

**College Students' Attitudes About the Importance of
Field/Project Based Experiences in Their Science
Education**

A survey of college undergraduate students

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Table of Contents:

I Introduction to the problem and background	Page 3
II. Research Questions	Page 6
III. Pilot study	Page 7
IV. This study: Survey Methods	Page 9
V. Results	Page 11
VI. Conclusions	Page 22
References cited	Page 25

List of Figures

Figure 1	Ethnic background of respondents
Figure 2	Income brackets of respondents
Figure 3	Parents' education
Figure 4	Attitudes about upper division classes
Figure 5	Attitudes about lower division classes
Figure 6	'Hands-on' opportunities in lower division classes
Figure 7	How students heard about their experiential learning opportunity
Figure 8	Attitudes about the importance of experiential learning

List of Tables

Table 1	Attributes of favorite classes
Table 2	What students consider important characteristics of their teachers
Table 3	Questions about experiential learning arranged into 'cognitive' and 'affective' groups

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I Introduction to the problem and background

This study investigates science students' attitudes about the importance of experiential learning, and what they found most important about the experience. It is part of a larger study investigating and interpreting science student attitudes towards experiential learning and science inquiry in their college curriculum. For the purposes of this survey study, experiential learning is defined as the following: a) intensive field-based experiences that are project based - these could be several days to weeks in the field, or a semester long class that emphasizes field work and student projects; b) internships and; c) student research project work (eg. independent research projects etc). A key element is that the students themselves are engaged in asking scientific questions, designing methods, collecting evidence to support their questions, and thinking critically about the process. The survey targets students engaging in ecological (particularly marine/coastal) or related biological/environmental studies.

In particular, this study focuses on students' views of their science classes, the importance of experiential learning for skill acquisition, knowledge acquisition, and personal development/motivation, access to these kinds of programs/classes, and the impact such programs/classes have on their engagement in science and their understanding of their role in science (their future if you will).

It has been well documented that experiential learning is one of the most effective ways for learners to acquire and demonstrate knowledge and skills (Barron, B.J, D.L. Schwartz, N.J Vye, A. Moore, A. Petrosino, L. Zech, J.D Bradsford, and Cognition and Technology group at Vanderbilt, 1998). Yet once students reach middle school, there are often very few opportunities to engage in these kinds of learning environments in school. By

the time students enter college, many are thinking about what field to enter, and choose classes accordingly. Although the numbers who choose a biology (or natural sciences) track are high, the numbers who drop out from that track are also very high (National Center for Educational Statistics <http://nces.ed.gov/pubs99/digest98/d98t209.html>; Sanderson A, B. Dugoni, T. Hoffer and L. Selfa, 1999). Experiential opportunities in the sciences are often not available to students until their last two years (or last year) in college, if at all. If these experiences were available earlier, would it help engage more students in the sciences and help them stay on a science track? How valuable are these kinds of experiences? What kind of impact do they have on students? What do students think about the importance of experiential learning in the sciences?

In the field of science education, a distinction is made between formal and informal learning. The nature of this difference however varies greatly. Some researchers argue that informal learning is almost entirely self guided, with very little structure or direct participation on the part of the teacher (Wells 1999; Griffin and Symington 1997; Gallas, 1994). Others take a more moderate view, arguing that informal learning can be a component of a larger, highly structured learning experience, or a learning experience in and of itself which is fairly structured and teacher guided (Fernandez-Manzanal et al, 1999; Minstrell 1999; Ryder et al, 1998; Jones 1997; Rosebery et al 1992;). One thing these researchers and others do have in common however is their belief in the importance of 'informal' learning to student acquisition and understanding of key concepts.

Of particular interest is the impact of these experiences on underrepresented people in science. Ethnic minorities and people from lower socioeconomic backgrounds are poorly represented in science for numerous reasons (Dale, 2000; Ellis 2000; National Center for

Educational Statistics, 1998; Sanderson et al. 1998; Allen et al. 1992). For some children and youth from non-mainstream (European-American) communities, engaging and succeeding in school is a difficult and sometimes unsuccessful endeavor (Stanton-Salazar, Vasquez, and Mehan 2000). Many of these youth are considered 'at risk' of failing or not completing high school. For these students the classroom and the school environment in general do not create a learning environment they can connect with. Interactive learning programs can create a sense of community for some of these youth, and create a means for them to participate as members of a community, making the academic information more relevant, and enabling them to see how they fit into the larger school community and beyond (Halpern 2002 Gibson and Bejinez, 2002; Halpern, 2002; Kahne, Nagaoka, Brown, O'Brien, Quinn and Thiede 2001, Posner and Vandell 1994). An understanding of how to better recruit and retain underrepresented youth in the sciences is critical to the development of the fields of science, and scientists with varied backgrounds and perspectives are essential to a well-rounded, cutting edge approach to discovery and scientific advancement.

Why informal learning? There is a growing body of evidence suggesting that students' behavior and relationships with subject matter change or are influenced through hands-on experiences. Several studies have documented that high school and science undergraduate students' gain a deeper understanding of science, how to apply it, and what their career goals are through field-based experiences and/or designing and carrying out research projects (Fernandez-Manzanal et al, 1999; Barron 1998; Ryder et al. 1998; Jones 1997). Other research points to the use of inquiry-based techniques, including student directed research/inquiry projects, to enhance learning of difficult concepts (Southerland et al. 2001; Bowen 2000; Hammer, 1996; Minstrell 1999; Rosebery 1992).

Within this theoretical context, this survey was designed to address the following research questions:

II. Research Questions

According to the students themselves:

- Are field/project-based classes or experiences important for developing students' understanding, engagement and retention in science?

Specific questions:

- What is the availability of these kinds of experiences to college undergraduate students?
 - What (if anything) motivated students to pursue science?
 - What was the nature of their college experience in science classes?
 - What do they perceive as the major attributes of a field oriented (experiential) class?
 - What impact did the experiential class have on their ability to 'do' and 'participate in' science: apply process
 - What impact did the experiential class have on their personal growth and motivation, including their perceived role in the sciences?
 - What specific skills and knowledge did they gain as a result of the experiential class?
 - How did participation in an experiential class affect their attitudes about science, their ability to apply it, and their future role

III. Pilot study

A pilot study was conducted on 11 students during a field ecology class taught in Big Sur California in the summer 2001. Students were given pre and post class questionnaires, and a subset of 3 students was interviewed.

In the Big Sur Pilot study, I set out to document the effects of intensive project-based learning, with an emphasis on group projects and discussion, on a small group of college undergraduate science majors. I sought to apply research and theory to my own teaching (I was the instructor). In particular I was interested in students' attitudes towards science, their understanding of the processes involved in asking and 'answering' a scientific question, and drawing conclusions, and their own personal understanding of what environmental science

and field research was. I was also interested in how they felt about the preparation they received in college, and why they were interested in this field of science.

The analysis showed a shift over the period of the class in student understanding about what science was, and their ability to understand and conduct field investigations into scientific questions. Working in small groups on complex questions which they had designed allowed them to develop reasoning skills, and participate in a discussion about the ‘truth’ behind their discovery. As Rosebury and colleagues point out (Rosebury et al 1992), ‘real’ science is a process of negotiating, arguing, and discussing meaning, not just observing measurements. Science is the art of convincing others about interpretations. I watched my students do this, and in the process gain confidence and a deeper understanding and appreciation of science.

In the process of reasoning through their results and drawing conclusions, which often involved hypothesizing causalities, students found it necessary to bring in many fields of science, including chemistry, physics, and molecular biology, and applying aspects of these to their particular ecological problem. Through this process they gained two critical insights which they had been taught but had never applied: 1) science is interconnected, and the different fields of science include pieces of the puzzle of a scientific question that are key to solving it, and 2) knowledge of these fields gives the investigator a distinct advantage to being able to draw conclusions. This latter insight helped the students see the relevance of classes they normally dreaded (eg. chemistry and physics) to their chosen field of study.

IV. This study: Survey Methods

This survey was a self administered questionnaire given to undergraduate (or recently graduated) science students. Surveys were either handed out to students directly in class, e-mailed, or handed to individuals. The survey took from 10-25 minutes to fill out. A total of 28 surveys were completed, of 55 surveys distributed.

Population surveyed:

Survey participants were college science students, either declared majors or seriously considering a science track, or recently graduated science students.

Survey questions:

The survey consisted of both open and close ended questions in 4 general categories, with 29 questions total. Four of the questions were further broken down into subquestions with specific attitude measures.

There were four major questions with subquestions measuring attitudes. The first was a series of questions about what they thought about their college science classes. These were answered on a five point scale (hated it, didn't like it much, liked it ok, loved it, or didn't take it). Questions about the important characteristics of a science teacher were answered on a 4 point scale (not at all important, somewhat important, important, or very important). Questions about their lower division science classes were answered on a 4 point scale (strongly disagree, disagree, agree, strongly agree). Questions about their experiential learning opportunity were answered on the same 4 point scale.

The four major categories were:

- 1) Background information about the student's education. This section included questions such as year in college, degree they are pursuing and career goal.
- 2) Their attitudes about their educational experience. Questions in this section were designed to better understand student attitudes about their upper and lower division classes and their teachers. It included questions such as 'rate your science classes on the following scale: hated it, didn't like it much, liked it ok, loved it or didn't take it. It also asks them to list the main attributes of their favorite classes, and to rate important attributes of a good science teacher.
- 3) Their experience and attitudes towards experiential learning opportunities they have participated in. This section asks open ended questions such as 'describe the experiential learning opportunity', and 'What were some of the most important things overall you feel you gained from this experiential learning opportunity'. It also asks students to rank statements about experiential learning on a 4 point scale such as: 'It helped me understand how to apply the scientific method and ask a scientific question'.
- 4) Background information about the student and their family. Students were asked questions about their age, ethnic group, socio-economic bracket of their parents, and parents' education.

V. Results

A. Student population surveyed

Students surveyed in this study consisted primarily of Anglo-American (78.57%) middle (43%) and upper income (43%) backgrounds. The non-Anglo-American respondents were Asian (7%), Chicano/a, Latino/a (11%), and other (Figure 1 and 2). In terms of their academic performance, 100% of the students self rated at average to excellent. In terms of

parent's education, the majority of respondents (87.5%) had parents (mother and father) who had at least attended college, 71.5% had parents who graduated college, and 37.5% had parents who attended graduate school (Figure 3).

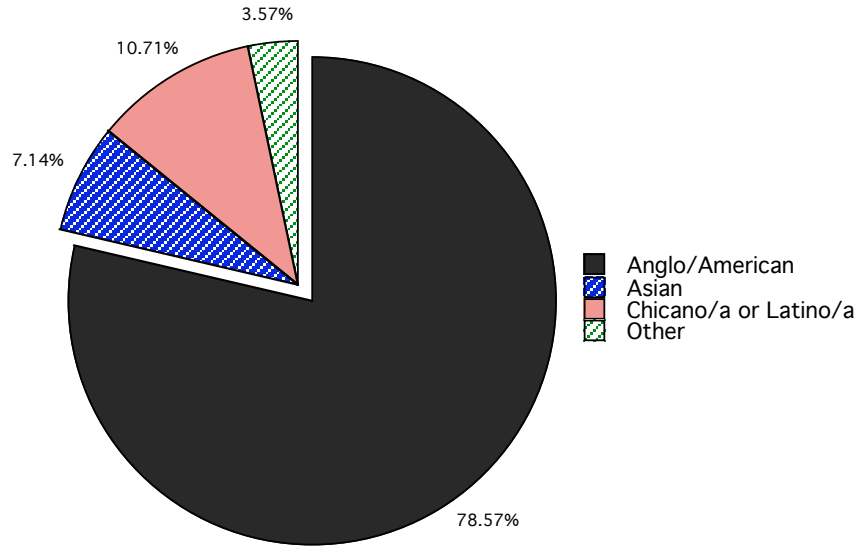


Figure 1: Ethnic group respondents most identified with

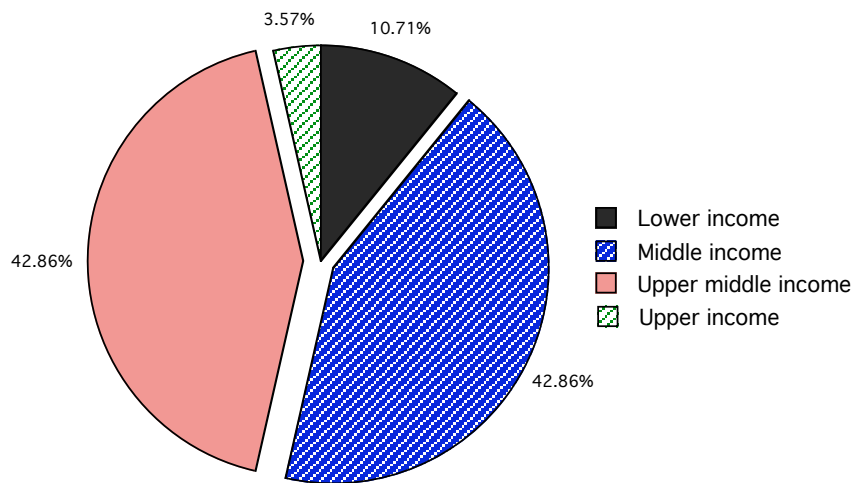
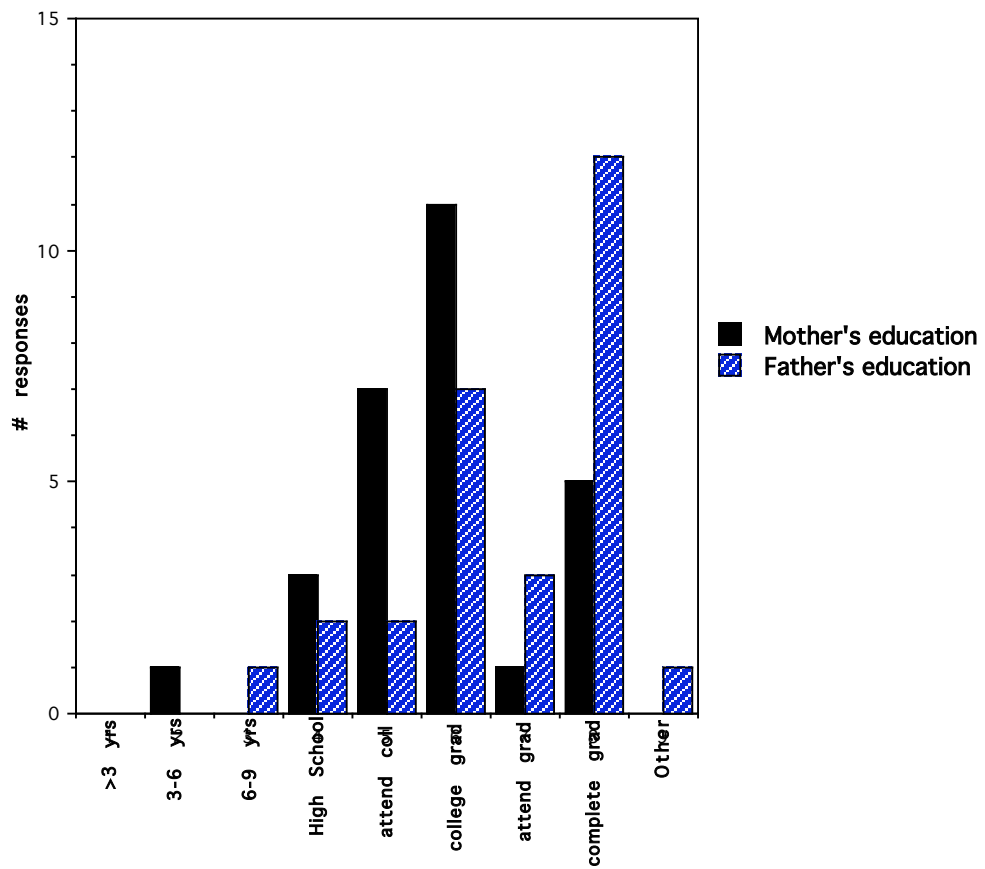


Figure 2: Income bracket of respondents

Figure 3: Parent's Education



Ninety three percent of respondents were juniors, seniors, or recently graduated.

Sixty percent were female and 40% were male. They tended to be students in their 20's, with

50% between the ages of 21-22, and 32% between the ages of 23-30. Eighty six percent of respondents were either in a biology track (with an emphasis on science rather than medicine) (82%), or environmental science (3%).

The major categories for career goals were Biologist most interested in field work (78%), Environmental scientist/conservation (40%), and Researcher (40%) (Note that respondents could check more than one category here). These students were also asked to describe their ideal job. Major themes included working outdoors, working with animals, working near the ocean, doing research, veterinary medicine, being a professor or teacher, business (such as own a pet store), making a difference, and not sure. Some students were clearly more interested in doing and directing research "...be a researcher at Scripps Institute of Oceanography and be a professor..", while others were more interested in assisting research or field work "...I would like to teach or help out with field work or research..". The majority however expressed a desire to be involved at a high level in their work (owner, director, researcher).

Seventy five percent of respondents said that there had been an important event or experience in their lives that attracted them to science and got them interested in it. Typical examples of those experiences reflect the socio-economic bracket of the majority of the respondents and include: an outdoor experience (including learning how to scuba dive), their parents (taking them on trips etc.), going to museums and aquariums, an internship/working on a project, and a class or teacher.

B. Attitudes about college science classes.

These questions were asked in an effort to assess how students feel about their classes, and what opportunities they had in lower division classes to 'do' science, or partake in inquiry based learning. Data presented here only include responses for classes that had a high probability of some hands-on component, or ones that seemed to fit the degree and career track of the majority of respondents: Ecology, Biology Lab class, Environmental Science, Independent study and Field class. The data are broken down by upper and lower division classes.

Although the majority of students liked or loved these classes in both cases, the scale is pushed more to the right (indicating a more favorable view) for upper division classes (Figures 4 and 5) than for lower division classes. This finding might not be surprising, and may in part be due to smaller class sizes and other factors in upper division classes. However it does raise the issue of retention in science, and the possibility that lower division classes are not as well liked and so do not help engage and retain students as well as the upper division classes do. This may be a factor worth investigating when considering retention of underrepresented students in science. Attributes of favorite classes included their small size, opportunities for hands-on work, and enthusiastic professors (Table 1).

Figure 4: Attitudes about lower division classes

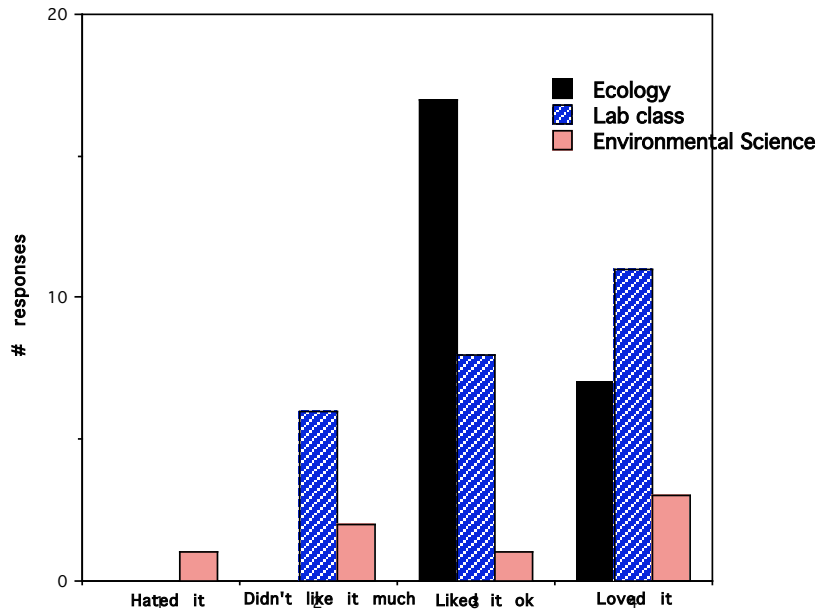


Figure 5: Attitudes about upper division classes

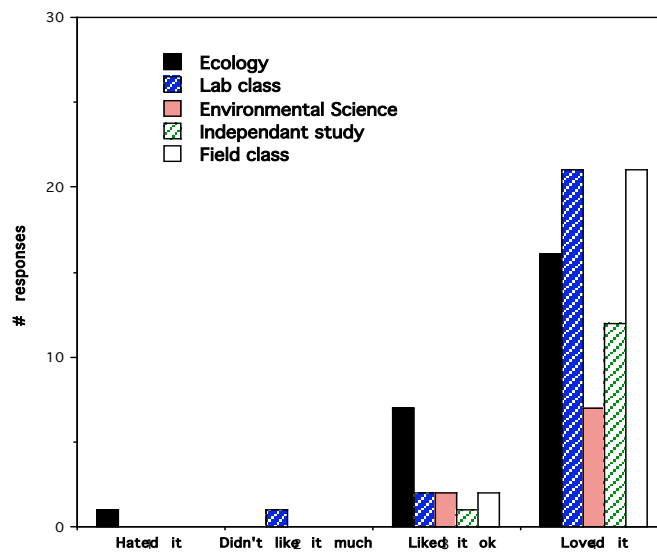
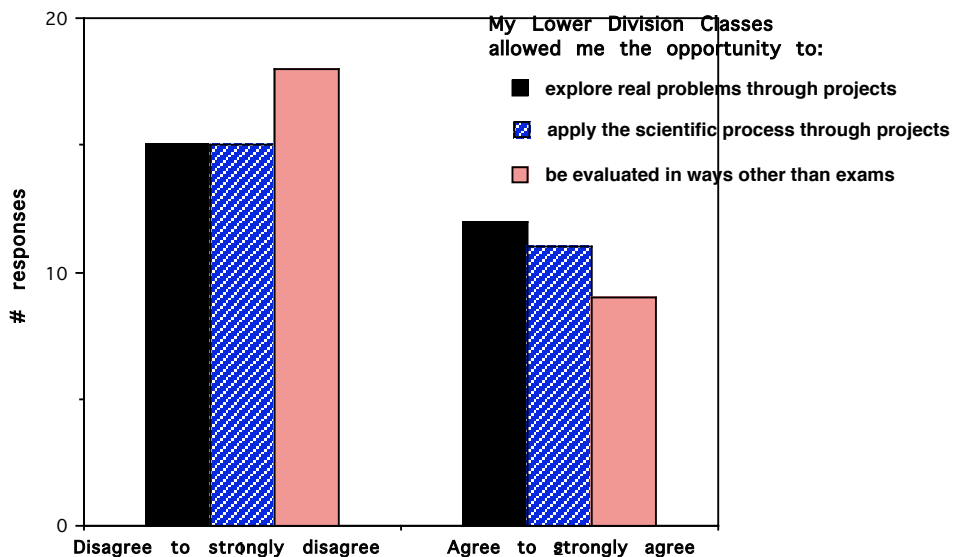


Table 1: Attributes of favorite classes

Class Attribute (how important is it?)	% Respondents agreeing
More Field Work	82%
More hands-on work	83%
Interesting material	89.3%
Enthusiastic professors	92.9%

When asked if their lower division classes offered them an opportunity to explore real problems and the scientific process through projects and be evaluated in ways other than exams (eg. on projects), 60% of respondents disagreed or strongly disagreed (Figure 6). While students feel these are important attributes of a good class (with the exception of being graded in ways other than exams - not asked in the attributes question), less than half of them feel they have the opportunity to do those things in lower division classes. Though not surprising, these results again draw attention to the issue of student retention: if they are not able to engage in lower division classes in ways they say are important, this may contribute to some of the observed drop-out, particularly for underrepresented students.

Figure 6: 'Hands on' opportunities in Lower Division classes



The following Table 2 summarizes what respondents thought were the most important characteristics of a good science teacher. While they thought knowledge was important, other factors pertaining to personality and practice were equally important.

Table 2: What students consider important characteristics of their teachers

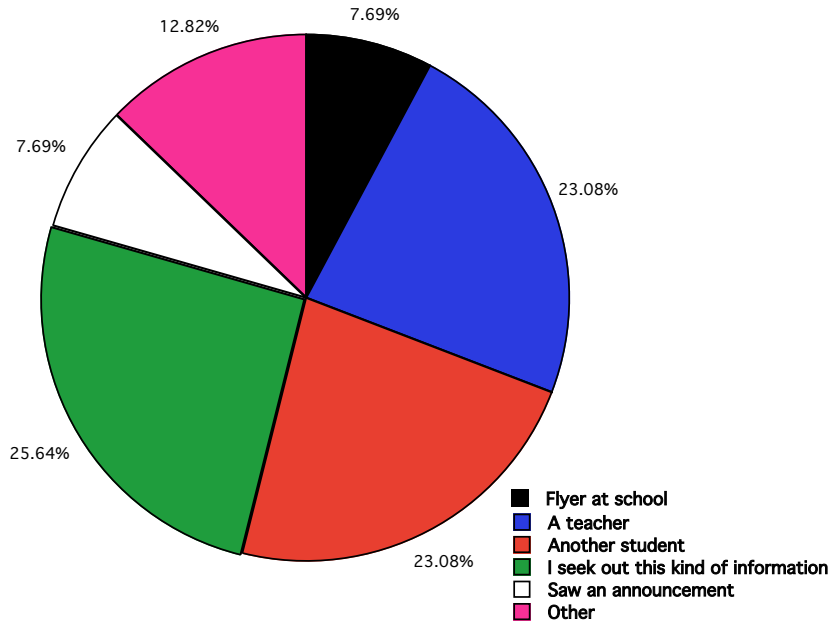
Characteristic	Agree that it is important	Agree that it is very important
Cares about me and how I do	36%	46.5%
Is easily approachable	21%	79%
Is passionate about what they do and teach	7%	93%
Knows their stuff	14%	86%
Likes to get us involved in <i>doing</i> science	18%	82%

C. Experiential learning

Results from the questions about experiential learning are based on surveys completed by 23 students. Five students declared they had not participated in an experiential learning opportunity. The majority of students described their experiential learning opportunity as a field class, or class with a major field component. Other categories included internships, and independent study.

In an effort to assess the availability of experiential learning opportunities (such as field classes), students were asked a variety of questions about access, advertisement and cost. Responses to these questions however are biased by the socio-cultural context of the majority of survey respondents. Seventy two percent of responses indicated hearing about the class through another student, a teacher, or they seek out that kind of information, with only 15% indicating learning about the opportunity through a flyer or announcement (Figure 7). Sixty five percent of respondents said they either disagreed or strongly disagreed that these kinds of experiences or classes are well advertised. Although it may seem desirable that students learn from each other, or are proactive in seeking out information, there are many students who do not have access to that type of networking or information. The issue then becomes not so much increasing the *numbers* of applicants to these programs (in many cases they are well attended), but the *types* of applicants: deliberate advertising to reach more diverse students. However, when asked if all science students have access to these kinds of experiences/classes, 56% of respondents said yes, reflecting perhaps their own ability to do so.

Figure 7: How students heard about their 'experiential learning' opportunity



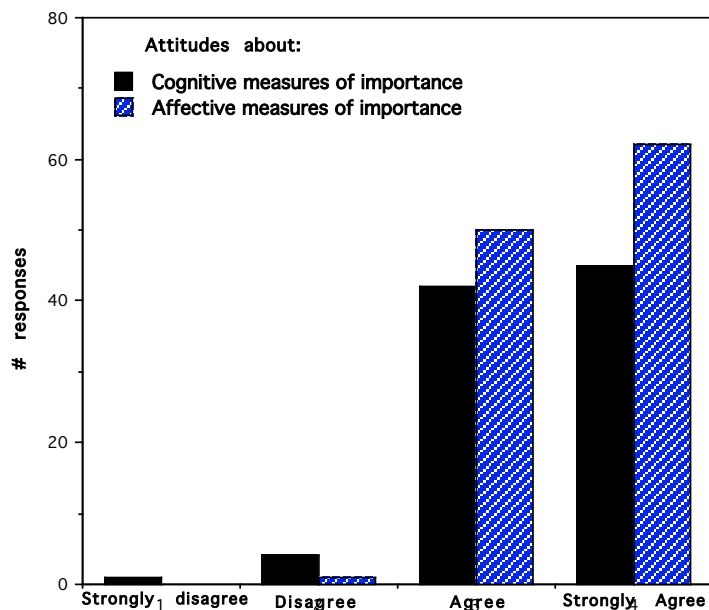
The section asking students to rate a statement about their experiential learning opportunity (from strongly disagree to strongly agree) included questions about cognitive importance and affective measures of importance. Table 3 lists the questions in each of these categories. Results (Figure 9) indicate that students overwhelmingly (97%) felt positively about their experiential learning. As interesting however is that the statements pertaining to the affective nature of the experience scored higher (more positively) than those describing the importance in cognitive development. One hundred percent of respondents felt positively about the importance of their experiential learning in helping them think about their future.

Table 3: Questions about experiential learning arranged into 'cognitive' and 'affective' groups

Cognitive	Affective
It helped me understand how to apply the scientific method and ask scientific questions	It got me excited about science

It helped me understand the relevance of my curriculum, such as the need for physics and chemistry	It made science more real for me because I was more involved
It helped me understand how to apply my skills and knowledge to a 'real life' situation	It gave me confidence in my ability to 'do' science and be a biologist/scientist
The experience helped me realize that real science is full of surprises, and a planned study may not go as planned	It gave me confidence in my ability to 'do' science and be a biologist/scientist
The experience helped me realize that data are not always what you think or hope in planning a study	It helped me think about my future and what I want to do

Figure 9: Attitudes about the importance of experiential learning



Responses to the open ended question " Reflect on how field experiences might change you as a person as well as a scientist or technician. What were some of the most important things overall you feel you gained from this experience, both academically and

personally?" also pointed to how important the experience was to students on a personal as well as academic level. Responses to this question were coded into the following categories: 1) helped me gain confidence/learn about me, 2) it was an important experience for me, 3) it improved my knowledge, 4) helped me gain important skills and understand scientific process, 5) helped me understand my career options, and 6) made science more real for me. Of the total responses coded, 52% of them pertained to affect (the importance to them personally) with comments such as: "I understand more about myself. I gained specific direction as to what I want to do with my future", "I realized I could use my creativity...", "I gained confidence in my ability...", "...It re-inspired me to love science again". Thirty two percent of responses fell into the knowledge/skills categories, and included statements such as "...making new equipment, designing experiments to yield accurate data...". a greater understanding of how to apply science", "...important skills such as experimental design, sampling...". Eighty two percent of all respondents made a statement in their open ended question that talked about how important the experiential learning was in helping them grow personally.

VI. Conclusions

Although the sample size for this study was small, it provided some insights into science student's attitudes towards experiential learning, and the importance of inquiry-based learning in their college career. It provides a starting point for looking more deeply into some of the issues.

First, it is not insignificant that the majority of the students are European -American and middle to upper middle class. Although there could be many reasons why the results of this particular survey came out that way, it is likely that the majority of students in

experiential learning classes at many major colleges and universities fit a similar profile. If it is truly a goal of policy makers, funders, scientists, and teachers to increase diversity in the sciences, then an effort to engage more underrepresented students early in their undergraduate experience through experiential learning may provide a mechanism to do so.

Many underrepresented students and minorities face difficult barriers in achieving success in school. Chief among these is the fact that many (in particular those from lower socio-economic brackets) do not have access to the same social capital—social networks and access to information and opportunities—as more 'mainstream' groups, due to their cultural and economic backgrounds (Gibson and Bejinez, 2002; Raley 2002; Portes and Rumbaut, 2001; Hooks 2000; Phelan et al. 1993). These social and cultural divisions among students can limit their access to social capital, and therefore institutional resources (such as access to information about experiential learning). With possibly less well educated parents, and parents who can't easily help their children take advantage of opportunities, many of these underrepresented students likely don't find out about opportunities, or can't afford them when they do (in terms of time as well as money). Therefore it is important to look at how students learn about experiential learning opportunities. Results from this survey show that the majority of the students learned about it 'word of mouth' or they seek out these kinds of opportunities. If we rely on 'word of mouth', that word will likely miss many mouths.

In looking at the results of what students think about their lower division classes, it is clear, despite the wealth of information pointing to the importance of hands-on inquiry based education, students do not feel they are getting much of that in their lower division classes. It seems relevant to ponder the following: if students are able to make it to college, and make a decision to pursue science (a monumental task for some students, especially many

underrepresented students), it doesn't seem enough to help them that far and then expect them to succeed on their own. Our system is designed for large, often impersonal lower division classes, and then the truly inspiring, more experiential classes just before graduation. Based on the results from this small study, students are gaining not just key knowledge and skills in their experiential learning classes, but they are making a connection, gaining confidence, and thinking about their future. The ability of experiential learning opportunities to motivate and engage students appears as important (if not more) as the cognitive benefits. Waiting until they are close to graduation for students to experience this seems a lost opportunity. If there were some way to offer even a taste of this to more lower division students, more of them, and more of a diversity of students, may retain an active interest in science, and be able to develop an informed plan for their path in higher education.

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