.A., B.S., etc.)
- ❑ Master’s degree (M.A., M.S., etc.)
- ❑ Ph.D. or Ed.D.
- ❑ M.D., D.O., D.D.S., or D.V.M.
- ❑ J.D. (Law)
- ❑ B.D. or M.DIV. (Divinity).
- ❑ Other

4. What is the highest level of formal education obtained by your parents?
(Mark one in each column)

	Father		Mother
Grammar school or less…………………………………...	☐	…..	☐
Some high school……………………………………………	☐	…..	☐
High school graduate………………………………..……..	☐	…..	☐
Postsecondary school other than college……………………	☐	…..	☐
Some college………………………………………………...	☐	…..	☐
College degree……………………………………………….	☐	…..	☐
Some graduate school……………………………………….	☐	…..	☐
Graduate degree……………………………………………..	☐	…..	☐

5. What is your father's occupation? ____

6. What is your mother's occupation? ____

7. Below are some reasons that might have influenced your decision to enroll in the Advanced Integrated Science Sequence (AISS). Rate the importance of each reason listed.
(Mark one answer for each possible reason.)

	Not Important		Somewhat Important		Very Important
My parents wanted me to enroll……………………..	☐	……...	☐	……...	☐
A high school teacher advised me…………………...	☐	……...	☐	……...	☐
A college counselor advised me……………………..	☐	……...	☐	……...	☐
I wanted the challenge of an accelerated course…….	☐	……...	☐	……...	☐
The AISS description on the JSD web site.................	☐	……...	☐	……...	☐
I received information about AISS in the mail……...	☐	……...	☐	……...	☐
I visited the Claremont Colleges…………………….	☐	……...	☐	……...	☐
I visited or sat in on JSD classes…………………….	☐	……...	☐	……...	☐
I liked the JSD faculty I met………………………...	☐	……...	☐	……...	☐
I knew at least one other person in the course………	☐	……...	☐	……...	☐
I wanted to accelerate progress through my major.....	☐	……...	☐	……...	☐
I want preference for a research fellowship…………	☐	……...	☐	……...	☐
I want to study abroad during college……………….	☐	……...	☐	……...	☐
I was attracted to its interdisciplinary nature………..	☐	……...	☐	……...	☐

Other (please specify____

8. Please indicate your probable undergraduate field of study. (Mark only one choice)

- ❑ Biology
- ❑ Human Biology
- ❑ Biology-Chemistry
- ❑ Chemistry
- ❑ 3/2 Engineering Option
- ❑ Environment, Economics, and Politics
- ❑ Environmental Science
- ❑ Management and Engineering
- ❑ Molecular Biology
- ❑ Neuroscience
- ❑ Organismal Biology and Ecology
- ❑ Physics
- ❑ Science and Management
- ❑ Mathematics
- ❑ Computer Science
- ❑ Psychology
- ❑ Science, Technology and Society
- ☐ Other

(Please specify________________)

9. Are you ❑ Pre-Med? ❑ Pre-Dental? ❑ Pre-Vet?

10. Rate yourself on the following traits compared to the average person your age. We want the most accurate estimate of how you see yourself. (Mark one answer for each possible reason.)

	Lowest 10%	Below Average	Average	Above Average	Highest 10%
Academic ability……………………..					
Artistic ability………………………..					
Competitiveness……………………..					
Computer skills………………………					
Cooperativeness……………………..					
Creativity……………………………					
Drive to achieve……………………..					
Risk taking……………………………					
Leadership ability…………………….					
Mathematical ability………………….					
Compassion…………………………..					
Self-confidence (intellectual)………..					
Self-confidence (social)………………					
Self understanding……………………					
Critical thinking ……………………..					
Problem solving ……………………..					
Spatial ability…………………………					

11. How well prepared for college in each of these areas do you feel?
(Mark one for each item)

	Poorly Prepared		Somewhat Prepared		Well Prepared
Science coursework…………………………………	☐	……....	☐	……....	☐
Mathematics coursework……………………………	☐	……....	☐	……....	☐
Laboratory experience………………………………	☐	……....	☐	……....	☐
Computer technology…………………. …..………..	☐	……....	☐	……....	☐
Writing skills……...…………………………………	☐	……....	☐	……....	☐
Working in groups……… ……………….…………	☐	……....	☐	……....	☐
Independent research………………………………..	☐		☐		☐

12. What is your best guess as to the chances that you will:
(Mark one for each item)

	Not Likely		Somewhat Likely		Very Likely
Graduate from college………………………………	☐	……....	☐	……....	☐
Graduate with a science major..……………………..	☐	……....	☐	……....	☐
Graduate with a mathematics major………………...	☐	……....	☐	……....	☐
Graduate with an engineering major………………	☐	……....	☐	……....	☐
Graduate with an interdisciplinary major ….………..	☐	……....	☐	……....	☐
Graduate with a non-science major………………….	☐	……....	☐	……....	☐
Change your major…………………………………	☐	……....	☐	……....	☐
Change your career choice ……………….…………	☐	……....	☐	……....	☐
Conduct your own research…………………….........	☐	……....	☐	……....	☐
Publish as an undergraduate…………………………	☐	……....	☐	……....	☐
Tutor another student…….…………………………	☐	……....	☐	……....	☐
Earn at least a "B+" average in college…….………..	☐	……....	☐	……....	☐
Seek help with your writing skills…………………..	☐	……....	☐	……....	☐
Communicate regularly with your professors………	☐	……....	☐	……....	☐
Work during the academic year…..…………………	☐	……....	☐	……....	☐
Form or join a study group……………….………….	☐	……....	☐	……....	☐
Study abroad………………………………………...	☐	……....	☐	……....	☐

13. What didn't you get in high school that you wish you had in order to be prepared for college level work?

____

____

____

15. How many hours per week outside of lecture-labs do you spend on work for the course?

- ❑ 0-4 hours
- ❑ 5-10 hours
- ❑ 11-15 hours
- ❑ 16-20 hours
- ❑ 21-25 hours
- ❑ 26-30 hours
- ❑ More than 30 hours

16. In a sentence or two, how do you divide the time you spend on out-of-class work for the course.

____

____

____

17. What have you enjoyed <u>most</u> about the course so far? Please be as specific as possible.

____

____

____

18. What have you enjoyed <u>least</u> so far? Please be as specific as possible.

____

____

____

19. Is there anything that you expected from this course that you have not yet gotten?

____

____

20. Is English your native language? ❑ Yes ❑ No

21. How would you classify yourself?

- ❑ African American/Black
- ❑ American Indian/Alaska Native
- ❑ Asian/Asian American
- ❑ Mexican American/Chicano
- ❑ Other Latino
- ❑ Native Hawaiian/Pacific Islander
- ❑ White/Non-Hispanic
- ❑ Other (please specify____)

22. Are there any additional comments you would like to make?

____

____

____

____

Number____________

Joint Science Department
Accelerated Integrated Science Sequence (AISS)
Freshman Survey – Spring

1. Please indicate your probable major as of the end of your freshman year. (Mark only one choice).

- ❑ Biology
- ❑ Human Biology
- ❑ Biology-Chemistry
- ❑ Chemistry
- ❑ 3/2 Engineering Option
- ❑ Environment, Economics, and Politics
- ❑ Environmental Science/Analysis
- ❑ Management and Engineering
- ❑ Molecular Biology
- ❑ Neuroscience
- ❑ Organismal Biology and Ecology
- ❑ Physics
- ❑ Science and Management
- ❑ Mathematics
- ❑ Computer Science
- ❑ Psychology
- ❑ Science, Technology and Society
- ❑ Other (Please specify______________________)
- ❑ Undecided

2. Are you: ❑ Pre-Med? ❑ Pre-Dental? ❑ Pre-Veterinary ❑ No, I am none of these

3. Have you changed your intended major during this year? ❑ Yes ❑ No

If you answered "yes," what went into your decision to change your major?

____

____

____

____

4. Please rate yourself on the following traits compared to the average person your age. We want the most accurate estimate of how you see yourself. (Mark one answer for each possible reason.)

	Lowest 10%	Below Average	Average	Above Average	Highest 10%
Academic ability……………………..					
Artistic ability………………………...					
Competitiveness……………………...					
Computer skills………………………					
Cooperativeness……………………...					
Creativity…………………………….					
Drive to achieve……………………...					
Risk taking……………………………					
Leadership ability…………………….					
Mathematical ability………………….					
Compassion…………………………..					
Self-confidence (intellectual)………...					
Self-confidence (social)………………					
Self understanding……………………					
Critical thinking ……………………...					
Problem solving ……………………..					
Spatial ability…………………………					

5. **Please respond to the following statements by checking the ONE answer that best fits.**

- **I feel confident that I have a solid understanding of introductory level biology concepts.**

❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

- **I feel confident that I have a solid understanding of introductory level chemistry concepts.**

❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

- **I feel confident that I have a solid understanding of introductory level physics concepts.**

❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

- **I feel confident about the amount of laboratory experience I gained this year.**

❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

- **I feel confident in the laboratory skills I acquired this year.**

❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

- **I am concerned that I have gaps in my understanding of basic biology content.**

❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

- **I am concerned that I have gaps in my understanding of basic chemistry content.**

❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

- **I am concerned that I have gaps in my understanding of basic physics content.**

❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

- **Learning fewer science concepts in depth will benefit me more than broad coverage of more topics.**

❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

- **I plan to participate in scientific research this the summer.**

❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

- **I plan to participate in scientific research in the summer after sophomore year.**

❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

5. Continued

- **I plan to participate in scientific research in the summer after junior year.**

  ❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

- **I plan to participate in scientific research every summer while in college.**

  ❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

- **I plan to participate in scientific research during future academic/school years.**

  ❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

- **I feel confident in my ability to ask and investigate an original research question.**

  ❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

- **I feel confident in my ability to use high-tech scientific equipment in a lab setting.**

  ❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

- **I feel confident in my ability to speak in front of a group of peers and professors.**

  ❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

- **I feel confident in my formal academic writing skills.**

  ❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

- **I feel confident that I will publish as an undergraduate.**

  ❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

- **I feel confident that I will study abroad as an undergraduate.**

  ❑ 1- strongly disagree ❑ 2-disagree ❑ 3-no opinion ❑ 4-agree ❑ 5-strongly agree

6. Rate the following for how effective they were in helping YOU learn the material in AISS? (Mark one for each item)

	Not Effective		Somewhat Effective		Very Effective
Lectures………………..………………………………	☐	……....	☐	……..	☐
Notes/handouts prepared by professors..……..……..	☐	……....	☐	……..	☐
Graded homework………...…………………………	☐	……....	☐	……..	☐
Textbooks……………………………………..........	☐	……....	☐	……..	☐
Simulation-type lab activities………………………..	☐	……....	☐	……..	☐
Answers provided before problem sets due………..	☐	……....	☐	……..	☐
Answers provided after problem sets turned in……..	☐	……....	☐	……..	☐
Research/primary source articles…………...……….	☐	……....	☐	……..	☐
Preparing for labs………...……………………........	☐	……....	☐	……..	☐
Doing labs…………………………………………...	☐	……....	☐	……..	☐
Studying for exams………...………………………..	☐	……....	☐	……..	☐
Taking exams……………...…………….………...	☐	……....	☐	……..	☐
Mathematical modeling exercises.…………………..	☐	……....	☐	……..	☐
Study partners or groups……………………..………	☐	……....	☐	……..	☐
Individual effort…………………..…………………	☐	……....	☐	……..	☐
Class discussions………..………..………………….	☐	……....	☐	……..	☐
Office hours…………………………………….....	☐	……....	☐	……..	☐
Interdisciplinary connections…………………...…..	☐	……....	☐	……..	☐
Laboratory reports/write-ups.………..………………	☐	……....	☐	……..	☐
Working in groups in class/lab.………...….……...	☐	……....	☐	……..	☐
Field trips……………..…………..…………………	☐	……....	☐	……..	☐

7. Describe one strategy you used or developed to help you manage the workload AISS?

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8. How have you changed as a science student during this semester of AISS as compared to fall semester?

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9. What do you feel is your greatest accomplishment in AISS this year?

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10. Describe an "aha moment" during this year when you feel you gained a deep scientific understanding or insight.

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11. Are there any additional comments about your experience in AISS you would like to make?

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Thank you for your time and thoughtfulness in completing this questionnaire.

Informed Consent Form--Accelerated Integrated Science Sequence (AISS) Evaluation--Freshman

You are invited to participate in a research study conducted by Lisa Ulsh, a doctoral student in the School of Educational Student at the Claremont Graduate University and her faculty advisor, Dr. David Drew. You were selected as participants because you are students in the Accelerated Integrated Science Sequence (AISS), a new National Science Foundation sponsored introductory course sequence in the Joint Science Department at the Claremont Colleges. The goal of this study is to provide the Joint Science Department with a rich picture of the types of students attracted to the AISS, to learn about your experience of the course in order to modify and improve it in future years, and to ascertain the success of the AISS as a gateway to majors offered by the Joint Science Department.

If you decide to participate, you will be asked to complete a survey consisting of 25 questions (estimated time to complete = 15 minutes) during the fall semester of 2009/early spring semester of 2010 and you will be invited to a half-hour individual interview with the researcher in April/May of 2010. The survey questionnaire will be handed out and collected by the researcher in a regular class meeting time without the course faculty present. Interviews sign-up times will be offered at a variety of times and will take place in an office or classroom in the Joint Sciences Building. A second survey will be conducted near the end of the spring semester of 2010. You may be invited to participate in follow-up surveys later in your college career. Additionally, the researcher will ask for access to the following data from your AISS application: high school math and science coursework and grades, AP courses and scores, and SAT and/or ACT scores.

The new AISS is made possible by a National Science Foundation grant awarded to Dr. Newton Copp, a professor in the Joint Science Department. The NSF requires that an evaluation be conducted on all such grants. To do this the researcher will analyze data gained from the surveys and interviews and created a report. She will also use this research in a qualifying examination paper in her doctoral program and may include it in publications in the future.

The potential benefits of this study to students include providing the AISS course instructors with group data that will help them to better understand the ways in which students are experiencing this introductory course in order to modify and improve it in the future. The potential risks associated with this study include the time and inconvenience of completing the survey and participating in the interview process, and the possibility that views expressed about the course, particularly if they are critical in nature, might put students at risk in the opinion of fellow students and/or Joint Sciences Department personnel. Every effort will be made to keep information that is obtained in connection with the study confidential. All surveys will be encoded by trained personnel in the Claremont Graduate University School of Education so that neither the researcher nor any persons in the Joint Science Department can link your identity to your responses. Notes from individual interviews will be encoded by the researcher so that no one's responses or personal characteristics can be determined by anyone looking at the analyses to be developed from the data. All identifying information will be deleted from these notes to ensure the participants' confidentiality. No audio or video recordings of the interviews will be made. While the researcher has the utmost concern for your confidentiality and will take the above mentioned steps to protect it when gathering and processing the data, you should be aware that anything you say to other students about your survey or interview responses has the risk of being disclosed to other fellow students or to Joint Sciences Department personnel, something over which the researcher has limited control.

Your participation in this study is voluntary. If you feel the risks of participating outweigh the benefits, you can refuse to participate. If you decide to participate, you can skip any survey or interview question with which you do not feel comfortable, or discontinue participation at any time without any penalty. If you have any questions, please feel free to contact Ms. Ulsh (researcher) or Dr. Drew (faculty advisor) at the School of Educational Studies, Claremont Graduate University, 150 E. 10th Street, Claremont, California, 91711, (909) 621-8914. The CGU Institutional Review Board, which is administered through the Office of Research and Sponsored Programs (ORSP), has approved this project. You may also contact ORSP at (909) 607-9406 with any questions.

You have been given a signed copy of this form to keep in your records.

Your signature indicates that you have read and understand the information provided, that the researcher answered any questions you had, that you are 18 years of age or older, that you willingly agree to participate, that you may withdraw your consent and discontinue your participation without penalty, and that you have received a copy of this form.

Print Name____

Signature____ Date_______________________

Informed Assent Form for Minor Student--Accelerated Integrated Science Sequence (AISS) Evaluation

You are invited to participate in a research study conducted by Lisa Ulsh, a doctoral student in the School of Educational Student at the Claremont Graduate University and her faculty advisor, Dr. David Drew. You were selected as participants because you are students in the Accelerated Integrated Science Sequence (AISS), a new National Science Foundation sponsored introductory course sequence in the Joint Science Department at the Claremont Colleges. The goal of this study is to provide the Joint Science Department with a rich picture of the types of students attracted to the AISS, to learn about your experience of the course in order to modify and improve it in future years, and to ascertain the success of the AISS as a gateway to majors offered by the Joint Science Department.

If you decide to participate, you will be asked to complete a survey consisting of 25 questions (estimated time to complete = 15 minutes) during the fall semester of 2009/early spring semester of 2010 and you will be invited to a half-hour individual interview with the researcher in April/May of 2010. The survey questionnaire will be handed out and collected by the researcher in a regular class meeting time without the course faculty present. Interviews sign-up times will be offered at a variety of times and will take place in an office or classroom in the Joint Sciences Building. A second survey will be conducted near the end of the spring semester of 2010. You may be invited to participate in follow-up surveys later in your college career. Additionally, the researcher will ask for access to the following data from your AISS application: high school math and science coursework and grades, AP courses and scores, and SAT and/or ACT scores.

The new AISS is made possible by a National Science Foundation grant awarded to Dr. Newton Copp, a professor in the Joint Science Department. The NSF requires that an evaluation be conducted on all such grants. To do this the researcher will analyze data gained from the surveys and interviews and created a report. She will also use this research in a qualifying examination paper in her doctoral program and may include it in publications in the future.

The potential benefits of this study to students include providing the AISS course instructors with group data that will help them to better understand the ways in which students are experiencing this introductory course in order to modify and improve it in the future. The potential risks associated with this study include the time and inconvenience of completing the survey and participating in the interview process, and the possibility that views expressed about the course, particularly if they are critical in nature, might put students at risk in the opinion of fellow students and/or Joint Sciences Department personnel. Every effort will be made to keep information that is obtained in connection with the study confidential. All surveys will be encoded by trained personnel in the Claremont Graduate University School of Education so that neither the researcher nor any persons in the Joint Science Department can link your identity to your responses. Notes from individual interviews will be encoded by the researcher so that no one's responses or personal characteristics can be determined by anyone looking at the analyses to be developed from the data. All identifying information will be deleted from these notes to ensure the participants' confidentiality. No audio or video recordings of the interviews will be made. While the researcher has the utmost concern for your confidentiality and will take the above mentioned steps to protect it when gathering and processing the data, you should be aware that anything you say to other students about your survey or interview responses has the risk of being disclosed to other fellow students or to Joint Sciences Department personnel, something over which the researcher has limited control.

Your participation in this study is voluntary. If you feel the risks of participating outweigh the benefits, you can refuse to participate. If you decide to participate, you can skip any survey or interview question with which you do not feel comfortable, or discontinue participation at any time without any penalty. If you have any questions, please feel free to contact Ms. Ulsh (researcher) or Dr. Drew (faculty advisor) at the School of Educational Studies, Claremont Graduate University, 150 E. 10th Street, Claremont, California, 91711, (909) 621-8914. The CGU Institutional Review Board, which is administered through the Office of Research and Sponsored Programs (ORSP), has approved this project. You may also contact ORSP at (909) 607-9406 with any questions.

Your signature indicates that you have read and understand the information provided, that the researcher answered any questions you had, that you willingly agree to participate, that you may withdraw your assent and discontinue your participation without penalty, that **because you are under 18 years of age both your signature on this form AND your parent's or legal guardian's signature on the informed consent form is required in order to you to participate in the stud**y. You have been given a signed copy of this form to keep in your records.

Print Name____

Signature____ Date_______________________

Informed Consent Form for Parents of Minor Students
Accelerated Integrated Science Sequence (AISS) Evaluation

Your son/daughter is invited to participate in a research study conducted by Lisa Ulsh, a doctoral student in the School of Educational Student at the Claremont Graduate University and her faculty advisor, Dr. David Drew. He/she was selected as a participant because he/she is a student in the Accelerated Integrated Science Sequence (AISS), a new, National Science Foundation sponsored introductory course sequence in the Joint Science Department at the Claremont Colleges. The goal of this study is to provide the Joint Science Department with a rich picture of the types of students attracted to the AISS, to learn about your experience of the course in order to modify and improve it in future years, and to ascertain the success of the AISS as a gateway to majors offered by the Joint Science Department.

If you decide to allow your son/daughter to participate, he/she will be asked to complete a survey consisting of 25 questions (estimated time to complete = 15 minutes) during the fall semester of 2009/early spring semester of 2010 and he/she will be invited to a half-hour individual interview with the researcher in April/May of 2010. The survey questionnaire will be handed out and collected by the researcher in a regular class meeting time without the course faculty present. Interviews sign-up times will be offered at a variety of times and will take place in an office or classroom in the Joint Sciences Building. A second survey will be conducted near the end of the spring semester of 2010. Your son/daughter may be invited to participate in follow-up surveys later in his/her college career. Additionally, the researcher will ask for access to the following data from your son's/daughter's AISS application: high school math and science coursework and grades, AP courses and scores, and SAT and/or ACT scores.

The new AISS is made possible by a National Science Foundation grant awarded to Dr. Newton Copp, Chair of the Joint Science Department. The NSF requires that an evaluation be conducted on all such grants. In addition to helping the Joint Science Department meet this requirement, the benefits of this research include providing the AISS course instructors with group data that will allow them to better understand the ways in which students are experiencing this introductory course. In addition, the researcher will analyze data gained from the surveys and interviews in fulfillment of a qualifying examination requirement for her doctoral program and may include it in publications in the future.

Every effort will be made to keep information that is obtained in connection with the study confidential and anonymous. All surveys will be encoded by trained personnel in the Claremont Graduate University School of Education so that neither the researcher nor any persons in the Joint Science Department can link your identity to your son's/daughter's responses. Notes from individual interviews will be encoded by the researcher so that no one's responses or personal characteristics can be determined by anyone looking at the analyses to be developed from the data. All identifying information will be deleted from these notes to ensure the participants' anonymity. No audio or video recordings of the interviews will be made. While the researcher has the utmost concern for your son's/daughter's anonymity and will take the above mentioned steps to protect it when gathering and processing the data, you should be aware that anything your son or daughter says to other students about his/her survey or interview responses has the risk of being disclosed to other fellow students or to Joint Sciences Department personnel, something over which the researcher has limited control.

Your son's/daughter's participation in this study is voluntary. If you feel the risks of participating outweigh the benefits, you can refuse to allow your son/daughter to participate. If you decide to allow him/her to participate, he/she will informed that he/she can skip any survey or interview question with which he/she does not feel comfortable, or discontinue participation at any time without any penalty. If you have any questions, please feel free to contact Ms. Ulsh (researcher) or Dr. Drew (faculty advisor) at the School of Educational Studies, Claremont Graduate University, 150 E. 10^{th} Street, Claremont, California, 91711, (909) 621-8914.

You have been given two copies of this form to sign. Please keep one and return the other form in the envelope provided.

Your signature indicates that you have read and understand the information provided, that the researcher answered any questions you had, that you are the parent or legal guardian of the minor student, that you willingly agree to allow your son/daughter to participate, that you may withdraw your consent and discontinue your son's/daughter's participation without penalty, that you have received a copy of this form.

Print Your Name ____

Print Your Son's/Daughter's Name ____

Your Signature____

Date_______________________________________

Appendix C

AISS Sophomore Survey
Informed Consent Form

Number ____________

Joint Science Department
Accelerated Integrated Science Sequence (AISS)
Sophomore Survey

1. Please indicate your probable major <u>as of right now</u>. (Mark only <u>one</u> choice).

- ❑ Biology
- ❑ Human Biology
- ❑ Biology-Chemistry
- ❑ Chemistry
- ❑ 3/2 Engineering Option
- ❑ Environment, Economics, and Politics
- ❑ Environmental Science
- ❑ Management and Engineering
- ❑ Molecular Biology
- ❑ Neuroscience
- ❑ Organismal Biology and Ecology
- ❑ Physics
- ❑ Science and Management
- ❑ Mathematics
- ❑ Computer Science
- ❑ Psychology
- ❑ Science, Technology and Society
- ❑ Other (Please specify____________________)
- ❑ Undecided

2. Are you: ❑ Pre-Med? ❑ Pre-Dental? ❑ Pre-Veterinary? ❑ No, I am none of these.

3. Have you changed your intended major during this year? ❑ Yes ❑ No

If you answered "yes," please complete: I changed from ________________________(major) to ________________________(major) and tell what went into your decision to change your major.

____

____

____

4. **What is the highest academic degree you intend to obtain?**

- ❑ None
- ❑ Bachelor's degree (B.A., B.S., etc.)
- ❑ Master's degree (M.A., M.S., etc.)
- ❑ Ph.D. or Ed.D.
- ❑ M.D., D.O., D.D.S., or D.V.M.
- ❑ J.D. (Law)
- ❑ B.D. or M.DIV. (Divinity).
- ❑ Other

5. **Please list by course name and number the SCIENCE (biology, chemistry, physics, geology) course(s) you are taking this year:**

Fall semester:

Spring semester:

6. **Please list by course name and number the MATHEMATICS course(s) you are taking this year:**

Fall semester:

Spring semester:

7. **Please list by course name and number any INTERDISCIPLINARY course(s) in your major (psychology, computer science, economics, engineering, government) you are taking this year:**

Fall semester:

Spring semester:

8. Please rate yourself on the following traits compared to the average person your age. We want the most accurate estimate of how you see yourself. (Mark <u>one</u> answer for each possible reason.)

	Lowest 10%	Below Average	Average	Above Average	Highest 10%
Time management…………………..					
Artistic ability………………………....					
Competitiveness……………………....					
Optimism………...…………………..					
Collaboration…………………………					
Creativity…………………………….					
Drive to achieve……………………....					
Risk taking……………………………					
Writing ability…………………….					
Mathematical ability………………….					
Compassion…………………………..					
Ability to reason logically……………					
Social self confidence………………					
Persistence…………..……………….					
Critical thinking ……………………....					
Problem solving ……………………..					
Spatial ability…………………………					
Determination..……………………….					
Ability to work hard…………………					

9. How well did AISS prepare you for the following?
(Mark <u>one</u> for each item)

	Poorly Prepared	Somewhat Prepared	Well Prepared	Not Taking It
Organic Chemistry lecture …………………				
Organic Chemistry lab………………………				
Physical Chemistry lecture…………………				
Physical Chemistry lab………………………				
Intermediate Mechanics (Physics 101)….......				
Calculus II, Math 31…………………………				
Calculus III, Math 32………………………..				
Other upper division science courses (list course_________________________)				
Other upper division science courses (list course_________________________)				
Other upper division mathematics courses (list course_________________________)				
Other upper division mathematics courses (list course_________________________)				
Collaborating with fellow students…………				
Working or preparing independently………				
Doing summer research……….……………				
Going to office hours………………………..				
Making connections between science disciplines……………………………………				
Continuing in a science major……………….				
Studying abroad in future years…………….		… …..		

10. Looking back on the AISS course, how do you think it most benefited you?

____

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____

11. If you did summer research after your freshman year, please describe how that experience impacted you as a science student.

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____

12. How has your opinion of the AISS course changed as a result of your experience as a sophomore?

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12. If given the chance to roll back time, would you choose the AISS course or the traditional introductory science pathway? Please explain why or why not.

____

____

____

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14. Are there any additional comments about your experience in AISS you would like to make?

____

____

____

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Thank you for your time and thoughtfulness in completing this questionnaire.

Informed Consent Form—Sophomore
Accelerated Integrated Science Sequence (AISS) Evaluation

As sophomores, you are invited to continue your participation in the research study of the Accelerated Integrated Science Sequence (AISS). This study continues to be conducted by Lisa Ulsh, a doctoral student in the School of Educational Studies at the Claremont Graduate University and her faculty advisor, Dr. David Drew. The goal of the ongoing study is to provide the Joint Science Department with a rich picture of AISS students as they progress through their undergraduate careers. Specifically, the study will look at your choice of declared major, your undergraduate science and mathematics coursework, your achievement in those courses, your performance on departmental standardized tests, your opinions on how well the AISS course served you as an introductory science course, and your perceptions of yourselves now and in the future. We will use this information to modify and improve the AISS course in future years, and to ascertain the success of the AISS as a gateway to majors offered by the Joint Science Department.

If you decide to participate, you will be asked to complete two surveys, one midyear and one near the end of your sophomore year. Each survey will consist of approximately 15 questions (estimated time to complete = 15 minutes). Additionally, you may be invited to a half-hour individual interview with the researcher in April/May of 2010. The survey questionnaires will be handed out and collected by the researcher in a setting without JSD faculty present, as they were last year. Interviews sign-up times will be offered at a variety of times and will take place in an available classroom in the Joint Sciences buildings. You may be invited to participate in follow-up surveys and interviews later in your college career.

The Accelerated Integrated Science Sequence is made possible by a National Science Foundation grant awarded to Dr. Newton Copp, a professor in the Joint Science Department. The NSF requires that an evaluation be conducted on all such grants. In addition to helping the Joint Science Department meet this requirement, the benefits of this research include providing the AISS course instructors with group data that will allow them to better understand the ways in which students are experiencing this introductory course. In addition, the researcher will analyze data gained from the surveys and interviews as part of the dissertation research for her doctoral program and may include it in publications in the future.

Every effort will be made to keep information that is obtained in connection with the study confidential and anonymous. All surveys will be encoded by trained personnel in the Claremont Graduate University School of Education so that neither the researcher nor any persons in the Joint Science Department can link your identity to your responses. Notes from individual interviews will be encoded by the researcher so that no one's responses or personal characteristics can be determined by anyone looking at the analyses to be developed from the data. All identifying information will be deleted from these notes to ensure the participants' anonymity. No audio or video recordings of the interviews will be made. While the researcher has the utmost concern for your anonymity and will take the above mentioned steps to protect it when gathering and processing the data, you should be aware that anything you say to other students about your survey or interview responses has the risk of being disclosed to other fellow students or to Joint Sciences Department personnel, something over which the researcher has limited control.

Your participation in this study is voluntary. If you feel the risks of participating outweigh the benefits, you can refuse to participate. If you decide to participate, you can skip any survey or interview question with which you do not feel comfortable, or discontinue participation at any time without any penalty. If you have any questions, please feel free to contact Ms. Ulsh (researcher) or Dr. Drew (faculty advisor) at the School of Educational Studies, Claremont Graduate University, 150 E. 10th Street, Claremont, California, 91711, (909) 621-8914.

You have been given a signed copy of this form to keep.

Your signature indicates that you have read and understand the information provided, that the researcher answered any questions you had, that you are 18 years of age or older, that you willingly agree to participate, that you may withdraw your consent and discontinue your participation without penalty, and that you have received a copy of this form.

Print Name____

Signature____ Date________________________

Appendix D

AISS Junior Survey
Informed Consent Form

Number____________

Joint Science Department
Accelerated Integrated Science Sequence (AISS)
Junior Survey

1. **Please indicate your probable undergraduate field of study.** (Mark only one choice)

- ❑ Biology
- ❑ Human Biology
- ❑ Biology-Chemistry
- ❑ Chemistry
- ❑ 3/2 Engineering Option
- ❑ Environment, Economics, and Politics
- ❑ Environmental Science
- ❑ Management and Engineering
- ❑ Molecular Biology
- ❑ Neuroscience
- ❑ Organismal Biology and Ecology
- ❑ Physics
- ❑ Science and Management
- ❑ Mathematics
- ❑ Computer Science
- ❑ Psychology
- ❑ Science, Technology and Society
- ❑ Dual Major

(Please specify_________________)

- ❑ Other/Not Science

(Please specify_________________)

2. **I selected this major in my ______ freshman ______ sophomore ______ junior year.**

3. **Have you done any of the following as an undergraduate?**

	Never 0	**Some times 1-3**	**Very Often 4-6**	**Often 7+**
Gone to hear a scientific speaker ………………				
Attended a scientific research seminar …………				
Participated in science lunch discussions ………				
Done an out-of-class scientific research project....				
Attended a scientific conference….......................				
Presented at a scientific conference ……………				
Assisted with a science club/activity for younger students………………………………………				
Taught a science class to younger students ……				
Helped with a science fair or science fair project				
Published scientific research ……………………..……				

4. Please describe how taking AISS as a freshman impacted your choice of major.

____

____

5. If you have chosen an interdisciplinary major or a dual major, please tell whether/how AISS influenced that decision. If not, skip to question 6.

____

____

6. What is the highest academic degree you intend to obtain?

- ❑ None
- ❑ Bachelor's degree (B.A., B.S., etc.)
- ❑ Master's degree (M.A., M.S., etc.)
- ❑ Ph.D. or Ed.D.
- ❑ M.D., D.O., D.D.S., or D.V.M.
- ❑ J.D. (Law)
- ❑ B.D. or M.DIV. (Divinity)
- ❑ Other (Please specify____)

7. Are you ❑ Pre-Med? ❑ Pre-Dental? ❑ Pre-Vet? ❑ None of these?

8. Do you plan to do your senior thesis project on an interdisciplinary topic?

❑ Yes ❑ No ❑ Undecided

9. Do you plan to enter a graduate program right after college?

❑ Yes ❑ No ❑ Undecided

10. Do you plan to enter the work force right after college?

❑ Yes ❑ No ❑ Undecided

11. Do you plan to work for a year or two, and then apply to graduate school?

❑ Yes ❑ No ❑ Undecided

12. If you plan to take time off before going to graduate school or not attend graduate school, what are the reasons?

____

____

____

13. Rate yourself on the following traits compared to the average undergraduate in their junior year. We want the most accurate estimate of how you see yourself. (Mark one answer for each).

	Lowest 10%	Below Average	Average	Above Average	Highest 10%
Academic ability					
Acquiring a broad general education					
Competitiveness					
Working effectively with others					
Creativity					
Drive to achieve					
Risk taking					
Leadership					
Mathematical ability					
Compassion					
Developing a personal code of values/ethics					
Social self-confidence					
Understanding yourself					
Problem solving					
Spatial ability					
Intellectual flexibility					
Writing clearly and effectively					
Quality of reasoning you bring to a problem					
Lab skills and techniques					
Seeing connections between disciplines					
Thinking critically and analytically					
Asking and answering a scientific question					
Understanding systematic inquiry					
Analyzing journal articles in your field					
Managing a heavy academic load					
Working comfortably in a college lab					
Engaging in academic discussions					
Learning effectively on your own					
Moving beyond memorization/regurgitation					

14. Please rate how the following factors affected your decision to major in a science in college. (Mark one for each item).

	Weak Influence	Moderate Influence	Strong Influence	Did Not Experience	Does Not Apply
JSD faculty/advisors provide advice on academic and career alternatives and how to best pursue them					
JSD faculty/advisors provide accurate information on required courses and appropriate sequencing of courses for major					
JSD faculty/advisors offer practical help or advice with problems that impinge on academic performance (such as finances, employment, time conflicts, health, and other personal matters)					
JSD faculty/advisors take a personal interest in my progress, problems, & overall career direction					
JSD faculty/advisors make themselves available to provide out-of-class academic and personal help					
JSD faculty/advisors provide quality learning experiences/teaching					
Intrinsic interest in science					
Intrinsic interest in mathematics					
Careers in science/mathematics are a family tradition					
High grades/achievement in science courses					
Low grades/achievement in science courses					
High grades/achievement in mathematics courses					
Low grades/achievement in mathematics courses					
High grades/achievement in non-science courses					
Low grades/achievement in non-science courses					
Lack of or loss of interest in college science					
Began to question a science major and associated lifestyle					
Science career options/rewards not worth the effort required to complete the major					
Prefer teaching approaches in non-science and mathematics courses					
Discovery of aptitude for non-science/mathematics subject					
Non-science major offers better education/more interest					
Morale undermined by competitive science/math culture					
Morale undermined by strict grading systems					
Science major is a means to a desired career end					
Participation in summer science/math research project					
Participation in science/math research project during the academic year					

(*Continued)*

14. Please rate how the following factors influenced your decision to major in a science in college*. (Mark* <u>*one*</u> *for each item).*

	Weak Influence	Moderate Influence	Strong Influence	Did Not Experience	Does Not Apply
Peer study/support groups in science/mathematics					
Reasons for choice of science major began to seem inappropriate					
Conceptual difficulties with one or more science subjects in college					
Conceptual difficulties with one of more mathematics courses in college					
Opportunities to pursue an interdisciplinary science major					
Laboratory facilities in JSD					
Other science majors you know					
Other mathematics majors you know					
Scholarship money available					
Earning potential of a career in science or mathematics					

15. Do you plan to study abroad as an undergraduate?

❑ Yes/plan to ❑ Yes/already have ❑ No

If yes, where and what will/did you study? If no, what are/were the reasons?

____

____

____

____

16. Lecture/discussion and labs were integrated in the AISS course. If one or more lab per week were separated from lecture/discussion, how do you think this would affect the course? Please explain in detail.

____

____

____

____

17. One of the benefits of AISS is to accelerate introductory coursework to provide flexibility in students' academic and co-curricular schedules as they move through their undergraduate years. Do you feel that taking AISS provided this flexibility in your schedule? ❑ Yes ❑ No

Please explain in a few sentences and, if you answered "yes," tell how you took advantage of this flexibility:

____

____

____

18. The course description describes AISS as a course that helps students work across the boundaries of traditionally separated areas of scientific knowledge. Have you been able to use your experience in AISS to do this in other courses? ❑ Yes ❑ No

If "no," please describe why not. If "yes," please describe a specific incident or course in which this occurred.

____

____

____

____

19. Were your undergraduate years changed by AISS? ❑ Yes ❑ No
Please explain in detail.

____

____

____

____

20. Do you think you will be a different kind of scientist because your introduction to college science was the Accelerated Integrated Science Sequence? ❑ Yes ❑ No
Please explain in detail.

____

____

____

21. As of today, how likely are you do pursue the following types of careers and fields? (Mark one for each item)

	Not Likely		Somewhat Likely		Very Likely
University Faculty Position……………….……………	☐	……...	☐	…….	☐
K-12 teacher (science/math)……..…..…………........	☐	……..	☐	…….	☐
Basic Research…..……………………………………...	☐	……..	☐	…….	☐
Medicine (Physician, Dentist, etc.)……	☐	……..	☐	…….	☐
Medicine (Nurse, Physical Therapy, Technician, etc.)...	☐	……..	☐	…….	☐
Pharmacy/Pharmaceutical Research….………………	☐	……..	☐	…….	☐
Management …………….…….…. ….……………	☐	……..	☐	…….	☐
Research & Development…………………………….	☐	……..	☐	…….	☐
Industry...……………………………………………..	☐	……..	☐	…….	☐
Sales/Marketing...……………………………………..	☐	……..	☐	…….	☐
Programming/Analyst……………………………….	☐	……..	☐	…….	☐
Biology/Life Sciences.…………………………..……	☐	……..	☐	…….	☐
Physical Sciences………………………………………	☐		☐	…….	☐
Neuroscience ……………………………………….	☐	……..	☐	…….	☐
Multi/Interdisciplinary Sciences……………………..	☐	……..	☐	…….	☐
Environmental Science/Ecology…………………......	☐	……..	☐	…….	☐
Computer and Information Science……………………	☐	……..	☐	…….	☐
Space Science………………………………………….	☐	……..	☐	…….	☐
Earth Science…………………………………………..	☐		☐	…….	☐
Engineering …………………………………….…......	☐	……..	☐	…….	☐
Consulting……………………………………………..	☐		☐	…….	☐
Other (Please specify___________________________)	☐	……..	☐	…….	☐

Thank you for your time and thoughtfulness in completing this questionnaire.

Informed Consent Form—Junior
Accelerated Integrated Science Sequence (AISS) Evaluation

As juniors, you are invited to continue your participation in the research study of the Accelerated Integrated Science Sequence (AISS). This study continues to be conducted by Lisa Ulsh, a doctoral student in the School of Educational Studies at the Claremont Graduate University and her faculty advisor, Dr. David Drew. The goal of the ongoing study is to provide the Joint Science Department with a rich picture of AISS students as they progress through their undergraduate careers. Specifically, the study will look at your choice of declared major, your undergraduate science and mathematics coursework, your achievement in those courses, your performance on departmental standardized tests, your opinions on how well the AISS course served you as an introductory science course, and your perceptions of yourselves now and in the future. We will use this information to modify and improve the AISS course in future years, and to ascertain the success of the AISS as a gateway to majors offered by the Joint Science Department.

If you decide to participate, you will be asked to complete two surveys, one midyear and one near the end of your junior year. Each survey will consist of approximately 25 questions (estimated time to complete = 20 minutes). Additionally, you may be invited to a half-hour individual interview with the researcher in April/May of 2010. The survey questionnaires will be handed out and collected by the researcher in a setting without JSD faculty present, as they were last year. Interviews sign-up times will be offered at a variety of times and will take place in an available classroom in the Joint Sciences buildings. You may be invited to participate in follow-up surveys and interviews in your senior year.

The Accelerated Integrated Science Sequence is made possible by a National Science Foundation grant awarded to Dr. Newton Copp, Chair of the Joint Science Department. The NSF requires that an evaluation be conducted on all such grants. In addition to helping the Joint Science Department meet this requirement, the benefits of this research include providing the AISS course instructors with group data that will allow them to better understand the ways in which students are experiencing this introductory course. In addition, the researcher will analyze data gained from the surveys and interviews as part of the dissertation research for her doctoral program and may include it in publications in the future.

Every effort will be made to keep information that is obtained in connection with the study confidential and anonymous. All surveys will be encoded by trained personnel in the Claremont Graduate University School of Education so that neither the researcher nor any persons in the Joint Science Department can link your identity to your responses. Notes from individual interviews will be encoded by the researcher so that no one's responses or personal characteristics can be determined by anyone looking at the analyses to be developed from the data. All identifying information will be deleted from these notes to ensure the participants' anonymity. No audio or video recordings of the interviews will be made. While the researcher has the utmost concern for your anonymity and will take the above mentioned steps to protect it when gathering and processing the data, you should be aware that anything you say to other students about your survey or interview responses has the risk of being disclosed to other fellow students or to Joint Sciences Department personnel, something over which the researcher has limited control.

Your participation in this study is voluntary. If you feel the risks of participating outweigh the benefits, you can refuse to participate. If you decide to participate, you can skip any survey or interview question with which you do not feel comfortable, or discontinue participation at any time without any penalty. If you have any questions, please feel free to contact Ms. Ulsh (researcher) or Dr. Drew (faculty advisor) at the School of Educational Studies, Claremont Graduate University, 150 E. 10th Street, Claremont, California, 91711, (909) 621-8914.

You have been given a signed copy of this form to keep.

Your signature indicates that you have read and understand the information provided, that the researcher answered any questions you had, that you are 18 years of age or older, that you willingly agree to participate, that you may withdraw your consent and discontinue your participation without penalty, and that you have received a copy of this form.

Print Name____

Signature____ Date____________________________

Appendix E

Aspiring Science Majors/Other Junior Science Majors Survey
Informed Consent Form

Number____________

Joint Science Department
Aspiring Science Majors/Other Junior Science Majors Survey

1. **Please indicate your probable major as of right now.** (Mark only one choice).

- ❑ Biology
- ❑ Human Biology
- ❑ Biology-Chemistry
- ❑ Chemistry
- ❑ 3/2 Engineering Option
- ❑ Environment, Economics, and Politics
- ❑ Environmental Science
- ❑ Management and Engineering
- ❑ Molecular Biology
- ❑ Neuroscience
- ❑ Organismal Biology and Ecology
- ❑ Physics
- ❑ Science and Management
- ❑ Mathematics
- ❑ Computer Science
- ❑ Psychology
- ❑ Science, Technology and Society
- ❑ Other
  (Please specify___________________)
- ❑ Undecided

2. **I selected this major in my ____freshman ____ sophomore ____ junior year.**

3. **Are you:** ❑ Pre-Med? ❑ Pre-Dental? ❑ Pre-Veterinary ❑ No, none of these

4. **Have you changed your intended major during this year?** ❑ Yes ❑ No

If you answered "yes," please complete: I changed from ____________________(major) to ____________________(major) and tell what went into your decision to change your major?

____

____

____

5. **What is the highest academic degree you intend to obtain?**
   - ❑ None
   - ❑ Bachelor's degree (B.A., B.S., etc.)
   - ❑ Master's degree (M.A., M.S., etc.)
   - ❑ Ph.D. or Ed.D.
   - ❑ M.D., D.O., D.D.S., or D.V.M.
   - ❑ J.D. (Law)
   - ❑ B.D. or M.DIV. (Divinity).
   - ❑ Other

6. **Have you done any of the following as an undergraduate?**

	Never 0	Some-times 1-3	Often 4-6	Very Often 7+
Gone to hear a scientific speaker				
Participated in science lunch discussions				
Attended a science seminar on campus............				
Presented at a science seminar on campus.........				
Done an out-of-class scientific research project...				
Attended a scientific conference off campus........				
Presented at a scientific conference off campus…				
Assisted with a science club/activity for younger students...				
Taught a science class to younger students				
Helped with a science fair or science fair project				
Published scientific research				

7. **Do you plan to do your senior thesis project on an interdisciplinary topic?**

   ❑ Yes ❑ No ❑ Undecided

8. **Do you plan to enter a graduate program right after college?**

   ❑ Yes ❑ No ❑ Undecided

9. **Do you plan to enter the work force right after college?**

   ❑ Yes ❑ No ❑ Undecided

10. **Do you plan to work for a year or two, and then apply to graduate school?**

    ❑ Yes ❑ No ❑ Undecided

11. **If you plan to take time off before going to graduate school or not attend graduate school, what are the reasons?** ______________________________

12. Rate yourself on the following traits compared to the average undergraduate in your year of college. We want the most accurate estimate of how you see yourself. (Mark <u>one</u> answer for each).

	Lowest 10%	Below Average	Average	Above Average	Highest 10%
Academic ability…………………………..					
Acquiring a broad general education……...					
Competitiveness…………………….........					
Working effectively with others…….........					
Creativity………………………………….					
Drive to achieve…………………….........					
Risk taking…………………………………					
Leadership………………………………….					
Mathematical ability……………………….					
Compassion………………………………..					
Developing a personal code of values/ethics					
Social self-confidence...……………………					
Understanding yourself……………….……					
Problem solving ……………..…………..					
Spatial ability………………………………					
Intellectual flexibility……………………...					
Writing clearly and effectively…………...					
Quality of reasoning you bring to a problem					
Lab skills and techniques…………………..					
Seeing connections between disciplines					
Thinking critically and analytically………...					
Asking and answering a scientific question..					
Understanding systematic inquiry………….					
Analyzing journal articles in your field…….					
Managing a heavy academic load………….					
Working comfortably in a college lab……..					
Engaging in academic discussions…..…….					
Learning effectively on your own………….					
Moving beyond memorization/regurgitation					

13. How well did your introductory science course work prepare you for the following? (Mark one for each item)

	Poorly Prepared	Somewhat Prepared	Well Prepared	Not Taking It
Organic Chemistry lecture …………………				
Organic Chemistry lab………………………				
Physical Chemistry lecture…………………				
Physical Chemistry lab………………………				
Intermediate Mechanics (Physics 101)….......				
Calculus II, Math 31…………………………				
Calculus III, Math 32………………………..				
Other upper division science courses (list course____________________________)				
Other upper division science courses (list course____________________________)				
Other upper division mathematics courses (list course____________________________)				
Other upper division mathematics courses (list course____________________________)				
Collaborating with fellow students………….				
Working or preparing independently……….				
Doing summer research……….……………				
Going to office hours………………………..				
Making connections between science disciplines……………………………………				
Continuing in a science major……………….				
Studying abroad in future years…………….				

14. Please rate how the following factors affected your decision to major in a science in college. (Mark one for each item).

	Weak Influence	Moderate Influence	Strong Influence	Did Not Experience	Does Not Apply
JSD faculty/advisors provide advice on academic and career alternatives and how to best pursue them					
JSD faculty/advisors provide accurate information on required courses and appropriate sequencing of courses for major					
JSD faculty/advisors offer practical help or advice with problems that impinge on academic performance (such as finances, employment, time conflicts, health, and other personal matters)					
JSD faculty/advisors take a personal interest in my progress, problems, & overall career direction					
JSD faculty/advisors make themselves available to provide out-of-class academic and personal help					
JSD faculty/advisors provide quality learning experiences/teaching					
Intrinsic interest in science					
Intrinsic interest in mathematics					
Careers in science/mathematics are a family tradition					
High grades/achievement in science courses					
Low grades/achievement in science courses					
High grades/achievement in mathematics courses					
Low grades/achievement in mathematics courses					
High grades/achievement in non-science courses					
Low grades/achievement in non-science courses					
Lack of or loss of interest in college science					
Began to question a science major and associated lifestyle					
Science career options/rewards not worth the effort required to complete the major					
Prefer teaching approaches in non-science and mathematics courses					
Discovery of aptitude for non-science/mathematics subject					
Non-science major offers better education/more interest					
Morale undermined by competitive science/math culture					
Morale undermined by strict grading systems					
Science major is a means to a desired career end					
Participation in summer science/math research project					
Participation in science/math research project during the academic year					

(*Continued)*

14. Please rate how the following factors influenced your decision to major in a science in college*.* *(Mark one for each item).*

	Weak Influence	Moderate Influence	Strong Influence	Did Not Experience	Does Not Apply
Peer study/support groups in science/mathematics					
Reasons for choice of science major began to seem inappropriate					
Conceptual difficulties with one or more science subjects in college					
Conceptual difficulties with one of more mathematics courses in college					
Opportunities to pursue an interdisciplinary science major					
Laboratory facilities in JSD					
Other science majors you know					
Other mathematics majors you know					
Scholarship money available					
Earning potential of a career in science or mathematics					

15. Looking back on your introductory science coursework, how do you think it most benefited you? Please be as specific as you can.

____

____

16. If you have done a research project in college (not part of a course), please describe what you did and how that experience impacted you as an aspiring scientist. If you have not yet participated in an out of class research project, do you intend to do so? Please explain why or why not?

____

____

17. If given the chance to roll back time, would you take your science and math courses in the same order or would you change the order in which you took this coursework? Please explain why or why not.

____

____

18. Please indicate your college and year below:

- ☐ Claremont McKenna
- ☐ Pitzer
- ☐ Scripps

- ☐ Sophomore
- ☐ Junior
- ☐ Senior

19. As of today, how likely are you do pursue the following types of careers and fields? (Mark one for each item)

	Not Likely	Somewhat Likely	Very Likely
University Faculty Position……………………….…………			
K-12 teacher (science/math)……..…….……………....….			
Basic Research….……………………………………....			
Medicine (Physician, Dentist, etc.)……			
Medicine (Nurse, Physical Therapy, Technician, etc.)...			
Pharmacy/Pharmaceutical Research…..…………………			
Management ……………………..………. ….………….			
Research & Development…………………………….			
Industry...………………………………………………..			
Sales/Marketing...………………………………………..			
Programming/Analyst…………………………………..			
Biology/Life Sciences.…………………………….……			
Physical Sciences………………………………………			
Neuroscience …………………………………….			
Multi/Interdisciplinary Sciences………………………			
Environmental Science/Ecology…………………......			
Computer and Information Science……………………			
Space Science…………………………………………			
Earth Science…………………………………………..			
Engineering …………………………………….......			
Consulting……………………………………………..			

20. Is English your native language? ❑ Yes ❑ No

21. How would you classify yourself?

- ❑ African American/Black
- ❑ American Indian/Alaska Native
- ❑ Asian/Asian American
- ❑ Mexican American/Chicano
- ❑ Other Latino
- ❑ Native Hawaiian/Pacific Islander
- ❑ White/Non-Hispanic
- ❑ Other (please specify_____________________________________)

Thank you for your time and thoughtfulness in completing this questionnaire.

Informed Consent Form—Junior
Accelerated Integrated Science Sequence (AISS) Evaluation

As juniors, you are invited to continue your participation in the research study of the Accelerated Integrated Science Sequence (AISS). This study continues to be conducted by Lisa Ulsh, a doctoral student in the School of Educational Studies at the Claremont Graduate University and her faculty advisor, Dr. David Drew. The goal of the ongoing study is to provide the Joint Science Department with a rich picture of AISS students as they progress through their undergraduate careers. Specifically, the study will look at your choice of declared major, your undergraduate science and mathematics coursework, your achievement in those courses, your performance on departmental standardized tests, your opinions on how well the AISS course served you as an introductory science course, and your perceptions of yourselves now and in the future. We will use this information to modify and improve the AISS course in future years, and to ascertain the success of the AISS as a gateway to majors offered by the Joint Science Department.

If you decide to participate, you will be asked to complete two surveys, one midyear and one near the end of your junior year. Each survey will consist of approximately 25 questions (estimated time to complete = 20 minutes). Additionally, you may be invited to a half-hour individual interview with the researcher in April/May of 2010. The survey questionnaires will be handed out and collected by the researcher in a setting without JSD faculty present, as they were last year. Interviews sign-up times will be offered at a variety of times and will take place in an available classroom in the Joint Sciences buildings. You may be invited to participate in follow-up surveys and interviews in your senior year.

The Accelerated Integrated Science Sequence is made possible by a National Science Foundation grant awarded to Dr. Newton Copp, Chair of the Joint Science Department. The NSF requires that an evaluation be conducted on all such grants. In addition to helping the Joint Science Department meet this requirement, the benefits of this research include providing the AISS course instructors with group data that will allow them to better understand the ways in which students are experiencing this introductory course. In addition, the researcher will analyze data gained from the surveys and interviews as part of the dissertation research for her doctoral program and may include it in publications in the future.

Every effort will be made to keep information that is obtained in connection with the study confidential and anonymous. All surveys will be encoded by trained personnel in the Claremont Graduate University School of Education so that neither the researcher nor any persons in the Joint Science Department can link your identity to your responses. Notes from individual interviews will be encoded by the researcher so that no one's responses or personal characteristics can be determined by anyone looking at the analyses to be developed from the data. All identifying information will be deleted from these notes to ensure the participants' anonymity. No audio or video recordings of the interviews will be made. While the researcher has the utmost concern for your anonymity and will take the above mentioned steps to protect it when gathering and processing the data, you should be aware that anything you say to other students about your survey or interview responses has the risk of being disclosed to other fellow students or to Joint Sciences Department personnel, something over which the researcher has limited control.

Your participation in this study is voluntary. If you feel the risks of participating outweigh the benefits, you can refuse to participate. If you decide to participate, you can skip any survey or interview question with which you do not feel comfortable, or discontinue participation at any time without any penalty. If you have any questions, please feel free to contact Ms. Ulsh (researcher) or Dr. Drew (faculty advisor) at the School of Educational Studies, Claremont Graduate University, 150 E. 10th Street, Claremont, California, 91711, (909) 621-8914.

You have been given a signed copy of this form to keep.

Your signature indicates that you have read and understand the information provided, that the researcher answered any questions you had, that you are 18 years of age or older, that you willingly agree to participate, that you may withdraw your consent and discontinue your participation without penalty, and that you have received a copy of this form.

Print Name____

Signature____ Date________________________

Appendix F

AISS Senior Survey
Informed Consent Form

Number____________

Joint Science Department
Accelerated Integrated Science Sequence (AISS)
Cohort 1 Senior Survey

1. **Please indicate your undergraduate field of study.** (Mark only one choice unless a dual major)

- ❑ Biology
- ❑ Human Biology
- ❑ Biology-Chemistry
- ❑ Chemistry
- ❑ 3/2 Engineering Option
- ❑ Environment, Economics, and Politics
- ❑ Environmental Science
- ❑ Management and Engineering
- ❑ Molecular Biology
- ❑ Neuroscience
- ❑ Organismal Biology and Ecology
- ❑ Physics
- ❑ Science and Management
- ❑ Mathematics
- ❑ Computer Science
- ❑ Psychology
- ❑ Science, Technology and Society
- ❑ Dual Major
  (Please specify__________________________)
- ❑ Other/Not Science
  (Please specify_____________________)

2. **I selected this major in my ______ freshman ______ sophomore ______ junior year.**

3. **Are you ❑ Pre-Med? ❑ Pre-Dental? ❑ Pre-Vet? ❑ None of these?**

4. **If you have chosen an interdisciplinary major or a dual major, please tell whether/how AISS influenced that decision. If not, skip to question 5.**

____

____

____

5. **What is the highest academic degree you intend to obtain?**

- ❑ None
- ❑ Bachelor's degree (B.A., B.S., etc.)
- ❑ Master's degree (M.A., M.S., etc.)
- ❑ Ph.D. or Ed.D.
- ❑ M.D., D.O., D.D.S., or D.V.M.
- ❑ J.D. (Law)
- ❑ B.D. or M.DIV. (Divinity)
- ❑ Other (Please specify____)

6. Have you done any of the following since taking the junior year survey/in the past year?

	Never 0 times	Some-times 1-3 times	Often 4-6 times	Very often 7+ times
Gone to hear a scientific speaker …………………..				
Attended a scientific research seminar ……………...				
Participated in science lunch discussions …………..				
Engaged in a research project out of class…………..				
Attended a scientific conference…...........................				
Presented at a scientific conference ………………...				
Published scientific research ……………………..……				
Taken a science elective you didn't need for your major…………...				
Taken a math/computer science elective you didn't need for your major………………………………….				

7. As you reflect on your college career, are there skills or ways of thinking that you feel you developed principally in AISS? Please describe as specifically as you can.

____

____

____

____

8. Did AISS influence your senior thesis research topic? ❑ No ❑ Yes. Please describe how:

____

____

____

____

9. What is the title of your senior thesis?

____

____

____

10. Is your senior thesis project on an interdisciplinary topic? ❑ Yes ❑ No

11. Please write a brief summary (3-5 sentences) of your senior thesis:

____

____

____

____

12. Have your taken the MCAT? ❑ No ❑ Yes (date________) ❑ Plan to (date__________)

13. Have taken the GRE General Test? ❑ No ❑ Yes (date_______) ❑ Plan to (date_______)

14. Have you taken any of the following GRE subject tests?

Biochemistry, Cell & Molecular Biology	❑ No	❑ Yes (date_____________)
Biology	❑ No	❑ Yes (date_____________)
Chemistry	❑ No	❑ Yes (date_____________)
Computer Science	❑ No	❑ Yes (date_____________)
Literature in English	❑ No	❑ Yes (date_____________)
Mathematics	❑ No	❑ Yes (date_____________)
Physics	❑ No	❑ Yes (date_____________)
Psychology	❑ No	❑ Yes (date_____________)

15. Do you plan to take any of the following GRE subject tests?

Biochemistry, Cell and Molecular Biology	❑ No	❑ Yes (date_____________)
Biology	❑ No	❑ Yes (date_____________)
Chemistry	❑ No	❑ Yes (date_____________)
Computer Science	❑ No	❑ Yes (date_____________)
Literature in English	❑ No	❑ Yes (date_____________)
Mathematics	❑ No	❑ Yes (date_____________)
Physics	❑ No	❑ Yes (date_____________)
Psychology	❑ No	❑ Yes (date_____________)

16. **Are you applying to graduate programs?** ❑ No ❑ Yes

If yes, in what field(s)?____

____

____

____

17. **Do you plan to enter a graduate program right after college?**

❑ No ❑ Yes ❑ Undecided

18. **Do you plan to enter the work force directly out of college and not attend graduate school?**

❑ No ❑ Yes ❑ Undecided

19. **Do you plan to work for a year or two, and then apply to graduate school?**

❑ No ❑ Yes ❑ Undecided

20. **If you plan to take time off before going to graduate school or plan not to attend graduate school, what are the reasons and what will you do during that time?**

____

____

____

____

____

Please continue to next page.

21. Rate yourself on the following traits compared to the average undergraduate in their senior year. We want the most accurate estimate of how you see yourself. (Mark one answer for each).

	Lowest 10%	Below Average	Average	Above Average	Highest 10%
Academic ability…………………………..					
Acquiring a broad general education……...					
Competitiveness……………………..........					
Working effectively with others…….........					
Creativity………………………………….					
Drive to achieve……………………..........					
Risk taking…………………………………					
Leadership………………………………….					
Mathematical ability……………………….					
Compassion………………………………..					
Developing a personal code of values/ethics					
Social self-confidence…...…………………					
Understanding yourself……………….……					
Problem solving ……………..……………..					
Spatial ability………………………………					
Intellectual flexibility……………………...					
Writing clearly and effectively…………...					
Quality of reasoning you bring to a problem					
Lab skills and techniques…………………..					
Seeing connections between disciplines					
Thinking critically and analytically………..					
Asking and answering a scientific question..					
Understanding systematic inquiry………….					
Analyzing journal articles in your field…….					
Managing a heavy academic load………….					
Working comfortably in a college lab……..					
Engaging in academic discussions…..…….					
Learning effectively on your own………….					
Moving beyond memorization/regurgitation					

22. Did you study abroad as an undergraduate? ❑ No ❑ Yes (date___________________)

If yes, where and what subjects did you study? If no, what are/were the reasons?

____

____

23. As of today, how likely are you do pursue the following types of careers and fields? (Mark <u>one</u> for each item)

	Not Likely	Somewhat Likely	Very Likely
University Faculty Position……………….……………			
K-12 teacher (science/math)……..….……………........			
Basic Research….……………………………………...			
Medicine (Physician, Dentist, etc.)……			
Medicine (Nurse, Physical Therapy, Technician, etc.)...			
Pharmacy/Pharmaceutical Research…..………………			
Management …………….………. ….…………			
Research & Development…………………………….			
Industry...……………………………………………..			
Sales/Marketing...……………………………………..			
Programming/Analyst……………………………….			
Biology/Life Sciences.………………………….……			
Physical Sciences………………………………………			
Neuroscience ………………………………………….			
Multi/Interdisciplinary Sciences………………………			
Environmental Science/Ecology………………….......			
Computer and Information Science……………………			
Space Science………………………………………….			
Earth Science…………………………………………..			
Engineering …………………………………….….....			
Consulting……………………………………………..			
Other (Please specify_________________________)			

Thank you for your time and thoughtfulness in completing this questionnaire.

Appendix G

Survey Instrument Coding Guides:

AISS Freshman Fall Survey
AISS Freshman Spring Survey
AISS Sophomore Survey
AISS Junior Survey
AISS Aspiring Science Majors/Other Junior Science Majors Survey
AISS Senior Survey

Joint Science Department
Accelerated Integrated Science Sequence (AISS)
Freshman Survey – Fall

1. **From what kind of high school did you graduate?** (Mark one)
   - 1 = Public school (not charter or magnet)
   - 2 = Public charter school
   - 3 = Public math/science magnet school
   - 4 = Other public magnet school
   - 5 = Private religious/parochial school
   - 6 = Private independent college-prep school
   - 7 = Home school

2. **Was that high school . . .?** (Mark all that apply)
   - Coeducational
   - Single gender
   - A day school
   - A boarding school
   - Small (less than 500 students)
   - Medium (between 500 and 1000 students)
   - Large (more than 1000 students)
   - Urban
   - Suburban
   - Rural

   1 = Yes
   2 = No
   99 = No Response

3. **What is the highest academic degree you intend to obtain?**
   - 1 = None
   - 2 = Bachelor's degree (B.A., B.S., etc.)
   - 3 = Master's degree (M.A., M.S., etc.)
   - 4 = Ph.D. or Ed.D.
   - 5 = M.D., D.O., D.D.S., or D.V.M.
   - 6 = J.D. (Law)
   - 7 = B.D. or M.DIV. (Divinity).
   - 8 = Other
   - 99 = No response

4. **What is the highest level of formal education obtained by your parents?**
   - 1 = Grammar school or less
   - 2 = Some high school
   - 3 = High School graduate
   - 4 = Postsecondary school other than college
   - 5 = Some college
   - 6 = College degree
   - 7 = Some graduate school
   - 8 = Graduate degree
   - 99 = No response

5. What is your father's occupation? Free response

6. What is your mother's occupation? Free response

7. Below are some reasons that might have influenced your decision to enroll in the Advanced Integrated Science Sequence (AISS). Rate the importance of each reason listed.

My parents wanted me to enroll	
A high school teacher advised me	
A college counselor advised me	1 = Not important
I wanted the challenge of an accelerated course	2 = Somewhat important
The AISS description on the JSD web site	3 = Very important
I received information about AISS in the mail	99 = No response
I visited the Claremont Colleges	
I visited or sat in on JSD classes	
I liked the JSD faculty I m	
I knew at least one other person in the course	
I wanted to accelerate progress through my major	
I want preference for a research fellowship	
I want to study abroad during college	
I was attracted to its interdisciplinary nature	

8. Please indicate your probable undergraduate field of study. (Mark one choice)

1 = Biology
2 = Human Biology
3 = Biology-Chemistry
4 = Chemistry
5 = 3/2 Engineering Option
6 = Environment, Economics, and Politics
7 = Environmental Science
8 = Management and Engineering
9 = Molecular Biology
10 = Neuroscience
11 = Organismal Biology and Ecology
12 = Physics
13 = Science and Management
14 = Mathematics
15 = Computer Science
16 = Psychology
17 = Science, Technology and Society
18 = Other
99 = No response

9. Are you

Pre-Med?	1 = Yes
Pre-Dental?	2 = No
Pre-Vet?	99 = No Response

10. Rate yourself on the following traits compared to the average person your age. We want the most accurate estimate of how you see yourself.

Academic ability
Artistic ability
Competitiveness
Computer skills
Cooperativeness
Creativity
Drive to achieve
Risk taking
Leadership ability
Mathematical ability
Compassion
Self-confidence (intellectual)
Self-confidence (social)
Self understanding
Critical thinking
Problem solving
Spatial ability

1 = Lowest 10%
2 = Below average
3 = Average
4 = Above average
5 = Highest 10%
99 = No Response

11. How well prepared for college in each of these areas do you feel?

Science coursework
Mathematics coursework
Laboratory experience
Computer technology
Writing skills
Working in groups
Independent research

1 = Poorly prepared
2 = Somewhat prepared
3 = Well prepared
99 = No Response

12. What is your best guess as to the chances that you will:

Graduate from college
Graduate with a science major
Graduate with a mathematics major
Graduate with an engineering major
Graduate with an interdisciplinary major
Graduate with a non-science major
Change your major
Change your career choice
Conduct your own research
Publish as an undergraduate
Tutor another student
Earn at least a "B+" average in college
Seek help with your writing skills
Communicate regularly with your professors
Work during the academic year
Form or join a study group
Study abroad

1 = Not likely
2 = Somewhat likely
3 = Very likely
99 = No Response

13. What didn't you get in high school that you wish you had in order to be prepared for college level work?

Free response

15. How many hours per week outside of lecture-labs do you spend on work for the course?

1 = 0 - 4 hours
2 = 5 - 10 hours
3 = 11 - 15 hours
4 = 16 - 20 hours
5 = 21 - 25 hours
6 = 26 - 30 hours
7 = More than 30 hours
99 = No Response

16. In a sentence or two, how do you divide the time you spend on out-of-class work for the course.

Free response

17. What have you enjoyed <u>most</u> about the course so far? Please be as specific as possible.

Free response

18. What have you enjoyed <u>least</u> so far? Please be as specific as possible.

Free response

19. Is there anything that you expected from this course that you have not yet gotten?

Free response

20. Is English your native language?

1 = Yes
2 = No
99 = No Response

21. How would you classify yourself?

1 = African American/Black
2 = American Indian/Alaska Native
3 = Asian/Asian American
4 = Mexican American/Chicano
5 = Other Latino
6 = Native Hawaiian/Pacific Islander
7 = White/Non-Hispanic
8 = Other (please specify____)
99 = No Response

22. Are there any additional comments you would like to make?

Free response

Joint Science Department
Accelerated Integrated Science Sequence (AISS)
Freshman Survey – Spring

1. Please indicate your probable major <u>as of the end of your freshman year</u>. (Mark only <u>one</u> choice).

1 = Biology
2 = Human Biology
3 = Biology-Chemistry
4 = Chemistry
5 = 3/2 Engineering Option
6 = Environment, Economics, and Politics
7 = Environmental Science/Analysis
8 = Management and Engineering
9 = Molecular Biology
10 = Neuroscience
11 = Organismal Biology and Ecology
12 = Physics
13 = Science and Management
14 = Mathematics
15 = Computer Science
16 = Psychology
17 = Science, Technology and Society
18 = Other
19 = Undecided
99 = No response

2. Are you Pre-Med?
Pre-Dental?
Pre-Vet?

1 = Yes
2 = No
99 = No Response

3. Have you changed your intended major during this year?

1 = Yes
2 = No
99 = No Response

If you answered "yes," what went into your decision to change your major?

Free response

4. **Please rate yourself on the following traits compared to the average person your age. We want the most accurate estimate of how you see yourself. (Mark <u>one</u> answer for each possible reason)**

Academic ability
Artistic ability
Competitiveness
Computer skills
Cooperativeness
Creativity
Drive to achieve
Risk taking
Leadership ability
Mathematical ability
Compassion
Self-confidence (intellectual)
Self-confidence (social)
Self understanding
Critical thinking
Problem solving
Spatial ability

1 = Lowest 10%
2 = Below average
3 = Average
4 = Above average
5 = Highest 10%
99 = No Response

5. **Please respond to the following statements by checking the <u>ONE</u> answer that best fits.**

I feel confident that I have a solid understanding of introductory level biology concepts.
I feel confident that I have a solid understanding of introductory level chemistry concepts.
I feel confident that I have a solid understanding of introductory level physics concepts.
I feel confident about the amount of laboratory experience I gained this year.
I feel confident in the laboratory skills I acquired this year.
I am concerned that I have gaps in my understanding of basic biology content.
I am concerned that I have gaps in my understanding of basic chemistry content.
I am concerned that I have gaps in my understanding of basic physics content.
Learning fewer science concepts in depth will benefit me more than broad coverage of more topics.
I plan to participate in scientific research this the summer.
I plan to participate in scientific research in the summer after sophomore year.
I plan to participate in scientific research in the summer after junior year.
I plan to participate in scientific research every summer while in college.
I plan to participate in scientific research during future academic/school years.
I feel confident in my ability to ask and investigate an original research question.
I feel confident in my ability to use high-tech scientific equipment in a lab setting.
I feel confident in my ability to speak in front of a group of peers and professors.
I feel confident in my formal academic writing skills.
I feel confident that I will publish as an undergraduate.
I feel confident that I will study abroad as an undergraduate.

1= Strongly disagree 2 = Disagree 3 = No opinion 4 = Agree 5 = Strongly agree
99 = No Response

6. Rate the following for how effective they were in helping <u>YOU</u> learn the material in AISS? (Mark <u>one</u> for each item)

Lectures	
Notes/handouts prepared by professors	
Graded homework	1 = Not effective
Textbooks	2 = Somewhat effective
Simulation-type lab activities	3 = Very effective
Answers provided before problem sets due	99 = No Response
Answers provided after problem sets turned in	
Research/primary source articles	
Preparing for labs	
Doing labs	
Studying for exams	
Taking exams	
Mathematical modeling exercises	
Study partners or groups	
Individual effort	
Class discussions	
Office hours	
Interdisciplinary connections	
Laboratory reports/write-ups	
Working in groups in class/lab	
Field trips	

7. Describe one strategy you used or developed to help you manage the workload AISS?

Free response

8. How have you changed as a science student <u>during this semester of AISS</u> as compared to fall semester?

Free response

9. What do you feel is your greatest accomplishment in AISS this year?

Free response

10. Describe an "aha moment" during this year when you feel you gained a deep scientific understanding or insight.

Free response

11. Are there any additional comments about your experience in AISS you would like to make?

Free response

Joint Science Department
Accelerated Integrated Science Sequence (AISS)
Sophomore Survey

1. **Please indicate your probable major as of right now.** (Mark only one choice)
   1 = Biology
   2 = Human Biology
   3 = Biology-Chemistry
   4 = Chemistry
   5 = 3/2 Engineering Option
   6 = Environment, Economics, and Politics
   7 = Environmental Science
   8 = Management and Engineering
   9 = Molecular Biology
   10 = Neuroscience
   11 = Organismal Biology and Ecology
   12 = Physics
   13 = Science and Management
   14 = Mathematics
   15 = Computer Science
   16 = Psychology
   17 = Science, Technology and Society
   18 = Other
   19 = Undecided
   99 = No response

2. **Are you** Pre-Med? Pre-Dental? Pre-Vet?
   1 = Yes
   2 = No
   99 = No response

3. **Have you changed your intended major during this year?**
   1 = Yes
   2 = No
   99 = No response
   Free response

4. **What is the highest academic degree you intend to obtain?**
   1 = None
   2 = Bachelor's degree (B.A., B.S., etc.)
   3 = Master's degree (M.A., M.S., etc.)
   4 = Ph.D. or Ed.D.
   5 = M.D., D.O., D.D.S., or D.V.M.
   6 = J.D. (Law)
   7 = B.D. or M.DIV. (Divinity).
   8 = Other
   99 = No response

5. **Please list by course name and number the SCIENCE (biology, chemistry, physics, geology) course(s) you are taking this year:**

Course numbers listed in database

1 = Yes
2 = No
99 = No Response

6. **Please list by course name and number the MATHEMATICS course(s) you are taking this year:**

Course numbers listed in database

1 = Yes
2 = No
99 = No Response

7. **Please list by course name and number any INTERDISCIPLINARY course(s) in your major (psychology, computer science, economics, engineering, government) you are taking this year:**

Course numbers listed in database

1 = Yes
2 = No
99 = No Response

8. **Please rate yourself on the following traits compared to the average person your age. We want the most accurate estimate of how you see yourself.** (Mark one answer for each possible reason)

Time management
Artistic ability
Competitiveness
Optimism
Collaboration
Creativity
Drive to achieve
Risk taking
Writing ability
Mathematical ability
Compassion
Ability to reason logically
Social self confidence
Persistence
Critical thinking
Problem solving
Spatial ability
Determination
Ability to work hard

1 = Lowest 10%
2 = Below average
3 = Average
4 = Above average
5 = Highest 10%
99 = No response

9. How well did AISS prepare you for the following? (Mark <u>one</u> for each item)

Organic Chemistry lecture
Organic Chemistry lab
Physical Chemistry lecture
Physical Chemistry lab
Intermediate Mechanics (Physics 101)
Calculus II, Math 31
Calculus III, Math 32
Other upper division science courses
Other upper division mathematics courses
Collaborating with fellow students
Working or preparing independently
Doing summer research
Going to office hours
Making connections between science disciplines
Continuing in a science major
Studying abroad in future years

1 = Poorly prepared
2 = Somewhat prepared
3 = Well prepared
4 = Not taking it
99 = No response

10. Looking back on the AISS course, how do you think it most benefited you?

Free response

11. If you did summer research after your freshman year, please describe how that experience impacted you as a science student.

Free response

12. How has your opinion of the AISS course changed as a result of your experience as a sophomore?

Free response

13. If given the chance to roll back time, would you choose the AISS course or the traditional introductory science pathway? Please explain why or why not.

Free response

14. Are there any additional comments about your experience in AISS you would like to make?

Free response

Joint Science Department
Accelerated Integrated Science Sequence (AISS)
Junior Survey

1. **Please indicate your probable undergraduate field of study. (Mark only one choice)**
   1 = Biology
   2 = Human Biology
   3 = Biology-Chemistry
   4 = Chemistry
   5 = 3/2 Engineering Option
   6 = Environment, Economics, and Politics
   7 = Environmental Science
   8 = Management and Engineering
   9 = Molecular Biology
   10 = Neuroscience
   11 = Organismal Biology and Ecology
   12 = Physics
   13 = Science and Management
   14 = Mathematics
   15 = Computer Science
   16 = Psychology
   17 = Science, Technology and Society
   18 = Other/No Science
   19 = Undecided (not on Junior survey, but on Freshman and Sophomore surveys)
   20 = Dual Major
   99 = No Response

2. **I selected this major in my ______ freshman ______ sophomore ______ junior year.**

   1 = Freshman
   2 = Sophomore
   3 = Junior
   99 = No Response

3. **Have you done any of the following as an undergraduate?**

Gone to hear a scientific speaker	
Attended a scientific research seminar	
Participated in science lunch discussions	1 = Never
Done an out-of-class scientific research project	2 =Sometimes
Attended a scientific conference	3 = Often
Presented at a scientific conference	4 = Very often
Assisted with a science club/activity for younger students	99 = No Response
Taught a science class to younger students	
Helped with a science fair or science fair project	
Published scientific research	

4. Please describe how taking AISS as a freshman impacted your choice of major.

Free response

5. If you have chosen an interdisciplinary major or a dual major, please tell whether/how AISS influenced that decision. If not, skip to question 6.

Free response

6. What is the highest academic degree you intend to obtain?

1 = None
2 = Bachelor's degree (B.A., B.S., etc.)
3 = Master's degree (M.A., M.S., etc.)
4 = Ph.D. or Ed.D.
5 = M.D., D.O., D.D.S., or D.V.M.
6 = J.D. (Law)
7 = B.D. or M.DIV. (Divinity)
8 = Other (Please specify_______________________________________)
99 = No response

7. Are you Pre-Med? Pre-Dental? Pre-Vet?

1 = Yes
2 = No
99 = No response

8. Do you plan to do your senior thesis project on an interdisciplinary topic?

1 = Yes 2 = No 3 = Undecided 99 = No response

9. Do you plan to enter a graduate program right after college?

1 = Yes 2 = No 3 = Undecided 99 = No response

10. Do you plan to enter the work force right after college?

1 = Yes 2 = No 3 = Undecided 99 = No response

11. Do you plan to work for a year or two, and then apply to graduate school?

1 = Yes 2 = No 3 = Undecided 99 = No response

12. If you plan to take time off before going to graduate school or not attend graduate school, what are the reasons?

Free response

13. Rate yourself on the following traits compared to the average undergraduate in their junior year. We want the most accurate estimate of how you see yourself. (Mark <u>one</u> answer for each).

Academic ability
Acquiring a broad general education
Competitiveness
Working effectively with others
Creativity
Drive to achieve
Risk taking
Leadership
Mathematical ability
Compassion
Developing a personal code of values/ethics
Social self-confidence
Understanding yourself
Problem solving
Spatial ability
Intellectual flexibility
Writing clearly and effectively
Quality of reasoning you bring to a problem
Lab skills and techniques
Seeing connections between disciplines
Thinking critically and analytically
Asking and answering a scientific question
Understanding systematic inquiry
Analyzing journal articles in your field
Managing a heavy academic load
Working comfortably in a college lab
Engaging in academic discussions
Learning effectively on your own
Moving beyond memorization/regurgitation

1 = Lowest 10 %
2 = Below average
3 = Average
4 = Above average
5 = Highest 10 %
99 = No response

14. Please rate how the following factors affected your decision to major in a science in college. (Mark <u>one</u> for each item).

JSD faculty/advisors provide advice on academic and career alternatives and how to best pursue them
JSD faculty/advisors provide advice on academic and career alternatives and how to best pursue them
JSD faculty/advisors provide advice on academic and career alternatives and how to best pursue them
JSD faculty/advisors provide advice on academic and career alternatives and how to best pursue them
JSD faculty/advisors provide accurate information on required courses and appropriate sequencing of courses for major

5 = Strong influence 4 = Moderate influence 3 = Weak influence
66 = Did not experience 77 = Does not apply 99 = No response

Continued

14. Please rate how the following factors affected your decision to major in a science in college. (Mark <u>one</u> for each item).

JSD faculty/advisors offer practical help or advice with problems that impinge on academic performance (such as finances, employment, time conflicts, health, and other personal matters)
JSD faculty/advisors take a personal interest in my progress, problems, & overall career direction
JSD faculty/advisors make themselves available to provide out-of-class academic and personal help
JSD faculty/advisors provide quality learning experiences/teaching
Intrinsic interest in science
Intrinsic interest in mathematics
Careers in science/mathematics are a family tradition
High grades/achievement in science courses
Low grades/achievement in science courses
High grades/achievement in mathematics courses
Low grades/achievement in mathematics courses
High grades/achievement in non-science courses
Low grades/achievement in non-science courses
Lack of or loss of interest in college science
Began to question a science major and associated lifestyle
Science career options/rewards not worth the effort required to complete the major
Prefer teaching approaches in non-science and mathematics courses
Discovery of aptitude for non-science/mathematics subject
Non-science major offers better education/more interest
Morale undermined by competitive science/math culture
Morale undermined by strict grading systems
Science major is a means to a desired career end
Participation in summer science/math research project
Participation in science/math research project during the academic year
Peer study/support groups in science/mathematics
Reasons for choice of science major began to seem inappropriate
Conceptual difficulties with one or more science subjects in college
Conceptual difficulties with one of more mathematics courses in college
Opportunities to pursue an interdisciplinary science major
Laboratory facilities in JSD
Other science majors you know
Other mathematics majors you know
Scholarship money available
Earning potential of a career in science or mathematics

5 = Strong influence 4 = Moderate influence 3 = Weak influence
66 = Did not experience 77 = Does not apply 99 = No response

15. Do you plan to study abroad as an undergraduate?

1 = Yes/plan to
2 = No
3 = Yes/already have

If yes, where and what will/did you study? If no, what are/were the reasons?

Free response

16. Lecture/discussion and labs were integrated in the AISS course. If one or more lab per week were separated from lecture/discussion, how do you think this would affect the course? Please explain in detail.

Free response

17. One of the benefits of AISS is to accelerate introductory coursework to provide flexibility in students' academic and co-curricular schedules as they move through their undergraduate years. Do you feel that taking AISS provided this flexibility in your schedule?

1 = Yes
2 = No

Please explain in a few sentences and, if you answered "yes," tell how you took advantage of this flexibility:

Free response

18. The course description describes AISS as a course that helps students work across the boundaries of traditionally separated areas of scientific knowledge. Have you been able to use your experience in AISS to do this in other courses?

1 = Yes
2 = No

If "no," please describe why not. If "yes," please describe a specific incident or course in which this occurred.

Free response

19. Were your undergraduate years changed by AISS?

1 = Yes
2 = No

Please explain in detail. Free response

20. Do you think you will be a different kind of scientist because your introduction to college science was the Accelerated Integrated Science Sequence?

1 = Yes
2 = No

Please explain in detail. Free response

21. As of today, how likely are you do pursue the following types of careers and fields? (Mark one for each item)

University Faculty Position
K-12 teacher (science/math
Basic Research
Medicine (Physician, Dentist, etc)
Medicine (Nurse, Physical Therapy, Technician, etc.)
Pharmacy/Pharmaceutical Research
Management
Research & Development
Industry
Sales/Marketing
Programming/Analyst
Biology/Life Sciences
Physical Sciences
Neuroscience
Multi/Interdisciplinary Sciences
Environmental Science/Ecology
Computer and Information Science
Space Science
Earth Science
Engineering
Consulting
Other (Please specify___________________________)

1 = Not likely
2 = Somewhat likely
3 = Very Likely
99 = No response

Joint Science Department
Aspiring Science Majors/Other Junior Science Majors Survey

1. Please indicate your probable major as of right now. (Mark only one choice).

1 = Biology
2 = Human Biology
3 = Biology-Chemistry
4 = Chemistry
5 = 3/2 Engineering Option
6 = Environment, Economics, and Politics
7 = Environmental Science
8 = Management and Engineering
9 = Molecular Biology
10 = Neuroscience
11 = Organismal Biology and Ecology
12 = Physics
13 = Science and Management
14 = Mathematics
15 = Computer Science
16 = Psychology
17 = Science, Technology and Society
18 = Other/No Science
19 = Undecided (not on Junior survey, but on Freshman and Sophomore surveys)
20 = Dual Major
99 = No Response

2. I selected this major in my ______ freshman ______ sophomore ______ junior year.

1 = Freshman
2 = Sophomore
3 = Junior
99 = No Response

3. Are you: Pre-Med
Pre-Dental
Pre-Vet

1 = Yes
2 = No
99 = No response

4. Have you changed your intended major during this year?

1 = Yes
2 = No
99 = No response

If you answered "yes," please complete: I changed from ________(major) to ________(major) and tell what went into your decision to change your major?

Free response

5. What is the highest academic degree you intend to obtain?

1 = None
2 = Bachelor's degree (B.A., B.S., etc.)
3 = Master's degree (M.A., M.S., etc.)
4 = Ph.D. or Ed.D.
5 = M.D., D.O., D.D.S., or D.V.M.
6 = J.D. (Law)
7 = B.D. or M.DIV. (Divinity)
8 = Other (Please specify____)
99 = No response

6. Have you done any of the following as an undergraduate?

Gone to hear a scientific speaker	
Attended a scientific research seminar	
Participated in science lunch discussions	1 = Never
Done an out-of-class scientific research project	2 =Sometimes
Attended a scientific conference	3 = Often
Presented at a scientific conference	4 = Very often
Assisted with a science club/activity for younger students	99 = No Response
Taught a science class to younger students	
Helped with a science fair or science fair project	
Published scientific research	

7. Do you plan to do your senior thesis project on an interdisciplinary topic?

1 = Yes 2 = No 3 = Undecided 99 = No response

8. Do you plan to enter a graduate program right after college?

1 = Yes 2 = No 3 = Undecided 99 = No response

9. Do you plan to enter the work force right after college?

1 = Yes 2 = No 3 = Undecided 99 = No response

10. Do you plan to work for a year or two, and then apply to graduate school?

1 = Yes 2 = No 3 = Undecided 99 = No response

11. If you plan to take time off before going to graduate school or not attend graduate school, what are the reasons?

Free response

12. Rate yourself on the following traits compared to the average undergraduate in your year of college. We want the most accurate estimate of how you see yourself. (Mark one answer for each).

- Academic ability
- Acquiring a broad general education
- Competitiveness
- Working effectively with others
- Creativity
- Drive to achieve
- Risk taking
- Leadership
- Mathematical ability
- Compassion
- Developing a personal code of values/ethics
- Social self-confidence
- Understanding yourself
- Problem solving
- Spatial ability
- Intellectual flexibility
- Writing clearly and effectively
- Quality of reasoning you bring to a problem
- Lab skills and techniques
- Seeing connections between disciplines
- Thinking critically and analytically
- Asking and answering a scientific question
- Understanding systematic inquiry
- Analyzing journal articles in your field
- Managing a heavy academic load
- Working comfortably in a college lab
- Engaging in academic discussions
- Learning effectively on your own
- Moving beyond memorization/regurgitation

1 = Lowest 10 %
2 = Below average
3 = Average
4 = Above average
5 = Highest 10 %
99 = No response

13. How well did your introductory science course work prepare you for the following? (Mark one for each item)

- Organic Chemistry lecture
- Organic Chemistry lab
- Physical Chemistry lecture
- Physical Chemistry lab
- Intermediate Mechanics (Physics 101)
- Calculus II, Math 31
- Calculus III, Math 32
- Other upper division science courses
- Other upper division mathematics courses
- Collaborating with fellow students
- Working or preparing independently

1 = Poorly prepared
2 = Somewhat prepared
3 = Well prepared
4 = Not taking it
99 = No response

Continued

13. How well did your introductory science course work prepare you for the following? (Mark one for each item)

Doing summer research	1 = Poorly prepared
Going to office hours	2 = Somewhat prepared
Making connections between science disciplines	3 = Well prepared
Continuing in a science major	4 = Not taking it
Studying abroad in future years	99 = No response

14. Please rate how the following factors affected your decision to major in a science in college. (Mark one for each item).

JSD faculty/advisors provide advice on academic and career alternatives and how to best pursue them
JSD faculty/advisors provide advice on academic and career alternatives and how to best pursue them
JSD faculty/advisors provide advice on academic and career alternatives and how to best pursue them
JSD faculty/advisors provide advice on academic and career alternatives and how to best pursue them
JSD faculty/advisors provide accurate information on required courses and appropriate sequencing of courses for major
JSD faculty/advisors offer practical help or advice with problems that impinge on academic performance (such as finances, employment, time conflicts, health, and other personal matters)
JSD faculty/advisors take a personal interest in my progress, problems, & overall career direction
JSD faculty/advisors make themselves available to provide out-of-class academic and personal help
JSD faculty/advisors provide quality learning experiences/teaching
Intrinsic interest in science
Intrinsic interest in mathematics
Careers in science/mathematics are a family tradition
High grades/achievement in science courses
Low grades/achievement in science courses
High grades/achievement in mathematics courses
Low grades/achievement in mathematics courses
High grades/achievement in non-science courses
Low grades/achievement in non-science courses
Lack of or loss of interest in college science
Began to question a science major and associated lifestyle
Science career options/rewards not worth the effort required to complete the major
Prefer teaching approaches in non-science and mathematics courses
Discovery of aptitude for non-science/mathematics subject
Non-science major offers better education/more interest
Morale undermined by competitive science/math culture
Morale undermined by strict grading systems
Science major is a means to a desired career end

5 = Strong influence 4 = Moderate influence 3 = Weak influence
66 = Did not experience 77 = Does not apply 99 = No response

Continued

14. Please rate how the following factors affected your decision to major in a science in college. (Mark <u>one</u> for each item).

Participation in summer science/math research project
Participation in science/math research project during the academic year
Peer study/support groups in science/mathematics
Reasons for choice of science major began to seem inappropriate
Conceptual difficulties with one or more science subjects in college
Conceptual difficulties with one of more mathematics courses in college
Opportunities to pursue an interdisciplinary science major
Laboratory facilities in JSD
Other science majors you know
Other mathematics majors you know
Scholarship money available
Earning potential of a career in science or mathematics

5 = Strong influence   4 = Moderate influence   3 = Weak influence
66 = Did not experience   77 = Does not apply   99 = No response

15. Looking back on your introductory science coursework, how do you think it most benefited you? Please be as specific as you can.

Free response

16. If you have done a research project in college (not part of a course), please describe what you did and how that experience impacted you as an aspiring scientist. If you have not yet participated in an out of class research project, do you intend to do so? Please explain why or why not?

Free response

17. If given the chance to roll back time, would you take your science and math courses in the same order or would you change the order in which you took this coursework? Please explain why or why not.

Free response

18. Please indicate your college and year below:

1 = Claremont McKenna	2 = Sophomore
2 = Pitzer	3 = Junior
3 = Scripps	4 = Senior

19. As of today, how likely are you do pursue the following types of careers and fields? (Mark <u>one</u> for each item)

University Faculty Position
K-12 teacher (science/math
Basic Research
Medicine (Physician, Dentist, etc)
Medicine (Nurse, Physical Therapy, Technician, etc.)
Pharmacy/Pharmaceutical Research
Management
Research & Development
Industry
Sales/Marketing
Programming/Analyst
Biology/Life Sciences
Physical Sciences
Neuroscience
Multi/Interdisciplinary Sciences
Environmental Science/Ecology
Computer and Information Science
Space Science
Earth Science
Engineering
Consulting
Other (Please specify___________________________)

1 = Not likely
2 = Somewhat likely
3 = Very Likely
99 = No response

20. Is English your native language?

1 = Yes
2 = No
99 = No response

21. How would you classify yourself?

1 = African American/Black
2 = American Indian/Alaska Native
3 = Asian/Asian American
4 = Mexican American/Chicano
5 = Other Latino
6 = Native Hawaiian/Pacific Islander
7 = White/Non-Hispanic
8 = Other (please specify______________________________________)
99 = No Response

Appendix H

Faculty Focus Group Questions

Joint Science Department
Accelerated Integrated Science Sequence (AISS)
Question Options for AISS Faculty Focus Group – Fall 2010

Instructor-Related Questions

1. What do you think is the most important aspect of AISS for students? for JSD?
2. How has the experience of teaching AISS affected your pedagogy? Describe one or two specific examples.
3. Have you made any changes to how you teach other courses as a result of your AISS experience? Describe one or two specific examples.
4. Do you team teach any other courses? If yes, which? If not, would you like to and can you give a thumbnail description of a course offering you can envision?
5. Do you think more interdisciplinary and/or team teaching and research would benefit JSD? How? Why? Please provide specific examples.
6. Do you see AISS as a viable model for interdisciplinary teaching and research in JSD? in other institutions? Why or why not?

Student-Related Questions

1. What do you think is the most important thing AISS provided students?
2. What is the effect of accelerating on student learning? on choice to major in science? on performance in a science major?
3. What is the effect of integrating on student learning? on choice to major in science? on performance in a science major?
4. Do you think AISS draws students into science in the Joint Science Department (JSD) who might not otherwise have chosen the Claremont Colleges? Evidence? How? Why? What about it?
5. Have you taught AISS students in subsequent courses? Can you describe their performance, approach to science/scientific thinking/attitude? Do you see a lasting effect of AISS?
6. How do you think the early research experience offered to AISS students affected them?

Appendix I

Survey Results, Cohort 2

Fall Freshman Survey — Cohort 2 AISS Students (2008-2009)

Table 40.

*Demographic Characteristics: AISS Cohort 2 Freshmen, Fall 2008 (N=25)**

Variable	N	Valid %**
Female	22	88
Male	3	12
Claremont McKenna College	6	24
Pitzer College	3	12
Scripps College	16	64
African American/Black	0	0
Asian American	5	20
Latino (not Mexican American)	1	4
White/Non-Hispanic	18	72
Other/Biracial	1	4
Native English speaker	23	92
Not Native English speaker	2	8
Father with a graduate degree	16	57.1
Mother with a graduate degree	12	49.2
Both parents with graduate degrees	11	39.2

Note. *25 of 27 students enrolled in AISS fall semester responded to the survey; response rate=93%
**Valid percent reflects percent of respondents who answered the question

Table 41.

High School Characteristics: AISS Cohort 2 Freshmen, Fall 2008 (N= 25)

Variable	N	Valid %
Public Comprehensive	16	64.0
Public Charter	1	4.0
Public STEM Magnet	1	4.0
Public non-STEM Magnet	0	0.0
Private Parochial	5	20.0
Private Independent	2	8.0
Coeducational	23	92.0
Single gender	2	8.0
Day	24	96.0
Boarding	1	4.0
Small (less than 500)	4	16.0
Medium (500 – 1000)	7	28.0
Large (more than 1000)	14	56.0
Urban	5	20.0
Suburban	18	72.0
Rural	2	8.0
Advanced Placement Calculus AB	18	72.0
Advanced Placement Calculus BC	11	44.0
Advanced Placement Biology	10	40.0
Advanced Placement Chemistry	6	24.0
Advanced Placement Physics B	7	28.0
Advanced Placement Physics C	3	12.0

Table 42.

SAT-I Scores: AISS Cohort 2 Freshmen, Fall 2008

	SAT-Math			SAT-Critical Reading		
	N	Mean	SD	N	Mean	SD
AISS Cohort 1	25*	748	41	25	734	56

Note. *2 students did not report SAT scores

Table 43.

Probable Majors[*] & Degree Aspirations: AISS Cohort 2 Freshmen, Fall 2008 (N=25)

Variable	N	Valid %
Biology	7	28.0
Chemistry	1	4.0
3/2 Engineering	1	4.0
Environment, Economics, & Politics	2	8.0
Molecular Biology	1	4.0
Neuroscience	2	8.0
Organismal Biology and Ecology	1	4.0
Physics	1	4.0
Science and Management	2	8.0
Other	7	28.0
Pre-Medicine	8	32.0
Pre-Dental	0	0.0
Pre-Veterinary	0	0.0
Degree aspirations—Bachelor's	2	8.0
Degree aspirations—Master's	6	24.0
Degree aspirations—Ph.D.	11	44.0
Degree aspiration—M.D.	6	24.0

Note. [*]Reflects 9 of the 17 majors offered by JSD

Table 44.

Selected Self-Concepts: AISS Cohort 2 Freshmen, Fall 2008 (N=25)

	AISS Cohort 1	
Self-Concepts	M*	SD
Academic ability	4.48	.51
Drive to achieve	4.28	.62
Mathematical ability	4.20	.50
Problem solving	4.04	.61
Critical thinking	4.00	.58
Compassion	3.88	.83
Cooperation	3.84	.69
Self understanding	3.76	.78
Competitiveness	3.71	.99
Intellectual self-confidence	3.68	.69
Spatial ability	3.60	.76
Leadership	3.56	.87
Creativity	3.36	.64
Risk taking	3.16	.97
Social self-confidence	3.12	.97
Computer skills	3.00	.76
Artistic ability	2.96	.99

Note. *Likert scale: 5=highest 10%, 4=above average, 3=average, 2=below average, 1=lowest 10%

Table 45.

Preparedness for College-level Work: AISS Cohort 2 Freshmen, Fall 2008 (N=25)

Variable	N	Valid %*	Mean	SD
Mathematics coursework	17	68.0	2.76	.52
Working in groups	15	60.0	2.60	.50
Science coursework	11	44.0	2.52	.59
Writing skills	14	56.0	2.52	.59
Laboratory experience	7	28.0	2.00	.76
Independent research	5	20.0	1.92	.70
Computer technology	6	24.0	1.84	.80

Note. * "Well prepared" on a Likert scale: 3=well prepared, 2=somewhat prepared, 1=poorly prepared

Spring Freshman Survey — Cohort 2 AISS Students (2008-2009)

Table 46.

Probable Majors[*] & Degree Aspirations: AISS Cohort 2 Freshmen, Spring 2009 (N=25)[**]

Variable	N	Valid %
Biology	6	24.0
Environment, Economics, & Politics	2	8.0
3/2 Engineering	2	8.0
Molecular Biology	0	0.0
Neuroscience	2	8.0
Physics	1	4.0
Science and Management	2	8.0
Other	8	32.0
Undecided/Did not know	2	8.0
Pre-Medicine	8	32.0
Pre-Dental	0	0.0
Pre-Veterinary	0	0.0

Note. [*]Reflects 7 of the 17 majors offered by JSD
**25 of the 26 students enrolled in AISS spring semester responded to the survey; response rate=96%

Table 47.

Selected Self-Concepts: AISS Cohort 2 Freshmen, Spring 2009 (N=25)

	AISS Cohort 1	
Self-Concepts	M*	SD
Academic ability	4.20	.50
Drive to achieve	4.12	.60
Mathematical ability	4.04	.54
Critical thinking	3.96	.45
Compassion	3.96	.80
Problem solving	3.92	.57
Cooperation	3.92	.70
Self understanding	3.92	.81
Intellectual self-confidence	3.76	.88
Creativity	3.68	.63
Leadership	3.64	.76
Spatial ability	3.60	.82
Competitiveness	3.56	.99
Social self-confidence	3.24	.93
Risk taking	3.08	.91
Computer skills	2.96	.79
Artistic ability	2.96	.93

Note. *Likert scale: 5=highest 10%, 4=above average, 3=average, 2=below average, 1=lowest 10%

Table 48.

Confidence in Science Content/Skills: AISS Cohort 2 Freshmen, Spring 2009 (N=25)

Variable	N	Valid %*	Mean	SD
Have a solid understanding of introductory physics concepts	16	64.0	4.24	1.01
In formal academic writing skills	23	92.0	4.12	.67
In laboratory skills acquired	21	84.0	4.00	.82
In laboratory experience gained	19	76.0	3.96	.89
Have a solid understanding of introductory biology concepts	20	80.0	3.68	.90
Have a solid understanding of introductory chemistry concepts	16	64.0	3.60	1.11
In ability to use high-tech scientific equipment in a laboratory setting	14	56.0	3.48	.87
In ability to ask and investigate an original research question	10	40.0	3.16	.90
Will publish as an undergraduate	3	12.0	2.80	.96

Note. * "Agree + strongly agree" on a Likert scale: 5=strongly agree, 4=agree, 3=no opinion, 2=disagree, 1=strongly disagree

Sophomore Survey — Cohort 2 AISS Students (2009-2010)

Table 49.

Probable Majors[*] & Degree Aspirations: AISS Cohort 2 Sophomores, Spring 2010 (N=19)

Variable	N	Valid %
Biology	6	31.6
3/2 Engineering	2	5.3
Neuroscience	1	5.3
Physics	1	5.3
Science and Management	2	10.5
Dual Major[†]	1	5.3
Other/Not Science Major	4	21.1
Undecided/Did not know	2	10.5
Pre-Medicine	6	31.6
Pre-Dental	0	100
Pre-Veterinary	0	100
Degree aspirations—Bachelor's	3	15.8
Degree aspirations—Master's	4	21.1
Degree aspirations—Ph.D.	6	31.6
Degree aspiration—M.D.	6	31.6

Note. [*] Reflects 6 of the 17 majors offered by JSD

[**] 19 of the 26 students who completed AISS responded to sophomore survey; response rate=73%

[†] Dual major in Biology and International Relations

Table 50.

Selected Self-Concepts: AISS Cohort 2 Sophomores, Spring 2010 (N=19)

	AISS Cohort 1	
Self-Concepts	M*	SD
Drive to achieve	4.26	.65
Problem solving	4.21	.63
Ability to reason logically**	4.16	.76
Ability to work hard**	4.16	.69
Determination**	4.11	.88
Critical thinking	4.11	.66
Mathematical ability	4.11	.66
Compassion	4.00	.00
Persistence**	3.95	.85
Writing ability**	3.84	.50
Time management**	3.84	.76
Spatial ability	3.84	.98
Competitiveness	3.79	.98
Creativity	3.79	.85
Optimism**	3.58	.96
Collaboration**	3.42	.96
Social self-confidence	3.26	.99
Artistic ability	3.05	.97
Risk taking	3.00	.98

Note. *Likert scale: 5=highest 10%, 4=above average, 3=average, 2=below average, 1=lowest 10%
**Self-concepts that appeared on sophomore survey, but not freshman surveys

Appendix J

Survey Results, Cohort 3

Fall Freshman Survey — Cohort 3 AISS Students (2009-2010)

Table 51.

Demographic Characteristics: AISS Cohort 3 Freshmen, Fall 2009 (N=26) *

Variable	N	Valid %**
Female	19	73.1
Male	7	26.9
Claremont McKenna College	9	34.6
Pitzer College	3	11.5
Scripps College	14	53.8
African American/Black	1	3.8
Asian American	6	23.1
Latino (not Mexican American)	0	0.0
White/Non-Hispanic	16	61.5
Other/Biracial	3	11.5
Native English speaker	26	100.0
Not Native English speaker	0	0.0
Father with a graduate degree	13	50.0
Mother with a graduate degree	14	53.8
Both parents with graduate degrees	9	34.5

Note. *26 of the 27 students enrolled in AISS fall semester responded to the survey; response rate=96%
**Valid percent reflects percent of respondents who answered the question

Tale 52.

High School Characteristics: AISS Cohort 3 Freshmen, Fall 2009 (N= 26)

Variable	N	Valid %
Public Comprehensive	14	53.8
Public Charter	0	0
Public STEM Magnet	0	0
Public non-STEM Magnet	2	7.7
Private Parochial	3	11.5
Private Independent	7	26.9
Coeducational	25	96.2
Single gender	1	3.8
Day	23	88.5
Boarding	3	11.5
Small (less than 500)	7	26.9
Medium (500 – 1000)	5	19.2
Large (more than 1000)	14	53.8
Urban	9	34.6
Suburban	16	61.5
Rural	1	3.8
Advanced Placement Calculus AB	9	34.6
Advanced Placement Calculus BC	2	7.7
Advanced Placement Biology	8	30.7
Advanced Placement Chemistry	3	11.5
Advanced Placement Physics B	3	11.5
Advanced Placement Physics C	3	11.5

Table 53.

SAT-I Scores: AISS Cohort 3 Freshmen, Fall 2009

	SAT-Math			SAT-Critical Reading		
	N	Mean	SD	N	Mean	SD
AISS Cohort 3	18*	727	40	18	691	53

Note. *8 students did not report SAT scores

Table 54.

Probable Majors[*] & Degree Aspirations: AISS Cohort 3 Freshmen, Fall 2009 (N=26)

Variable	N	Valid %
Biology	5	19.2
Biochemistry	6	23.1
Chemistry	2	7.7
Environment, Economics, & Politics	2	7.7
Environmental Science	1	3.8
Human Biology	1	3.8
Management and Engineering	1	3.8
Neuroscience	2	7.7
Physics	2	7.7
Other	4	15.3
Pre-Medicine	6	23.1
Pre-Dental	0	0.0
Pre-Veterinary	0	0.0
Degree aspirations—Bachelor's	2	7.7
Degree aspirations—Master's	5	19.2
Degree aspirations—Ph.D.	13	50.0
Degree aspiration—M.D.	6	23.1

Note. [*]Reflects 9 of the 17 majors offered by JSD

Table 55.

Selected Self-Concepts: AISS Cohort 3 Freshmen, Fall 2009 (N=26)

	AISS Cohort 1	
Self-Concepts	M*	SD
Cooperation	4.07	.63
Drive to achieve	4.00	.63
Academic ability	3.96	.44
Critical thinking	3.92	.63
Compassion	3.85	.92
Self understanding	3.81	.80
Intellectual self-confidence	3.77	.65
Mathematical ability	3.73	.60
Problem solving	3.73	.67
Leadership	3.62	.90
Spatial ability	3.62	.64
Competitiveness	3.50	.98
Social self-confidence	3.50	.99
Creativity	3.50	.71
Risk taking	3.27	.87
Computer skills	3.19	.63
Artistic ability	2.96	.77

Note. *Likert scale: 5=highest 10%, 4=above average, 3=average, 2=below average, 1=lowest 10%

Table 56.

Preparedness for College-level Work: AISS Cohort 3 Freshmen, Fall 2009 (N=26)

Variable	N	Valid %*	Mean	SD
Working in groups	23	88.5	2.88	.53
Science coursework	17	65.4	2.62	.57
Mathematics coursework	15	57.7	2.54	.57
Writing skills	13	50.0	2.38	.70
Laboratory experience	10	38.5	2.15	.78
Computer technology	6	23.1	2.04	.66
Independent research	5	19.2	1.88	.71

Note. * "Well prepared" on a Likert scale: 3=well prepared, 2=somewhat prepared, 1=poorly prepared

Spring Freshman Survey — Cohort 3 AISS Students (2009-2010)

Table 57.

Probable Majors[*] & Degree Aspirations: AISS Cohort 3 Freshmen, Spring 2010 (N=23)[**]

Variable	N	Valid %
Biology	4	17.4
Biochemistry	1	4.3
Chemistry	3	13.0
Environment, Economics, & Politics	1	4.3
Environmental Science	0	0.0
Molecular Biology	2	8.7
Neuroscience	2	8.7
Physics	4	17.4
Other	3	13.0
Undecided/Did not know	2	8.7
Pre-Medicine	3	13.0
Pre-Dental	0	0.0
Pre-Veterinary	0	0.0

Note. [*]Reflects 8 of the 17 majors offered by JSD
[**]23 of the 26 students enrolled in AISS spring semester responded to the survey; response rate=88%

Table 58.

Confidence in Science Content/Skills: AISS Cohort 3 Freshmen, Spring 2010 (N=23)

Variable	N	Valid %*	Mean	SD
Have a solid understanding of introductory physics concepts	21	91.3	4.17	.90
Have a solid understanding of introductory chemistry concepts	20	86.9	4.04	.93
In ability to ask and investigate an original research question	18	78.3	4.00	.80
Have a solid understanding of introductory biology concepts	17	73.9	3.91	.90
In formal academic writing skills	16	69.6	3.78	.85
In laboratory skills acquired	15	65.2	3.65	.88
In laboratory experience gained	12	52.2	3.48	1.04
In ability to use high-tech scientific equipment in a laboratory setting	11	47.8	3.43	.95
Will publish as an undergraduate	5	21.7	2.87	.87

Note. * "Agree + strongly agree" on a Likert scale: 5=strongly agree, 4=agree, 3=no opinion, 2=disagree, 1=strongly disagree

Table 59.

Selected Self-Concepts*: AISS Cohort 3 Freshmen, Spring 2010 (N=23)*

	AISS Cohort 1	
Self-Concepts	M*	SD
Academic ability	3.96	.97
Cooperation	3.96	.93
Drive to achieve	3.78	.99
Compassion	3.78	.90
Intellectual self-confidence	3.61	.66
Spatial ability	3.61	.72
Mathematical ability	3.57	.66
Creativity	3.57	.66
Critical thinking	3.52	.73
Self understanding	3.48	.95
Leadership	3.43	.98
Problem solving	3.39	.72
Risk taking	3.39	.99
Competitiveness	3.35	.98
Computer skills	3.26	.62
Artistic ability	3.17	.83
Social self-confidence	2.91	.98

Note. *Likert scale: 5=highest 10%, 4=above average, 3=average, 2=below average, 1=lowest 10%

Appendix K

Survey Results, Cohort 4

Fall Freshman Survey — Cohort 4 AISS Students (2010-2011)

Table 60.

Demographic Characteristics: AISS Cohort 4 Freshmen, Fall 2010 (N=27)[*]

Variable	N	Valid %[**]
Female	23	85.2
Male	4	14.8
Claremont McKenna College	9	33.3
Pitzer College	3	11.1
Scripps College	15	55.6
African American/Black	1	3.7
Asian American	5	18.5
Latino (not Mexican American)	0	0.0
White/Non-Hispanic	19	70.4
Other/Biracial	2	7.4
Native English speaker	24	88.9
Not Native English speaker	3	11.1
Father with a graduate degree	16	59.3
Mother with a graduate degree	7	25.9
Both parents with graduate degrees	5	18.5

Note. [*]27 of 27 students enrolled in AISS fall semester responded to the survey; response rate=100%
[**]Valid percent reflects percent of respondents who answered the question

Table 61.

High School Characteristics: AISS Cohort 4 Freshmen, Fall 2010 (N= 27)

Variable	N	Valid %
Public Comprehensive	18	66.7
Public Charter	0	0.0
Public STEM Magnet	0	0.0
Public non-STEM Magnet	1	3.7
Private Parochial	3	11.1
Private Independent	5	18.5
Coeducational	26	96.3
Single gender	1	3.7
Day	26	96.3
Boarding	1	3.7
Small (less than 500)	6	22.2
Medium (500 – 1000)	3	11.1
Large (more than 1000)	18	66.7
Urban	6	22.2
Suburban	0	0.0
Rural	21	77.8
Advanced Placement Calculus AB	--	--
Advanced Placement Calculus BC	--	--
Advanced Placement Biology	--	--
Advanced Placement Chemistry	--	--
Advanced Placement Physics B	--	--
Advanced Placement Physics C	--	--

Table 62.

SAT-I Scores: AISS Cohort 4 Freshmen, Fall 2010

	SAT-Math			SAT-Critical Reading		
	N	Mean	SD	N	Mean	SD
AISS Cohort 1	24*	743	33	24	736	48

Note. *3 students did not report SAT scores

Table 63.

Probable Majors [*] *& Degree Aspirations AISS Cohort 4 Freshmen, Fall 2010 (N=27)*

Variable	N	Valid %
Biology	7	25.9
Human Biology	1	3.7
Biochemistry	3	11.1
Chemistry	2	7.4
Environmental Analysis	1	3.7
Molecular Biology	1	3.7
Neuroscience	5	18.5
Physics	1	3.7
Science and Management	1	3.7
Other	5	18.5
Pre-Medicine	11	40.7
Pre-Dental	0	0.0
Pre-Veterinary	1	3.7
Degree aspirations—Bachelor's	0	0.0
Degree aspirations—Master's	6	22.2
Degree aspirations—Ph.D.	11	40.7
Degree aspiration—M.D.	9	33.3
Degree aspiration—J.D.	1	3.7

Note. [*] Reflects 9 of the 17 majors offered by JSD

Table 64.

Selected Self-Concepts: AISS Cohort 4 Freshmen, Fall 2010 (N=27)

	AISS Cohort 1	
Self-Concepts	M*	SD
Academic ability	4.30	.61
Compassion	4.19	.74
Drive to achieve	4.15	.66
Self understanding	3.93	.78
Mathematical ability	3.89	.85
Problem solving	3.89	.64
Cooperation	3.88	.75
Critical thinking	3.81	.68
Intellectual self-confidence	3.74	.71
Competitiveness	3.70	.72
Leadership	3.56	.80
Creativity	3.44	.70
Social self-confidence	3.37	.84
Spatial ability	3.26	.94
Risk taking	3.19	.74
Computer skills	2.96	.85
Artistic ability	2.93	.80

Note. *Likert scale: 5=highest 10%, 4=above average, 3=average, 2=below average, 1=lowest 10%

Table 65.

Preparedness for College-level Work: AISS Cohort 4 Freshmen, Fall 2010 (N=27)

Variable	N	Valid %*	Mean	SD
Mathematics coursework	17	62.9	2.70	.54
Working in groups	15	55.6	2.74	.45
Science coursework	11	40.7	2.59	.57
Writing skills	14	51.8	2.52	.58
Laboratory experience	7	25.9	1.96	.76
Independent research	5	18.5	1.44	.64
Computer technology	6	22.2	1.63	.69

Note. * "Well prepared" on a Likert scale: 3=well prepared, 2=somewhat prepared, 1=poorly prepared