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Article

Undergraduate Science Research: A Comparison of Influences and Experiences between Premed and Non-Premed Students

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Most students participating in science undergraduate research (UR) plan to attend either medical school or graduate school. This study examines possible differences between premed and non-premed students in their influences to do research and expectations of research. Questionnaire responses from 55 premed students and 80 non-premed students were analyzed. No differences existed in the expectations of research between the two groups, but attitudes toward science and intrinsic motivation to learn more about science were significantly higher for non-premed students. Follow-up interviews with 11 of the students, including a case study with one premed student, provided explanation for the observed differences. Premed students, while not motivated to learn more about science, were motivated to help people, which is why most of them are pursuing medicine. They viewed research as a way to help them become doctors and to rule out the possibility of research as a career. Non-premed students participated in research to learn more about a specific science topic and gain experience that may be helpful in graduate school research. The difference in the reasons students want to do UR may be used to tailor UR experiences for students planning to go to graduate school or medical school.

INTRODUCTION

Few academic pursuits exist with the competitive reputation of medical school admissions. Since 2002, the number of medical school applicants has increased by over 30%, while the number of medical school matriculants has increased by only 11.5% (Association of American Medical Colleges, 2009). Entrance to medical school has consequently become increasingly competitive over the past decade. Along with clinical and volunteer experiences, research experience is rec-

ommended for those interested in attending medical school (Rockler-Gladen, 2007; Freedman, 2009).

Several of the top research and primary care medical schools (U.S. News and World Report, 2009) mention research experiences in their admissions guidelines. The vast majority of those schools offer summer research programs for undergraduate students with possible interest in medical school. Harvard Medical School (2010), for instance, evaluates applicants based not only on grade point average and MCAT scores but also on extracurricular activities, research, and service experiences. Johns Hopkins' medical school website tells potential applicants that, "The ability to conduct, evaluate, and understand research will be critical as medicine advances." Eighty percent of its medical students do research during their medical school experience (Johns Hopkins Medicine, 2010). Stanford University's School of Medicine highlights its strong commitment to student research, explaining that, "Investigative experience sharpens critical reasoning. Students who are educated in a research environment are stimulated to seek a deeper understanding of disease and develop their ability to analyze scientific literature, making them valued members of any medical field, whether it be academic

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medicine, community-based practice, health care policy or emerging technologies” (Stanford School of Medicine, 2010). Undergraduate research (UR) is, therefore, one experience that many students pursue to prepare them for medical school and to set themselves apart in the application process.

Most universities do not differentiate research experiences for those pursuing medical school and those pursuing other endeavors. The majority of students doing UR in science plan to continue their education upon completion of their bachelor’s degree (Bauer and Bennett, 2003). The obvious choices for further education in the sciences are pursuit of a master’s or doctorate degree in science or the pursuit of a medical doctor degree. The pursuit of a medical degree is quite different in nature than the pursuit of a science graduate degree. The influences on premed and non-premed students’ decisions to do research may also be quite different. The purpose of this study is to compare influences on research decisions and expectations of undergraduate science researchers who are planning to go to medical school and those who are not.

The research questions addressed in this study are as follows:

1. How do the influences to do undergraduate research compare between premed and non-premed students?
2. How do the expectations of undergraduates doing research in science compare between premed and non-premed students?
3. How do premed and non-premed students explain their experiences in research?

The goal of this study is to gain an understanding of the possible differences between aspiring medical students and their non-premed counterparts in regard to their influences and expectations of their research experiences. With that understanding, UR programs may be able to tailor their recruitment efforts and their research opportunities to best suit students with different future goals.

METHODS

Approach

A mixed methods approach was taken to address the research questions. Quantitative analysis via *t* tests was used to examine the differences in means between questionnaire responses from premed and non-premed students. Follow-up interviews with both premed and non-premed undergraduate researchers provided depth of understanding to further explain the quantitative results.

Questionnaire

The quantitative data were collected through an online questionnaire. A pilot questionnaire was administered during the summer of 2009 to 20 undergraduate science majors who were doing research at the time. Pilot questionnaire items were open-ended questions (see Table 1). Responses from the pilot questionnaire were used to construct Likert-scale questions for the actual research questionnaire. The questionnaire was composed of 53 Likert-scale questions (see Table 2) for nonresearch participants and 63 Likert-scale questions for research participants. The 10 additional questions related to

Table 1. Pilot questionnaire

1.	What are the advantages of doing undergraduate research in science?
2.	What are the disadvantages of doing undergraduate research in science?
3.	What people influenced you most in your decision to do undergraduate research in science?
4.	What specifically motivated you to do undergraduate research in science?
5.	What barriers are there to doing undergraduate research in science?
6.	What factors helped you be able to do undergraduate research in science?
7.	What are your expectations for your science research experience?
8.	What are your plans for participating in science research in the future?

the students’ expectations of their research experience and are shown in Table 5. All participants answered questions related to their attitudes and beliefs about science research. They also responded to items on accessibility, self-efficacy, and motivation related to doing UR in science. Several demographic questions at the end of the questionnaire asked students to identify their gender, major, race, grade point average, and postgraduation intentions. Their postgraduation intentions were used to separate participants into premed and non-premed groups.

An email was sent to all upper-level science majors via their department email list software. Approximately 1700 upper-level undergraduates are science majors at a major university in the southeastern United States. The email lists utilized included those for the following majors: biochemistry and molecular biology, biology, cell biology, chemistry, ecology, forestry and natural resources, genetics, microbiology, and physics and astronomy. The email that students received included a link that brought them to the survey questionnaire in SurveyMonkey (www.surveymonkey.com). The last item on the questionnaire asked students to provide an email address if they were willing to participate in follow-up interviews. Those who provided their email were contacted for interviews. The questionnaire was completed by 135 upper-level science majors spanning the life science and physical science disciplines.

Reliability

Questionnaire items were tested for reliability using Cronbach’s alpha, which measures the internal consistency reliability coefficient. A lenient cutoff for exploratory research is a value of .60 (Garson, 2010). Anything above .60 is acceptable, and below .60 is unreliable. Beliefs, attitudes, social influences, intrinsic motivation, self-efficacy, and accessibility were found to be reliable above the .60 level. The Cronbach’s alpha for items related to extrinsic motivation was .343, which indicates that those items are not reliable when analyzed as a group. The items related to expectations of research were not tested for reliability as a construct because the responses to individual expectation items were of more interest than a combined expectations mean. Each expectations item was analyzed individually to compare the means between premed and non-premed science majors.

Table 2. Survey instrument

1. Beliefs about science research—Please indicate your level of agreement with each of the following statements.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Science research is important to humanity.	<input type="radio"/>				
Everyone should experience science research.	<input type="radio"/>				
Only people with advanced degrees can do science research.	<input type="radio"/>				
The work of scientists has little effect on the lives of other people.	<input type="radio"/>				
Most problems can be solved with science research.	<input type="radio"/>				
Humans depend on science research in their everyday lives.	<input type="radio"/>				
Anyone can do science research.	<input type="radio"/>				
Most science is applicable to everyday life.	<input type="radio"/>				

2. Attitudes about science research—Please indicate your level of agreement with each of the following statements.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I would like to become a scientist.	<input type="radio"/>				
I would enjoy working with other people in a research setting.	<input type="radio"/>				
I enjoy my science classes.	<input type="radio"/>				
Doing science research is boring work.	<input type="radio"/>				
I like interacting with science professors.	<input type="radio"/>				
I prefer to work alone.	<input type="radio"/>				
I like talking about science with others.	<input type="radio"/>				
I would be unhappy in a career as a scientist.	<input type="radio"/>				
Doing science research is exciting.	<input type="radio"/>				
I enjoy exploring questions for which there is no clear answer.	<input type="radio"/>				

3. Accessibility and self-efficacy—Please indicate your level of agreement with each of the following statements.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Any student can participate in undergraduate research in science.	<input type="radio"/>				
The process of finding a research mentor was simple.	<input type="radio"/>				
Information on undergraduate science research at the University of Georgia is easily accessible.	<input type="radio"/>				
Applying to do undergraduate research was time consuming.	<input type="radio"/>				
I am confident in my ability to do undergraduate research in science.	<input type="radio"/>				
I am well prepared to do undergraduate research in science.	<input type="radio"/>				
I am capable of conducting undergraduate research in science.	<input type="radio"/>				
There are barriers for some students to do undergraduate research in science.	<input type="radio"/>				
I was not sure whether my research mentor would want to work with me.	<input type="radio"/>				
I have the knowledge and skills required to do research.	<input type="radio"/>				

4. Motivations and social factors—Please indicate the extent to which you agree with each of the following factors influencing your decisions regarding participation in undergraduate research in science.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Parental influence	<input type="radio"/>				
Interest in science	<input type="radio"/>				
Desire to go to graduate school or professional school (med, vet, dental, pharmacy)	<input type="radio"/>				
Desire to learn more about science	<input type="radio"/>				
Influence of friends	<input type="radio"/>				
Exploring the possibility of a future in science research	<input type="radio"/>				
Influence of academic advisor	<input type="radio"/>				
Influence of K–12 teacher	<input type="radio"/>				
Influence of college professor	<input type="radio"/>				
Enjoyment of science	<input type="radio"/>				
Earning course credit ^a	<input type="radio"/>				
Earning money ^a	<input type="radio"/>				
Getting a good letter of recommendation ^a	<input type="radio"/>				
Improving my resume ^a	<input type="radio"/>				
Getting into graduate or professional school ^a	<input type="radio"/>				

(Continued)

Table 2. Continued

5. Demographic information

- a. Are you female or male?
- b. Have you ever done undergraduate research in science? If so, please explain the context and duration of your research.
 - i. No
 - ii. Yes
- c. What is your academic major?
- d. Which of the following describe your race (you may choose more than one)?
 - i. Black
 - ii. White
 - iii. Asian or Pacific Islander
 - iv. Latino or Hispanic
 - v. Native American
 - vi. Other (please specify)
- e. What is your GPA?
 - i. Less than 2.5
 - ii. 2.5–2.99
 - iii. 3.0–3.49
 - iv. 3.5–4.0
- f. What do you plan to do after graduating from the University of Georgia?
 - i. Graduate school—science
 - ii. Graduate school—nonscience
 - iii. Medical school
 - iv. Veterinary school
 - v. Pharmacy school
 - vi. Dental school
 - vii. Nursing school
 - viii. Job—science related
 - ix. Job—not science related
 - x. Not sure
 - xi. Other (please specify)
- g. If you are willing, please provide your email address for possible follow-up interviews. You may discontinue your participation in this study at any time.

^aNot included in quantitative analysis

Mean Comparisons

The Statistical Program for the Social Sciences (SPSS), version 17.0 (IBM SPSS, 2008), was used to compute mean comparisons. Mean responses between premed and non-premed students were compared for each of the following seven constructs related to science research that emerged from the pilot questionnaire: beliefs, attitudes, social influences, intrinsic motivation, extrinsic motivation, self-efficacy, and accessibility. All participants ($n = 135$) completed questionnaire items for the seven constructs. Those respondents who were participating in research ($n = 80$) also completed questionnaire items related to their expectations of their research experience. Mean expectations were compared between premed and non-premed students. Independent sample, two-tailed Student's t tests were used to determine the significance of differences between mean expectations and outcomes. The Student's t test is a parametric test that calculates a t value that is compared with a critical value to determine whether the difference between the two samples is significant. The independent sample t test is used when two groups are independent of each other (i.e., not correlated), which is what we have in the case of premed and non-premed UR students. They have no effect on each other, so they are considered independent. A two-tailed test was used because there is no expected directionality to the potential difference between students' expectations and outcomes (Garson, 2008).

Interviews

Follow-up interviews were conducted with 11 of the participants who participated in UR in science to look at differences and similarities between the way they talked about their influences, expectations, and research experiences. Five of the 11 interview participants were premed science majors and six were non-premed science majors. Interviews took place on the university campus and lasted an average of 30 min. Interview questions were based on the participants' responses to the questionnaire items so were consequently different for each participant (see Table 3). Interview questions addressed the seven constructs of interest—beliefs, attitudes, social influences, intrinsic motivation, extrinsic motivation, self-efficacy, and accessibility—as well as expectations of research for those participating in research. The goal of the interviews was to gain more reflective explanations and clarification for the questionnaire responses. Each interview was digitally recorded and then transcribed.

Qualitative methods for the analysis of interview data were gleaned from grounded theory methods (Strauss and Corbin, 1990). Analysis followed a constant comparative method in which comparisons are made during each stage of analysis. Interview transcripts were coded, line by line, and codes were grouped into categories based on their relatedness and the research questions. The data within each of those initial codes were then examined to determine subcategories of each

Table 3. Interview protocol

-
1. Why did you decide to do undergraduate research in science?
Follow-up question(s): In your survey, you indicated that Can you explain your response?
 2. In your questionnaire, you indicated . . . about your beliefs toward science and research. Can you explain that response?
 3. In your questionnaire, you indicated . . . about your attitudes toward science and research. Can you explain that response?
 4. How did people in your life influence your pursuit of undergraduate research in science?
Follow-up question(s): In your survey, you indicated that Can you explain?
 5. How did your intrinsic motivation—learning more about science, pursuing an enjoyment or interest in science, understanding whether your future plans include science research—influence your pursuit of undergraduate research in science?
Follow-up question(s): In your survey, you indicated that Can you explain?
 6. How did your extrinsic motivation—earning credit, earning money, getting a recommendation letter, getting into graduate or professional school—influence your pursuit of undergraduate research in science?
Follow-up question(s): In your survey, you indicated that Can you explain?
 7. How did your self-confidence in your ability to do research influence your pursuit of undergraduate research in science?
Follow-up question(s): In your survey, you indicated that Can you explain?
 8. How did the accessibility of information and opportunities influence your pursuit of undergraduate research in science?
Follow-up question(s): In your survey, you indicated that Can you explain?
 9. How did your intrinsic motivation—learning more about science, pursuing an enjoyment or interest in science, understanding whether your future plans include science research—influence your pursuit of undergraduate research in science?
Follow-up question(s): In your survey, you indicated that Can you explain your response?
-

overarching category. For example, subcategories within the influences on doing UR category included learning about science, wanting to make a difference, gaining skills, and gaining knowledge. During coding and organization of data, memos were written to elaborate the categories and brainstorm ideas for possible themes to explain the data within subcategories. For instance, within the subcategory “wanting to make a difference,” there were obvious differences between the way that premed and non-premed students talked about how they wanted to make a positive difference in the world. When common trends like this surfaced in interviews, a note was made and the notes were revisited to help develop rich meaning to describe students’ influences. The themes developed from the analysis of the subcategories were then compared back to the quantitative data. Where similarities existed, the qualitative data were used to provide further evidence and explanation of the quantitative data. Where discrepancies existed, the data were revisited to search for meaning that may explain the differences.

Case Study

A semester-long case study was carried out with one premed science major, Chris, who was doing UR for the first time.

The purpose of the case study was to gain both depth and breadth of understanding of a student’s influences and experiences as one first begins research and how those influences and experiences may evolve over the course of the first semester of research. Three 30-min interviews and five 1- to 2-h in-laboratory observations comprised the case study. Each interview was digitally recorded and transcribed.

Observations of Chris were guided by the following questions: How does a premed student behave in a science laboratory research setting? How does a premed student doing science research feel that the research experience relates to his future goals? To what extent does a premed student become invested in the work in a science research laboratory? To what extent does a premed student relate to the other individuals in the lab? Without observations of other students doing research, the case-study data cannot be used to compare premed and non-premed students. The level of interaction with Chris, however, allowed for great depth of understanding of his experience in research, how it evolved over the course of a semester, and how he views research in relation to his life and his future goals.

Field notes were taken by hand during the observation and were digitally transcribed immediately following the observation. The field notes were coded using gerunds to describe what Chris was doing. Some examples include calculating, pipetting, interacting, and reading. The data related to each code were then examined to identify themes that described Chris’s behaviors in the lab. For example, whenever Chris spoke with someone else in the lab, there was always some degree of humor involved. Joking and kidding was an ever-present aspect of his interactions with other lab members. The themes constructed from observation data were then compared with the data from interviews. In many cases, the observation data agreed with interview data and were useful in providing greater detail and explanation that cannot be gathered in interviews. In other cases, the observation data contradicted interview data. In these cases, the interview and observation data were further examined to draw meaning from the nature of the disagreement.

RESULTS

Results from the quantitative analysis are presented as mean comparisons, and the qualitative results are used to provide further explanation for and depth to the results of the quantitative analysis.

Mean Comparisons

Results from the mean comparisons between premed and non-premed students’ responses to items related to beliefs, attitudes, social influences, intrinsic motivation, self-efficacy, and accessibility are illustrated in Table 4.

There was little difference between mean responses for the constructs of beliefs, social influences, self-efficacy, and accessibility. Mean responses on attitudes and intrinsic motivation constructs of non-premed students were significantly higher than those of premed students. Results from the mean comparisons of individual items of research expectations are illustrated in Table 5. There were no significant differences

Table 4. Mean comparison of constructs between premed and non-premed science majors as measured by independent samples *t* tests^a

Construct	Premed mean	Non-premed mean	Difference
Beliefs	4.04	3.94	0.10
Attitudes	3.72	3.99	0.27*
Social influences	2.84	2.86	0.02
Intrinsic motivation	3.93	4.43	0.50**
Self-efficacy	3.67	3.64	0.03
Accessibility	2.78	2.78	0.00

^a*N* = 135**p* < 0.05; ***p* < 0.01

in expectations of premed and non-premed undergraduate researchers.

Explanations

Beliefs and Attitudes. The non-premed interview participants talked more, in general, about “liking science” than did the premed participants. This distinction reinforces the difference in attitudes toward science research found in the questionnaire results. Five of the six non-premed participants went into detail about their fascination with science or their curiosity to continue learning more about science. Holly, for instance, explains how her interest in science goes back at least as far as high school:

I took AP biology in high school and I really liked biology and I liked genetics even more because I thought it was really cool how genes work and I've always been interested in the fact that we speak and we have feelings and we have emotions and those things all translate into atoms and molecules. I always wonder how all these little things can create such a big effect and how does it all work? So I've always been interested in those kinds of things.

Julia talked about her interest in science in terms of her research:

It's just fascinating. Especially parasites because they started so early on in the evolutionary scale and they can just, you can take it on to everything. They started off at the very beginning. They are just great to work with and interesting for evolutionary purposes.

When the non-premed students talked about why they decided to pursue science and science research, their affinity for the subject and its content was apparent across the board.

With the premed students there was less continuity. One of the premed participants, Theresa, remembered liking science from an early age, but she never talked about what science content she was interested in or what really captivated her about science. Instead she remembered watching *Bill Nye, the Science Guy* and *The Magic School Bus* and enjoying those programs. Others of the premed students were ambivalent about their interest in science. Michael, for example, did not enjoy science classes in high school at all, but as he went through college he realized that he appreciated the objective nature of science. Ann was ambivalent about her affinity for science, saying, “I'm not a fan of every part of science. I'm in physics now. I don't like physics. There are certain areas in science that I'm just not a fan of, but I do like science.”

Overall, the non-premed researchers went into greater depth in describing their research projects than did the premed researchers. Thomas, one of the non-premed researchers, went into detail explaining his research on “larval mosquito proteins and their interaction with an auxin created by the Bt toxin.” He explained how he was working with the addition of other peptides to determine whether toxicity would increase or decrease. Thomas appeared to have a strong grasp on the content of his research and how the day-to-day work that he accomplished contributed to the project as a whole. When another non-premed researcher, Holly, was asked about her research, she first gave a short response noting transcription factors and the cell cycle. When asked in a follow-up question whether her research was considered cancer research, she responded,

Um, kind of. It's easy to think oh, cell cycle—cancer. But it is related to transcription factors. They already know that transcription factors affect the cell cycle, but this one is a minor transcription factor so we were changing it to see the effect on the time that cells go through

Table 5. Mean comparison of individual items related to expectations of research experiences between premed and non-premed undergraduate researchers

Doing UR will. . .	Non-premed			Premed			Difference ^a
	Mean	SD	<i>N</i>	Mean	SD	<i>N</i>	
Be enjoyable	4.26	0.785	44	3.96	0.889	32	0.30
Help me gain knowledge	4.79	0.409	44	4.64	0.569	32	0.15
Help me gain skills	4.71	0.506	45	4.60	0.577	31	0.11
Obtain a letter of recommendation	4.41	0.686	42	4.33	0.637	31	0.08
Increase my grade point average	3.61	1.153	41	3.74	1.137	30	−0.13
Help me clarify career goals	4.41	0.715	44	3.88	1.054	33	0.53
Help me make peer connections	4.30	0.878	42	3.84	0.898	33	0.46
Help me make faculty connections	4.42	0.732	41	4.13	0.626	32	0.19
Allow me to publish my research	3.88	0.907	40	3.33	1.111	29	0.55
Help me in applying for grad/prof school ^b	4.04	1.061	45	4.22	0.843	32	−0.19

^aNone were significantly different at *p* < 0.05.^bMedical, veterinary, dental, pharmacy, or nursing

certain phases of the cell cycle. So if you inhibited it, we predicted that it would be phosphorylated by this kinase and we stop it from being phosphorylated and see what happens to the cell cycle.

When most of the premed participants were asked about their research, they responded in a more general way, giving a surface explanation of their research and what they do. When Michael, a premed researcher, was asked about his research project, he explained that they were “looking at the effects of exercise on cognitive function,” but he did not elaborate when asked follow-up questions. Similarly, Tyler, another premed researcher, described his research as “analyzing the intercellular proteins of fungi,” and he did not provide additional information in follow-up questions. One exception was premed researcher Ann, who went into detail about her research with the model organism *Caenorhabditis elegans* and a particular gene that has a human homologue that functions in cell cycle regulation. Ann talked more overall than most of the other participants, and it was late in her interview when she finally provided a detailed explanation of her work.

Access and Self-Efficacy. Regardless of whether students were premed or not, they had similar issues with accessibility of research. There are certain programs for promotion of UR that help students find mentors, funding, and other support for research experiences. These programs usually cater to certain groups of students, such as honors students or underrepresented populations. None of these programs cater strictly to premed students. Those students in both the premed and the non-premed groups who had access to the programs said that it greatly influenced their experiences in UR, while those who did not have access were frustrated at the lack of resources available to make UR more accessible.

Several interview participants, regardless of premed status, who had participated in research talked about the influence that honors or minority programs had on helping them get started with research. Kelly said, “Because if I wasn’t in the [minority participation] program, I really wouldn’t have known anything about doing undergraduate research.” Matthew said, “I don’t feel like there’s a lot of research opportunities either. I’ve only seen maybe five at the most for people who aren’t in an honors program or something,” and Chris said, “If you can’t do [the honors program] you have to jump through a lot more hoops and do a lot more personal effort to try to get somebody.” Similarly, Tyler explained that

The [honors program] really opens up everything like that and I feel like it might be tougher for some students because there are a lot of research opportunities out there but it’s hard to find where to start and how to get into those.

It’s possible for students outside of the honors and minority participation programs to do research, but the perception is that it requires more effort.

Self-efficacy for doing research was similar among the premed and non-premed groups as well. None of the students who were interviewed had high self-efficacy for doing research when they began their UR experiences. All of them spoke of intimidation and hesitancy when speaking with research faculty. Holly expressed the confusion that she felt and that she expected other students felt, saying, “I think a lot of times students are intimidated to talk to their professors and

say, ‘Can I do a project with you?’ How do you start that conversation? How do you go about that?” Ann spoke of her intimidation in a similar way, saying, “So I had a list of all the labs I was interested in but I hadn’t contacted any of them because I was too scared to give the wrong impression and then they wouldn’t want me in their lab.” Even though Ann had taken the initiative and was intrinsically motivated to look up potential mentors, she lacked the confidence to make actual contact with them. Jodi earned the highest academic fellowship awarded at the university. She had participated in humanities research but was more interested in science. She planned to participate in science research in the upcoming semester but was unsure of whether she was prepared for it. She said, “Sometimes it just seems like I can’t talk to [faculty] because I am not smart enough. And just thinking that I need more science classes, more stuff under my belt before I can do [research].” Other students look up to fellows such as Jodi as those students with the most talent, ability, and opportunities. If Jodi has low self-efficacy about participation in science research, it is not surprising that self-efficacy could have a significant impact on the number of students participating in UR in science. While this is an interesting issue and one that should be further pursued, it was one that came up across the board with both premed and non-premed students.

Motivation and Social Factors. Non-premed students expressed more intrinsic motivation in wanting to learn about science and wanting to satisfy their curiosity about science. Julia was a non-premed researcher studying parasites. When asked why she did research, Julia had the following exchange with the interviewer:

Julia: Well a lot of people do the kind of research I do because they grow up in malaria endemic areas and they want to find a cure for malaria, but I’m one of those people who just wants to do it because it’s fascinating.

Interviewer: That’s a really interesting perspective. So you’re not like, “I hope I cure . . .”

Julia: Well, it would be really cool [laughter], but that’s not my ultimate goal. I guess it’s just to understand how it all works.

For her it was about the fascination with science, not necessarily about the glory of finding a cure.

The premed students did not lack intrinsic motivation with respect to doing UR, as can be interpreted from the questionnaire data. They were less intrinsically motivated to learn about science than were the non-premed students, but they were highly motivated to do something with their lives that would help other people. Because doing UR was something that they saw as helping them to achieve their ultimate goal of becoming a doctor and helping people, they were intrinsically motivated to do research. Helping people is what all of them talked about when asked why they wanted to go to medical school, and doing UR in science was something they saw as helping them reach that end. Ann said,

I want to be a doctor just to—it’s pretty cliché—help people. I started tutoring last year in a Latino community and a lot of them aren’t very well off. When I saw them I was like, it would be really good if I came back and was a doctor and I could help people like them. I’m not in it for the money, so I could sacrifice my time and help these people who actually need it.

Several of the premed students said that while they were relatively certain that they wanted to go to medical school, they saw research as an opportunity to see what it would be like to have a career as a science researcher. Theresa explained that she was not completely sure whether she wanted to be a science researcher or a doctor before having her experience in research. After her research experience, she said, "I want to go to medical school because I don't like research—it's too tedious and I just don't have the qualities of a science researcher." She went on to explain that she felt she could have a greater positive impact as a doctor, saying,

There's like an 80% guarantee that you'll find the right answer in time if you're a doctor. You'll see the results immediately. You'll see the people you're helping. Especially in India—I'm definitely planning to go back to India after I graduate.

The most basic difference setting apart those who wanted to pursue medicine and those who wanted to pursue careers in research was the focus of their intrinsic motivations. For those who had curiosity and deep interest in learning more about science, they pursued science research, while those who were more interested in social interactions and having a positive effect on the lives of humans pursued medicine. Similar to Theresa, Ann used research to rule out the possibility of doing science research as a career as opposed to being a doctor:

Ann: I was on the fence about going into research or going to med school, so I really needed to figure it out.

Interviewer: And after just a few months, you feel like it's helped you make that decision?

Ann: Yeah [laughter]. I feel like I knew probably after my first month that research wasn't for me. It's not that I hate it or anything; I just don't think that I could do this for another 50 years.

Conversely, Kelly and Holly were non-premed students who thought they might pursue medical school until they started doing research and realized the possibilities for careers in science beyond being a doctor.

A Premed Student's UR Experience: The Case of Chris

Four main topics dominated all of our interactions with and observations of Chris: his research, his classes, the fraternity of which he was the vice president, and sports—and not necessarily in that order. In the first interview with Chris, he was very brief when explaining his research. He basically said that it was about "fungus on tomatoes," and that was the extent of it. The details of his research were never the first thing that he mentioned when we met for an interview or observation. He was more likely to make comments about social interactions with others in the lab, talk about the big plans his fraternity was making for the weekend, or ask us whether we saw Saturday's football game. Occasionally his thoughts were preoccupied by an upcoming test or paper. He was very conscientious about doing well to ensure his good standing for medical school applications.

Even though Chris knew that our main interest was his research experience, it was not what he focused on in our interactions, but it was not because he did not understand his research or that there was a lack of depth in his work. Quite the contrary, in the last three observations of Chris working

in the lab, he explained every step of his culturing and testing of different strains of fungi and how it related to his mentor's larger research goals. He demonstrated strong command of the research language, and both he and his mentor were confident in his knowledge and skills related to his work. Talking about the intricacies of his research was not of utmost importance to Chris when describing his research experiences, but when prompted, he was able to thoroughly explain and demonstrate any step in his research project. He also understood the big picture of his research and how it fit with his faculty mentor's overall research goals.

When asked whether he thought the research experience would help him once he was in medical school, Chris said that it probably would not help very much in his studies. He saw it as something that would help him get in but not something that would help him as a doctor. "Knowing about fungus on tomatoes isn't going to help me save anyone's life," Chris explained. He did not, however, see his time in the lab as a total waste. The importance of this social aspect of his research experience was apparent from the outset. In his first interview, which was before he had started his research, Chris talked about what he expected to get out of his experience:

I'm kind of a people person, so I really enjoy meeting new people and making connections, so just beyond the fact that I'll maybe get some good recommendations, I'll also get to know some cool people and always have someone I can fall back on or ask some questions.

The importance of relationships continued to surface in observations and in the other two interviews with Chris. In the lab, Chris was the first to greet anyone who entered the lab. Other undergraduate researchers in the lab would sometimes work quietly by themselves, but Chris would always approach them and ask them how they were doing, whether they were going out that night, and whether they were going to the game on Saturday. In his final interview, he said that he felt like his lab group was a family. Chris explained that while science research was not what he wanted to do for his career, he would maintain the friendships that he made—with other undergraduates, graduate students, postdoctoral researchers, and his faculty mentor—for the rest of his life.

There were several times in our observations of Chris that he exhibited creative problem solving in his research. Once, there were not enough flask holders for all the flasks that he needed to put on a mixing machine, so he rigged the setup with the materials that he had, using a few springs that he found in drawers. Another time, when he needed to transfer fungal cells from a plate to a solution in a flask, Chris was rooting around in the container of loops, looking for one in particular. He explained that there was one loop that he had engineered to pick up the greatest number of cells at once, so he wanted to find that one. Once he found it, he explained how he had figured out just how to bend it to pick up the most cells. And on a different day, when he had to fill over 100 vials with several different solutions, we noticed that Chris had a sophisticated scheme to remember which had already been filled and with what. When asked whether his mentor told him the system to use, he said, "No, I came up with it because I'd mess everything up if I didn't." Later on, in our final interview, we spoke with Chris about these instances and asked whether he thought his problem solving had anything to do with being a scientist. Chris simply said, "No, I'm

just a tinkerer." Even through trials and errors, problem solving, and critical thinking, Chris never identified himself as a scientist. He was just a premed student working hard to get into medical school and happy to make some friends along the way.

DISCUSSION

Comparison of Influences to Do UR

Both premed and non-premed students saw UR as a means to an end, but the end was different between the two groups. In general, premed students used UR as a way to help them get into medical school and as a way to help them clarify their decision to go to medical school. Non-premed students wanted to learn more about science and research and wanted to see what it would be like to be a science graduate student or have a career as a science researcher. These different ends translated into the way students described their influences to do research and their experiences in research.

The premed students interviewed here indicated that their decisions to pursue medicine as a career were less about their interest in science and more about their interest in helping people. Each of the premed participants discussed the desire for human interaction in his or her career. UR experiences are touted as acculturating students to a community of practice of scientists. The community of practice represented by most UR programs, though, is that of research scientists, not of clinicians or practitioners. Premed students are encouraged to participate in research, but the notion that they may not identify with the experience the way that science majors intending to pursue graduate school or careers in science research may identify with the research experience is not explored.

Comparison of Student Expectations of UR Experiences

The lack of difference in the expectations of premed and non-premed students in the quantitative data is interesting but not altogether shocking. In both cases, students expect to gain skills, knowledge, and letters of recommendation. These expectations likely come as little surprise to most faculty research mentors. Even students who go into the experience less than enthused about research expect to learn something. And whether students love doing science research and want to do it for the rest of their lives or they are just trying to get through a semester of research to put it on their resumes, the letter of recommendation for the next step—medical school, graduate school, or job—is of utmost importance to them.

Comparison of Student Explanations of UR Experiences

Hunter *et al.* (2007) looked at gains in a number of different categories related to UR experiences. One of those categories was "becoming a scientist," which included gains in behaviors and attitudes necessary to becoming a science researcher. Hunter *et al.* (2007) interviewed faculty and students about their perceptions of gains after the UR experience, and more faculty responses included gains in "becoming a scientist" than did student responses. The authors suggest that students realize that they are making gains in knowledge and skills but do not recognize that those gains translate to ac-

quired professional habits. It may also be that some students simply do not identify as scientists or as wanting to be a scientist, so they don't think specifically about gains in "becoming a scientist." Several of the premed interview participants indicated on their questionnaires that they were not interested in a career as a scientist. When each of them was asked in the interview to explain their answer, all of them responded the same way. They said that they were not thinking of a doctor as a scientist. Students see doctors and scientists as completely different entities, and most will likely identify more closely with one or the other. If the ultimate goal of UR is not necessarily to make career science researchers out of all students participating, then perhaps the objectives of UR experiences should include the application of the research experience to the field that the students do wish to pursue.

The social dimensions of science are often unnoticed by students participating in UR (Ryder *et al.*, 1999). While most students doing UR do interact, depend on, and help others in their research setting each time they work on the research, they fail to recognize that the social interactions are indeed a component of the nature of science. If UR programs incorporated a focus on the social nature of science and encouraged students to discuss or reflect on how social interactions are critical to progress in science research, then perhaps UR students would have an overall better understanding of the nature of science and the premed students, in particular, may feel like there is less of a difference between the careers of scientists and doctors. This could possibly be accomplished through lab meetings or through the use of blogs where students reflect on their experiences in the lab and other lab members can comment on the posts.

Closing Thoughts and Implications

Trosset *et al.* (2008) describe course-embedded UR experiences and compare the perceived gains of the research courses with those of summer UR apprenticeships. The course-embedded UR experiences covered specific topics, such as genomics and eukaryotic microbes, and they were found to have similar trends in perceived gains as the summer UR experiences. Certain areas, such as working independently, were scored as higher gains in the summer UR group, but other areas—especially those that the course was designed to highlight, such as understanding the research process and skill in scientific writing—were higher in the course-embedded research experiences. Course-embedded research experiences could be designed to address the interests of premed students while providing them authentic experiences in research. Courses focused on clinical health research or drug development research may be of practical interest to premed students and may provide a community of practice that they can identify with more closely than some other research experiences. Further, course-embedded research experiences directed specifically toward premed students could focus on particular gains or skills that are of interest to medical students, such as collaboration, critical thinking, and problem solving.

Russell (2008) analyzed extensive questionnaire data related to UR experiences and found no patterns of differences between research characteristics and outcomes among different demographic groups determined by race or gender. While demographic distinctions may not separate students

in their influences and experiences in UR, their academic major or future intentions may set them apart from each other. Future research should utilize larger samples of students to gain greater insight into the differences in what influences premed and non-premed students to do UR and how the different groups of students actually experience the UR opportunities they are afforded.

Future research should also focus on the correspondence between expectations and outcomes of the research experience for both undergraduate students and their mentors. While understanding the expectations of students with different career and educational goals is an important first step, understanding to what degree those expectations are met in different circumstances will help colleges and universities work to better prepare students and faculty mentors for a fulfilling UR experience.

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