Uncovering Students' Preconceptions of Undergraduate Research Experiences

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Abstract

Like all learners, undergraduate research interns bring to their research internships a variety of initial ideas, opinions, expectations, beliefs and attitudes about research internships. However, there is little published research on students' preconceptions about research internships and the relationships of these preconceptions to actual experiences. There is also a dearth of information about potential influences of preconceptions on the learning process and gains that accrue in students involved in undergraduate research experiences (UREs). Using qualitative data from twenty-five undergraduate research interns' reflective journals, the current study examines students' preconceptions of UREs and how those preconceptions compare with students' actual experiences. The analysis showed that prior to their research experiences, participants imagined research environments/laboratories as stern places devoid of social interactions. Interns also held preconceived traditional stereotypical views of their faculty mentors as scientists. Other preconceptions included the expectation of extensive one-on-one mentoring from faculty mentors and the preconception of research work as team rather than independent work. Further, the study found that students' preconceptions were mostly contradicted by their experiences in their research internships. The limitations of the study and the practical implications of the findings for devising meaningful and effective undergraduate research experiences are discussed.

Introduction

The past decade has witnessed the transformation of undergraduate research experiences (UREs) from a traditional "cottage industry" into a strong "movement" [1]. Supported by funding from federal, local and private agencies (e.g., National Science Foundation, National Institutes of Health and Howard Hughes Medical Institute), American colleges and universities are increasingly creating opportunities for authentic research experiences for undergraduate students in STEM (Science Technology Engineering and Mathematics) and non-STEM disciplines. Institutions of higher learning have found undergraduate research programs effective in retaining students within STEM disciplines and for expanding the STEM pipelines to students from traditionally underrepresented racial and socioeconomic groups. Similarly, there is a growing body of literature on the benefits and gains that accrue in students and institutions as a result of their participations in UREs. Participation in faculty-mentored UREs has been linked to positive educational outcomes for students; UREs have been shown to enhance students' understanding of research and scientific processes [2-4], contribute to achievement of career clarification and interest in graduate/professional education [5-7], and assist the development and improvement of critical thinking and communication skills [8].

Despite national interest and increasing awareness of the benefits of UREs, research in this area is still emerging; there is much uncovered ground, many unanswered questions and unexplored issues regarding the structures, contexts and dynamics of UREs [9]. For example, while much is known about the benefits and gains of UREs and strategies for developing and implementing effective UREs, less is known about students' lived experiences in undergraduate research internships and learning processes. Almost non-existent are studies describing the processes through which the acclaimed benefits of UREs are derived. Another gap in the URE literature is the lack of empirical evidence on possible differences between gains from faculty- mentored versus graduate or postdoctoral researcher-mentored UREs. As rightly noted by Dolan and Johnson [10], while most research and evaluation reports on UREs are based on the assumption that interns receive one-on-one mentoring from faculty, in practice, undergraduate interns are often directly mentored by aspiring researchers such as graduate students and postdoctoral assistants. Other limitations that we have observed include the lack of research on the potential benefits of faculty-mentored UREs to faculty, challenges encountered by students and faculty in their UREs, effects of contextual factors on the reported gains and benefits of UREs to students, and the pre-participation conceptions or misconceptions of UREs held by interns and faculty mentors.

Clearly, these identified gaps cannot be exhaustively examined in a single book, manuscript or journal article. Addressing the paucity in URE research will require time and concerted efforts from researchers, and every little effort will contribute to the development of a holistic view of UREs. For example, a recently edited book: *Creating Effective Undergraduate Research Programs in Science: The Transformation from Student to Scientist* [11] constitutes a great effort in synthesizing the existing knowledge of UREs and uncovering some areas where future research is needed.

Our focus in the current study is on only one of the identified gaps: students' preconceptions of UREs. We define preconceptions as the pre-participation or initial ideas students have about undergraduate research internships, including their expectations about the learning experience. To our knowledge, there is little or no research on students' preconceptions about research internships, the sources of these preconceptions and how they compare with actual experiences, and their potential influences on the learning process and gains that accrue in both students and mentors. Like all learners, undergraduate research interns bring to their research internship a variety of initial ideas, opinions, motivations, expectations, conceptions, beliefs and attitudes about research internships in particular, and research and scien-

tific processes in general. Our goal in this study is to examine the preconceptions held by students prior to entering their UREs, and whether or not those preconceptions matched students' experiences during the research internship.

The need to identify students' preconceptions, sources of these preconceptions, and the preconceptions' impacts on students' learning outcomes can neither be ignored nor overemphasized. Research in teacher education [12, 13, 14] and science education [15, 16] has demonstrated the influence of students' preconceptions on their learning experiences and associated outcomes. For example, Chan and Lee posited that students' preconceptions about a learning process might be an impediment and (or) impetus to their learning experiences and that identifying and understanding these preconceptions can help in creating effective learning processes [17]. Similarly, Leh [18] argued that:

> Students' preconceptions of an impending event or experience are important to discern prior to the event in order to eliminate those behaviors or thought processes that can interfere with the learning process during that particular experience (p.117).

While preconceptions are not necessarily misconceptions, they have the potential to interfere with students' learning outcomes and can hinder students from harnessing the benefits of their learning experiences. In line with Leh [18], we submit that identifying and understanding interns' preconceived ideas and notions about research internships will enhance and facilitate the development and implementation of effective URE programs and help faculty mentors to structure research internships in ways that optimize benefits to students and faculty. Our study is guided by two research questions: (1) what are students' preconceptions of UREs? (2) How do students' expectations and preconceptions compare with their actual experiences in their undergraduate research internships? These research questions necessitate a qualitative exploration of students' preconceptions and experiences and in their research internships.

Descriptions	Spring 2009 program participants (n=34)	Study participants (n=25)
Gender		
Male	13	8
Female	21	17
Academic standing		
Sophomore	8	4
Junior	19	15
Senior	7	6
Academic major		
Engineering and Technology	13	8
Science (including Health Sciences & Agriculture)	18	15
*Liberal Arts**	3	2
Previous research experience		
Yes	18	13
No	16	12
Aspiration for graduate education		
Yes	26	21
No	4	2
No response	4	2

Note: *= All interns, including those enrolled in Liberal Arts majors participated in authentic STEM research experiences that cross traditional boundaries between academic disciplines.

Table 1: Characteristics of Participants

Methodology

Participants in this study are undergraduate students that participated in a URE program at a large Midwestern land grant research university in the spring semester of 2009. The URE program was designed to involve undergraduate students in interdisciplinary STEM research under the guidance of faculty mentors with the goal of enhancing their aspirations for graduate education and research-oriented careers. Students engage in hands-on research during the academic year on projects funded through one or more of the 10 centers within the university's interdisciplinary research park. Participation in the program affords students the opportunity to apply classroom knowledge to real-world applications by creating innovative solutions through the combination of multiple disciplines. The program is marketed to all undergraduate students with sophomore standing or greater and a minimum 3.0 GPA. A total of thirty-four students participated in the program in the spring of 2009, out of which twenty-five participated in the current study. Table 1 compares the demographic and academic characteristics of the study participants with the spring 2009 program participants.

The study uses qualitative data from students' reflective journal entries. As part of the assessment of students' learning outcomes and evaluation of the impact of the program, students were required, three weeks into the semester, to complete guided-reflective journal entries via Blackboard®, an online learning tool. Students were to reflect and write about the preconceptions and expectations they had for their research internships. Each student was required to write between one page and one and a half pages of reflection. The specific questions were: "Before you began your internship, what did you think the lab (or workplace) would be like? What did you think you would be doing? Has your experience differed from your assumptions? If so, are these differences positive, negative or a combination of both?" We examined students' journal entries to uncover their expectations and perceptions of UREs prior to their participation, and we compared these expectations with students' reported experiences in the program.

Because the data for the study come from written texts (i.e., students' journals); the method of conventional content analysis where words, sentences, paragraphs or comments are usually the units of analysis [25] was employed for the analysis with the goal of generating categories of preconceptions reported by the students. Content analysis is very useful in "the subjective interpretation of the context of text data through systematic classification process of coding and identifying themes or patterns" [19, p. 1278]. The authors read students' journal entries to identify statements or phrases reflecting their expectations and preconceptions of undergraduate research experiences as well as their actual experiences in the program. This process yielded a total of 78 statements/phrases reflecting a variety of initial ideas, beliefs and expectations held by the 25 respondents. The 78 statements were sorted and coded by grouping similar statements and phrases together in the same category. In line with Hunter and colleagues [8], the codes were not preconceived but emerged from the data. New codes were added as new ideas emerged from the data. We invited two members of our research group who were not directly involved in the study to read the quotes and judge their fit with the existing code assignments. One researcher agreed with all code fits, and the other disagreed with the code assignment for three quotes. We discussed the disagreements with the second researcher and opted not to change code assignment for these three quotes.

Findings and Discussions

Five categories of preconceptions emerged from the data: (1) preconceptions of scientists and research environments, (2) preconceptions of the ease (or difficulty) of research endeavors, (3) preconceptions of duties in research apprenticeship/involvement in the research projects, (4) preconceptions about team versus independent work, and (5) preconceptions of mentoring and supervision. The categories of preconceptions are discussed next. Some examples of student verbatim comments are included to illustrate the range of preconceptions reported by the students.

Preconceptions of scientists and research environments

Twenty-five of the comments expressed students' initial ideas about scientists and the social dynamics of research and laboratory environments. The responses, in general, reflected students' preconceived stereotypical views of science as an isolating endeavor; research as a solitary endeavor; and scientists as socially isolated individuals. For example, seven comments in this category revealed students' initial perceptions of scientists as "people in lab coats" and laboratories as "science fiction sites." These preconceived traditional stereo-

types are best explained in the students' own words:

> In a room filled with huge equipment that makes weird noise, a person in a white gown is holding a pipette, dropping a dimly glowing drop on a glass beaker. This is not a scene from science fiction movie, but it is what I imagined my research lab would look like…..{But} When I went to see a graduate student who would guide me throughout my research experience, he was in a casual clothes, not white gown that doctors usually wear.

> My first image of a laboratory was the classic scenario of people in white lab coats looking at bubbling chemicals in test tubes. My only previous experiences in laboratories were for classes like Chemistry and Biology.

> [I thought] Dr. XXXX would be walking around the laboratory with great purpose as I shadow her, the Igor to her *Victor Frankenstein*.

Similarly, eight of the comments in this category described explicitly students' preconceptions of scientific laboratories and research environments as "stern" or "serious" places. Respondents indicated that they did not expect to have any form of social or interpersonal relationships with their co-researchers (i.e., faculty mentors, postdoctoral associates and graduate students.) Some of their comments were:

> My previous assumption was that labs are all serious and quiet (which some probably are, depending) all the time-- which thankfully is not the case! The lab I am in has a very welcoming atmosphere. We also have lab parties and even went to Indiana Beach this summer. The music in the lab also adds to the fun, relaxed, yet focused atmosphere.

> I would have to say that this research experience did not encompass the usual or typical laboratory setting I had envisioned. I had anticipated research to be something stern, and while it still upholds that seriousness, there is much leeway for interesting exploration and discussion.

Moreover, four of the responses in this category revealed that students did not expect that communication and interpersonal skills would be important for effective functioning in research groups and laboratories. For example:

> I have never felt that interpersonal skill was that important in research work before. As I said previously, I need to set up a meeting with my professor or other professors who are also working in this project weekly. If I don't have good interpersonal skill, I couldn't communicate with these professors nicely and introduce my research to them. That would be a big trouble.

Finally, three comments in the category referred to students' preconceptions of laboratories as large work spaces:

> I was also a little surprised by the size of the lab. The space I have to work in here is very minimal. More work surface would have been nice for when I need to weigh and measure the sculpin. I had expected a large workspace, though I don't necessarily need one.

As the examples of comments show, students' preconceptions were contrary to their experiences: The analysis revealed that the research internships helped the students to identify their preconceived stereotypical views of science and scientists as misconceptions.

Preconceptions of the ease (or difficulty) of research endeavors

Twenty-four statements described students' preconceptions about the ease or difficulty of conducting research during their internships. We grouped these statements into two categories: fifteen of the comments in this category represented students' preconceptions that the research internship would be without setbacks while the remaining nine of the comments referred to students' preconceptions that the internship might be difficult and challenging.

Preconceptions that research internship would be familiar and without setbacks

Most of the statements assigned to this subcategory expressed students' preconceived notion that their research projects would run smoothly, and without setbacks. As their comments suggest, the students expected their research to be similar to their laboratory classes where they simply followed stipulated procedures and achieved desired or expected results. Their statements revealed that they did not expect errors or that research processes would sometimes involve some maneuvers in the face of challenges. However, contrary to their preconceptions, the students are increasingly becoming aware that unlike their "staged" laboratory classes, research in reality is challenging, creative, and may not always lead to the desired results. They are also discovering that researchers commit errors and make mis-

takes in their research endeavors.

> We ran into several problems with mislabeling specimens and samples, losing samples, and incorrectly entering data into the computer. I hadn't realized how easy it is to ruin a piece of data until I experienced these problems. Now we have several self-checking processes to ensure the issues can be resolved if they reoccur.
>
> It also somewhat surprised me to see how inconsistent data can be. In my case, we hope to see a correlation between leafhopper diversity and insect Order diversity, but this correlation is never consistent for every sample. It caused me realize that science is never absolute, and even the most accepted theories have small percentages of failures. There are always other factors which might influence the results.

Six of the comments in this sub-category referred to students' preconceptions that the dynamics of their research internships would be similar to their experiences in their prior laboratory classes in chemistry, biology and (or) physics; thus, they expected their research internships to be familiar rather than strange experiences. However, the comments further revealed that, a few weeks into their UREs, the interns begin to see that research internships, though similar to laboratory sessions, are in some ways quite different. Unlike their laboratory sessions, where they are simply students demonstrating scientific concepts, their roles in the UREs are as researchers seeking to solve problems or trying to answer certain questions connected to bigger hypotheses. Some of their comments were:

> I thought working at the lab [research internship] would be similar to laboratory classes, so I was pretty confident that [I] would do really well. However, working at the lab [research internship] was absolutely different from the classes I have taken. Although the materials and the techniques used at the lab and classes are the same, the role of the self is totally different… The role in the class was a student so I just needed to follow instructions… On the other hand, the role in the lab (research internship) is like a co-worker with faculty and graduate students. Working at the lab [research internship] is like working in the real world.
>
> Experiments [in laboratory classes] had very linear processes which were meant to demonstrate a concept, but lab work [research internship] in reality is always to test new ideas. It has an entirely different atmosphere than a classroom.

In addition, some statements expressed the preconception that research procedures, like protocols in laboratory classrooms, are short and can be completed quickly. However, students begin to realize that research procedures can often be long and slow:

> The pace of data output and discovery is a lot slower than I expected due to the technical difficulties that I have continuously run into with working on prototypes. But in the process I gained a lot of valuable knowledge that I will use the rest of my career.

An observed trend in their comments is that students tend not to be deterred by the challenges and problems encountered in their UREs; their comments suggest that these challenges help them to learn problem solving skills and to see that research is a rigorous and creative endeavor.

Preconceptions that the research process will be difficult and challenging

The comments in this sub-category were made by students who expected their research internships to be difficult and challenging. Some of the students had preconceived ideas that their research internship would be time-consuming and that balancing the internship with their classes and other aspects of their education and personal life would be difficult. Some of the comments were:

> Before the internship, I was uncertain about the workload. I was afraid that I would not be able to balance the internship with school and work. I thought that this would require a great deal of time right from the beginning. The amount of work I have been assigned so far has been appropriate and also interesting.
>
> I assumed I would be spending long periods of time in the lab doing tests and taking measurements.

Other comments revealed that some students expected their UREs to be difficult because they felt inadequately prepared for the internship:

> I was nervous because I have never interned before or participated in a job other than fast food, so I had very little experience in the terminology and in the actual research.

Preconceptions of duties in research apprenticeship and immersion in research projects

This category was comprised of eighteen comments. The statements reflected students' preconceptions and experiences regarding immediate versus gradual immersion into their assigned research projects. There was an obvious dichotomy in students' initial ideas in this regard. On the one hand, a majority of the comments in this category (thirteen) reflected students' preconceptions that their involvement in their assigned research projects would be immediate rather than gradual. On the other hand, five of the comments revealed that some students expected gradual immersion into their research projects.

Responses reflecting preconceived immediate immersion expressed students' desire to perform or carry out "main" or "real" research as soon as they began their UREs and the realization that their immersion into their respective assigned research project would be gradual. As described in the following responses, many students expected an immediate opportunity to perform technical and complex tasks and operate sophisticated instruments and gadgets, but were required to perform simple and menial tasks, and gradually move to perform more technical or complex activities:

> Based on the learning contract, I had hoped that I would start using my previous experience in Matlab and LabVIEW and help in the quantum optics project. With tools such as Matlab and LabVIEW, I had anticipated that I would gain more experience with image processing. Instead, I was assigned a small circuit problem in which I was asked to design a circuit to meet certain input and output specifications. .. Still, I believe that I am taking the first few steps necessary to become an integral member of this ongoing project.

> I thought that I would be using high tech technology to measure the toxicity of nanosilver particles on algae. I assumed it would take me months just to understand how all the equipment worked. The methods I use to measure the toxicity of nanosilver particles on algae isn't as high tech technology as I expected either. I just take a sample, put it under a microscope and count the number of algae cells I see and multiply it by a conversion factor that tells me the approximate number in the whole solution.

> I had imagined that I would be working on the main experiment itself; however, I am currently not assigned to the main experiment. But in spite of this, I am finding the overall experience very useful. I am really learning a lot from the research.

Their disappointments notwithstanding, the students commented that they were learning the importance of menial tasks and gradual immersion:

> Working in the lab has taught me that even grand discoveries have menial tasks to be done, but it's all important to the ultimate goal: Discovering something new.

As earlier indicated, there were five comments reflecting the preconceptions of students who expected to perform simple roles and menial tasks but were instead assigned to technical tasks using sophisticated tools and equipments.

> I thought that since I was a freshman/sophomore I would be given solely menial tasks to do like washing dishes or something. On the contrary, when the almost a million dollar orbitrap mass spectrometer arrived this summer, Dr. XXXXX let me be one of the first to analyze a sample on it.

> When I first started this work, I thought I was just going to be a helper in the research lab. However, I was very glad to have my own work in the research team and being a part of it.

> Before I began my lab experience, I thought the research was just simply doing what my supervisor told me to do as an assistant.

Preconceptions about team versus independent work

Ten comments reflected students' preconceptions that their UREs will require team rather than independent work. Their responses revealed that students' experiences included more independent work than they had anticipated. Although contrary to their expectations, students' comments revealed that they are learning to appreciate that team work does not necessarily mean that everybody in the team is doing the same thing together at the same time, but that it may also mean that everybody in the team is working on specific parts of the job and that each person's tasks and efforts contribute to the big picture.

> Also I expected to be involved in a team comprising few graduate students and the faculty already working towards improvements on the desired project and its goals.

> I expected to be a keen member responsible for making key yet small reporting of statistical data related to the project experiments and the results arising out of those experiments. (But, I had to) learn on my own, which I think makes all the learning more beneficial. .. There isn't a team that is working on the project but I have been given full support towards any concern that I might have regarding the project. Looking at it now, I guess an individual working on a project has more responsibility than an entire team working on it.

> Before I started my research internship, I thought that research people would always work in a team. Each member of the team would discuss his/her work frequently with other team members, and other team members may also provide some useful suggestions to this researcher. However, right now, I am doing my research work independently.

> Although I meet with my professor weekly to discuss our research process, I am still feeling lonely sometime because I don't have any person to work with me, listen to my ideas about the research, and give my some good suggestions.

We made three observations from the comments in this category: (1) Prior to their internships, students defined teamwork as everybody working at the same time on the same project, (2) the internship experiences helped students to redefine team work as each member working on small chunks and working towards the big picture, (3) students now view UREs as opportunities to become independently-minded researchers.

It is worth mentioning that there was only one comment about the expectation of independent work; the student who made this comment also mentioned that they had done work independently:

> I expected to be working mostly independently. I have done work independently, but have also spent a lot of time learning and collaborating with my lab director.

Preconceptions of mentoring and supervision

This category was comprised of 10 comments referencing students' preconceptions that they would receive sufficient mentoring from their faculty mentor. The students had the notion that their UREs would afford them opportunities to work beside "Nobel Laureates," only to find out that they would be mostly supervised by graduate and postdoctoral mentors. While the students spoke positively about their mentors, mostly graduate students, they mentioned that they had expected to work more closely with the faculty mentor than they did. Students also mentioned that they expected more supervision, especially from the faculty mentor, than they were receiving.

> Before I started, I thought I would have more supervision and direction than I ended up having. I thought that someone would be telling me exactly what to do and checking on me as I performed the experiments. It turned out that I did get instructions from the PI and the graduate students on several critical aspects like how to use the mass spectrometer and do some procedures; however, other times, I was given a more general outline to what I would be doing.

> I expected to be working closely with my faculty advisor. Looking back, I should have realized that a laboratory is not that different than a business. In the workplace, once the worker has been given basic training, she is on her own. Part of me wished that I did have someone behind me with step-by-step instructions. I soon found that I would be interacting with [graduate student] much more than I would with [faculty mentor]

> I wish I were able to interact more with my PI because I feel like I could learn a lot from him. I have really enjoyed working with my lab director though and have learned so much since August. Although the collaboration process was not what I expected it to be and the work that I have done was not entirely what I expected, as a whole, the experience thus far has been a positive one.

These examples illustrate students' preconceptions that they would receive extensive mentoring and supervision from their faculty mentors, and that the mentoring provided by the faculty mentors would be essential in maximizing their (students') learning and participation in their research internships.

Conclusions and Implications

Using qualitative data from twenty-five students' reflective journals, the current study examines students' preconceptions of UREs and how those preconceptions compare with students' actual experiences. Our analyses of stu-

dents' responses revealed that students held a range of preconceived ideas regarding their research internships. Specifically, our analyses showed that the participants in this study expected their research environment to be stern and devoid of social interactions, and they expected their faculty mentors and other researchers in the group to fit into the traditional stereotypical images of scientists. Also, students expected to receive extensive one-on-one mentoring from their faculty mentors and they expected team rather than independent work. Further, the interns expected their research learning process to be similar to their previous laboratory experiences and they did not expect to encounter as many obstacles and challenges as they did in their research internships. However, students differed in their preconceptions of their research duties and immersion into the research process. While some students expected to perform technical tasks and operate sophisticated equipment, others expected to perform menial tasks.

Our study also revealed that the experiences of the interns in this study tend to contradict their preconceptions. For example, students expected teamwork but experienced mostly independent work; some students expected "weird" labs and antisocial lab members but reported having good interpersonal relationships with members of their research groups. Students' responses suggest that novice undergraduate researchers value research and laboratory environments that are socially warm and provide opportunities for active participation in research activities.

The results of this exploratory study cannot be generalized beyond the scope and context of the study. The responses analyzed are from twenty-five students in one URE program in one large university. Moreover, the interdisciplinary nature of the URE program studied may be atypical. Therefore, our findings may not be representative of students from other URE programs in other colleges of similar (or different) size. The limitations notwithstanding, our study provides some insight into the preconceptions of undergraduate research interns and may serve as groundwork for a deeper exploration of students' preconceptions, the sources of those preconceptions, and the preconceptions' effects on students' learning experiences in their UREs. The findings underscore the fact that there are many unknowns about the dynamics of UREs and students' experiences in these programs. As suggested by one of the reviewers of this manuscript, the findings regarding participants' preconceptions of the unpredictability and "human-ness" of research as well as their stereotypical views of scientists and research environments may not be unconnected to their misconceptions about the nature of science. Although we do not have sufficient data to explore the linkage between students' perceptions and their views of science in this study, we believe that future studies regarding UREs are needed to identify and clarify possible relationships between students' expectations, preconceptions and experiences in UREs and their views of the nature of science.

While we do not intend to overemphasize the findings of the study, we would like to address three practical implications for effective UREs. First, undergraduate internships may be useful in dispelling students' stereotypical images of science and scientists. Our findings and the results of previous studies [20, 21] suggest that undergraduate students in STEM disciplines often hold stereotypical perceptions (or misconceptions) of scientists as impersonal individuals in glasses and lab coats. In other words, being students in a STEM discipline does not necessarily imply that students hold positive images of science and scientists. On the positive side, however, students' comments also revealed that their experiences in the research internship contradicted their preconceived stereotypical views of scientists, thereby reinforcing Rosenthal's [20] assertion that students' interactions with scientists enhance their perceptions of scientists as normal individuals rather than stereotypes.

Second, our study suggests that uncovering students' preconceptions of UREs might offer educators the opportunity to help students align their expectations with the realities of UREs. To enhance meaningful learning and maximize benefits to students, faculty mentors and program staff need to identify and address students' expectations and preconceptions of UREs. Although writing in the context of nursing education, Gallagher's [22] recommendation that "educationalists must fully utilize the preconceptions held by each student and adopt an overtly constructive approach to the design and delivery of nursing curricula" (p. 881) is very applicable to undergraduate research internship programs. A first step, according to Gallagher [22] is to help learners understand that "theory" and "practice" are often different. For example, most UREs are developed on the assumption that students will receive one-on-one mentoring from faculty. Most students enter their UREs with this "theory" in mind and end up disap-

pointed when their experience or "practice" does not match up with their preconception of faculty mentoring in UREs. It appears that most of the students in our study were disappointed that they did not receive extensive one-on-one mentoring from their faculty supervisors. According to Dolan and Johnson [10], and as the results of our study suggest, extensive one-on-one mentoring of students by faculty is often impractical in large research universities because of "insufficient numbers of faculty and competing demands for their time" [10, p.2], hence undergraduate interns are often mentored by graduate and (or) postdoctoral researchers. Thus, it becomes imperative for faculty to be aware that students hold this expectation and to uncover this and other preconceptions and expectations through interviews and discussions and address them before admitting students for research internships in their research groups. Faculty mentors who find it impossible to commit to extensive one-on-one mentoring of undergraduate interns might have to explain beforehand so that students don't create unrealistic expectations or become disappointed when they are mentored by graduate students. Faculty may also need to explain to undergraduate students the structure of research groups, including the critical roles that graduate students and postdoctoral fellows play in research mentoring. The importance of having these and other important conversations with interns prior to their UREs cannot be overstated [10, 22]. For example, interns' UREs will be enhanced by pre-participation discussions of how scientists-in-training start by accomplishing less central tasks until their skills and knowledge develop and how even menial tasks are critical to the research of the group. In line with Gallagher's opinion [22], we recommend that experiential or hands-on educational programs like UREs will be more effective if students' past experiences and preconceptions about the learning processes are taken into consideration and addressed in an atmosphere free from blame.

Third, the range of preconceptions reported by the undergraduate research interns in this study is an indication of the importance of providing students with guidelines for their research internships. As noted by Hunter and colleagues [23] students often enter into their UREs without knowing what to expect. Hence, we agree with Monte's [24] suggestion that faculty mentors and research group leaders may need to draft guidelines or concise documents that: (1) define for students what is involved in doing research in general, (2) include some brief tips for success and (3) contain faculty mentors' expectations of students. Further, we share Monte's observation that research internships tend to be unique for each student; two students working on the same project in the same laboratory under the same supervisor may not have the same experience. Thus, faculty mentors need to be flexible in applying the guidelines and in meeting the needs of their students. We recommend that faculty mentors read Monte's article in the December 2001 issue of *Council on Undergraduate Research Quarterly* for an example of undergraduate research guidelines.

References

[1] Blanton, R. L. (2008). "A brief history of undergraduate research, with consideration of its alternative futures." In R. Taraban & R. L. Blanton (Eds.), *Creating effective undergraduate research programs in science: The transformation from student to scientist* (pp. 233-246). New York, NY: Teachers College Press.

[2] Halstead, J.A. (1997). "What is undergraduate research?" *Journal of Chemical Education, 74*, pp. 1390- 1391.

[3] Kardash, C. M. (2005). "Evaluation of an undergraduate research experience: Perceptions of undergraduate interns and their faculty mentors," *Journal of Educational Psychology, 92*, pp. 191 – 201.

[4] Russell, S. H., Hancock, M. P., and McCullough, J. (2007). "The pipeline: Benefits of undergraduate research experiences," *Science, 316*, pp. 548-549.

[5] Lopatto, D. (2004). "Survey of Undergraduate Research Experiences (SURE): First findings," *Cell Biology Education, 3*, pp. 270 – 277.

[6] Landrum, R. E., and Nelsen, L. R. (2002). "The undergraduate research assistantship: An analysis of the benefits," *Teaching of Psychology, 29*, pp. 15-19.

[7] Bauer, K. W. and Bennett, J. S. (2003). "Alumni perceptions used to assess undergraduate research experience," *The Journal of Higher Education, 74*, pp. 210-230.

[8] Hunter, A., Laursen, S. L., and Seymour,

E. (2007). "Becoming a scientist: The role of undergraduate research in students' cognitive, personal, and professional development," *Science Education, 91*, pp. 36-74.

[9] Taraban, R. (2008). "What is undergraduate research, and why should we support it?" In R. Taraban & R. L. Blanton (Eds.), *Creating effective undergraduate research programs in science: The transformation from student to scientist* (pp. 3-10). New York, NY: Teachers College Press.

[10] Dolan, E. and Johnson, D. (2009). "Toward a holistic view of undergraduate research experiences: An exploratory study of impact on graduate/postdoctoral mentors," *Journal of Science Education Technology.* Retrieved July 1, 2009 from http://www.springerlink.com/content/tq58626813263232/fulltext.pdf

[11] Taraban, R. and Blanton, R. L. (2008). *"Creating effective undergraduate research programs in science: The transformation from student to scientist,"* New York, NY: Teachers College Press.

[12] Morrison, J. A. and Lederman, N. G. (2003) "Science teachers' diagnosis and understanding of students' preconceptions," *Science Education, 87*, pp. 849– 867.

[13] Weinstein, C. S. (1989). "Teacher education students' preconceptions of teaching, *"Journal of Teacher Education, 40*, pp. 53-60.

[14] Carter, K. and Doyle, W. "Preconceptions in Learning to Teach," *The Educational Forum, 59*(2), pp. 186-195.

[15] Clement, J. (1993). "Using bridging analogies and anchoring intuitions to deal with students' preconceptions in physics. *Journal of Research in Science Teaching, 30*, pp. 1241-1257.

[16] Clement, J., Brown, D., and Zietsman, A. (1989). "Not all preconceptions are misconceptions: Finding 'anchoring conceptions' for grounding instruction on students' intuitions," *International Journal of Science Education, 11*, pp. 554-565.

[17] Chan, A. and Lee, M. J. W. (2005). "An MP3 a day keeps the worries away: Exploring the use of podcasting to address preconceptions and alleviate anxiety amongst undergraduate information technology students." In D.H.R. Spennemann & L. Burr (Eds), *Good Practice in Practice: Proceedings of the Student Experience Conference* (pp. 58–70). Wagga Wagga, Australia. September 5–7, 2005.

[18] Leh, S. K. "Preconceptions: A concept analysis for nursing," *Nursing Forum, 42*, pp. 109-122.

[19] Hseieh, H. and Shannon, S. E. (2005). "Three approaches to qualitative content analysis," *Qualitative Health Research, 15*, pp. 1277-1288.

[20] Rosenthal, D. B. (1993) "Images of scientists: A comparison of biology and liberal studies Majors," *School Science and Mathematics, 93*(4), pp. 212-216.

[21] Thomas, M. D., Henley, T. B., and Snell, C. M. (2006)."The draw a scientist test: A different population and a somewhat different story," *College Student Journal, 40*, pp. 140-148.

[22] Gallagher, P. (2007). "Preconceptions and learning to be a nurse," *Nurse Education Today, 27*, pp. 878-884.

[23] Hunter, A., Laursen, S. L., and Seymour, E. (2008). "Benefits of Participating in Undergraduate Research in Science: Comparing Faculty and Student Perceptions," In R. Taraban & R. L. Blanton (Eds.), *Creating effective undergraduate research programs in science: The transformation from student to scientist* (pp. 233-246). New York, NY: Teachers College Press.

[24] Monte, A. (2001). "Mentor expectations and student responsibilities in undergraduate research," *The Council on Undergraduate Research Quarterly, 22*(2), pp 66-71.

[25] Stemler, S. E. (2001). "An overview of content analysis," *Practical Assessment, Research & Evaluation, 7(*17). Retrieved March 27, 2010 from http://PAREonline.net/getvn.asp?v=7&n=17.

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