AC 2010-2235: CAREERWISE: AN INTERDISCIPLINARY EXPERIENCE FOR GRADUATE STUDENTS

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*Career*WISE: An Interdisciplinary Experience for Graduate Students

We are not students of some subject matter, but students of problems. And problems may cut right across the borders of any subject matter or discipline[1]*. (Popper, 1963, p. 88)*

Interdisciplinary research (IDR) has become the *sine qua non* of scientific inquiry. Because IDR stretches beyond the walls of single disciplines, it is thought to offer the most promise when tackling important problems that are not well-suited to shallow lenses. The key to interdisciplinary research is the integration and synthesis of existing disciplinary methods and perspectives to explore complex problems in nature and society. IDR is pluralistic in method, may be undertaken by individuals or groups, and can be challenging to distinguish from concepts such as multidisciplinary, cross-disciplinary, and transdisciplinary[2].

The National Academies targeted interdisciplinarity as essential to some areas of research and charged a broad-based committee of scholars to make recommendations about ways to further stimulate and support IDR[2]. Accordingly, hundreds of millions of dollars have been awarded via specific programs by the National Science Foundation (NSF) and the National Institutes of Health, among others, to interdisciplinary teams of research collaborators. Beyond programs targeted for interdisciplinary teams, sponsors often encourage and favor collaborations among faculty from different disciplines. NSF's Research and Evaluation on Education in Science and Engineering (REESE)[3] program is one example; the program solicitation notes that funded projects typically feature collaborative teams from a variety of disciplines.

Researchers emphasize the strong potential of IDR for addressing the grand challenges in science and engineering. At least as important as exploring and solving problems, however, is the preparation of tomorrow's researchers, the future corps for discovery and innovation. Already 15 years ago, the influential COSEPUP report[4] called for graduate education that emphasized depth of disciplinary knowledge but also greater breadth of knowledge and professional skills and the capacity to integrate and synthesize. One of the major initiatives of the National Science Foundation answered the call: the Integrative Graduate Education and Research Traineeship (IGERT) Program[5,6]. In IGERT, groups of faculty and doctoral students from a number of disciplines at one university integrate research and education around an interdisciplinary theme or problem. The IGERT Program aims to create a cultural change in doctoral education in an environment that goes beyond disciplinary boundaries and focuses on the experiences of the trainees. Since its inception in 1998, this program has funded over 4800 interdisciplinary trainees in 96 institutions.

Viewed this way, graduate education for tomorrow's interdisciplinary researchers is aimed at building a student's capacity to integrate knowledge and different forms of thinking, borrow tools and concepts from a variety of disciplines, and produce a cognitive advancement that would be almost impossible to produce from the perspective of a single discipline[7]. This integrative approach not only requires developing expertise in the primary discipline, but also building familiarity with the vocabulary, methods, tools and paradigms of the other disciplines[8]. As Robert A. Day announced the National Academies Futures Initiative in 2003, he described

the importance of reconstituting education as follows: "Training individuals who are conversant in ideas and languages of other fields is central to the continued march of scientific progress in the 21st century[9]."

Scholars have proposed that interdisciplinary projects provide unique learning opportunities for participants. For example, situated learning theories suggest that interdisciplinarity may enhance learning because typical problems found in that research are complex and simulate real word problems[10,11]. Participating in interdisciplinary research may promote higher-order thinking, and the ability to seek fundamental connections among disciplines; students may increase their ability to focus on connections among ideas, to interpret and apply knowledge across different contexts, and to cope with difficult real-life type of tasks[12]. Additionally, Ivanitskaya[13] suggests that interdisciplinary work may increase epistemological development, or an implicit set of beliefs about the nature of knowledge and learning. Students enrolled in interdisciplinary courses can develop perspectives on the difficulty of knowledge acquisition, relativism, uncertainty and subjectivity. These beliefs influence the involvement of the student in the learning process, program attrition, and the ability to cope with complex problems[13]. Exposure to an interdisciplinary environment positively influences graduate students' interdisciplinary understanding[8].

Other positive outcomes from interdisciplinary research activity have also been suggested. For example, interdisciplinary engineering programs have increased retention rates. Students in the First-Year Engineering Projects (FYEP) course at the University of Colorado at Boulder were retained at higher levels through the seventh semester of their programs[14]. Moreover, if students experience the excitement found at the interfaces of different sciences[15] they may be more motivated to persist in science and engineering careers.

Despite years of debate about the virtues of disciplinary versus interdisciplinary approaches to research, there now appears to be a growing consensus that the quality of the product is enhanced as multiple lenses are applied to it. Given the considerable demands of the academy and industry for highly prepared knowledge workers, the richness of education provided to graduate students becomes ever more essential. Consistent with the outcomes movement in education, including engineering education, it is important not just to understand the forms of education provided but also the experiences of the students being educated and the learning outcomes achieved.

This paper presents findings from a preliminary investigation into the experiences of graduate students who are members of an interdisciplinary research team. The *Career*WISE (CW) project at Arizona State University, part of a large interdisciplinary research program supported by the National Science Foundation, serves as the vehicle for studying student experiences. There are two major thrusts for the *Career*WISE research program: (a) to understand the forces that lead some women to leave PhD programs in engineering and the sciences before attaining the degree, and (b) to design and evaluate a web-based intervention that increases a woman's resilience, coping, and problem-solving skills and examine the relationship between these skills and women's choices to persist in their PhD programs.

Since its inception in 2006, the *Career*WISE team has consisted of students, faculty and staff from a wide-range of disciplines, including psychology, physical sciences, engineering, educational technology, curriculum and instruction, education policy, theatre, and arts and media

design. Additionally the CW project actively attempts to provide professional development opportunities for students on the team. CW graduate researchers acquire roles based on their skills and interests and create and maintain scholarly networks through collaboration across disciplines.

Reported here are the results of a survey distributed to current and former CW graduate research assistants (GRAs). This preliminary study sets the stage for a fuller examination of learning outcomes for graduate students engaged in an extended interdisciplinary research experience.

Research Methodology

Participant Recruitment: At the time of this research, the CW project was led by four primary faculty members. The faculty represented the following disciplines: counseling psychology, educational leadership and policy, educational technology, and engineering. In addition, the project funded 11 research assistants (RAs) and one program coordinator (since this research, two additional RAs have been hired). The gender breakdown for these research assistants is 36% male (N=4) and 64% (N=7) female. Of these, 55% (N=6) are from a psychology discipline, 27% (N=3) are from education and communication disciplines, and 18% (N=2) are from STEM disciplines. Additionally, 55% (N= 6) of research assistants have worked on the project for less than a year, while 45% (N=5) have been employed between one and three years.

All current and former RAs who are still officially affiliated with the project (one former RA is now a member of the faculty leadership team) were invited to participate in the evaluation. There are approximately 15 additional graduate students who have previously been part of the project, but are not currently affiliated with CW; they were not invited to participate in the current survey.

A cover letter and questionnaire were sent electronically. It was emphasized in the cover letter that participation was voluntary and that there would be no penalty for choosing not to participate. Consent for participation was granted by the participants upon returning the survey.

Participant Demographics. Of the population (N=12, which includes 11 current and one former RA), eight members of the CW team participated in the study. Of the eight participants, two reported being employed by the project, and one reported volunteering; the remaining participants did not specify employment status. While auxiliary roles varied among participants, the primary role for five participants was related to content writing or editing. Three participants cited managerial responsibilities related to being a team lead as a principal role on the project, and three participants mentioned having helped with participant recruitment. One participant reported duties related to developing and organizing research methods, and one participant cited video editing as a primary responsibility during the first year on the project.

Procedure. Data were collected in the form of a questionnaire containing both closed and open-ended questions. Participants were granted two weeks to complete the anonymous questionnaire. To ensure this anonymity, participants were instructed to type their responses, and then print the questionnaire before physically (vs. electronically) returning it to the *Career*WISE office.

Participants completed a 12-item questionnaire about their experiences as part of the CW project. Participants reflected and described what they had gained as participants in a large interdisciplinary project as well as the challenges that they had faced. Participants responded to questions about the changes in their knowledge and skills related to: interdisciplinary teams, disciplinary cultures, gender issues in educational and career settings (topic of the CW project), and the creation of instructional materials for online use (topic of CW project). They were asked how they had used these skills in external settings. Additionally, participants rated the likelihood of their joining an interdisciplinary research project in the future. A copy of the questionnaire can be found in Appendix A.

Results

When analyzing survey responses, themes were not identified in advance; rather, they were identified based on the questionnaire responses themselves. Results are presented in the following categories related to the questionnaire given to the participants: learning outcomes, benefits to students [of working on an interdisciplinary project], challenges faced, [interest in] future interdisciplinary work, and other comments. A summary and discussion of the results follows.

Learning outcomes

Participants reported a variety of learning outcomes associated with their involvement on the project. Overall, participants reported the benefit of learning from senior members of the team, faculty leaders, and students from disciplines outside their own as contributing to their personal and professional growth. A research skills theme emerged from participants reporting that they had enhanced their writing and methodological skills related to conducting research both on and outside of the project. For those students serving leadership roles on *Career*WISE, a team management theme emerged; they reported improving managerial and group management skills while on the project. Additional themes of mentorship and collaboration emerged from those participants who reported having found support through mentorship from faculty or those who had an opportunity to make good friendships with other students. Finally, a theme related to expanding content expertise was apparent from those who reported gaining knowledge about psychology topics because of their writing assignments on the project. Learning outcomes relative to specific questionnaire categories were also reported and their discussion follows.

> *Nature of Interdisciplinary Teams.* While on the project, participants reported that they learned how to incorporate different work, personal and research styles to solve problems in unique ways. Additionally, they learned how to listen and respect different ideas through networking with colleagues across disciplines. Overall, participants reported improving communication skills through their interactions with other project members as well as through professional networking at advisory board meetings and conferences. Learning how to balance schedules on a large team was also cited as an important dimension of interdisciplinary work on the project.
>
> *Nature of Disciplinary Cultures.* It was apparent that disciplinary norms impacted students' interactions on the project. An important outcome of working on this project

was the opportunity to learn about the differences between disciplines, departments, and individuals with respect to task assignments, work styles, and communication skills. For example, students from technical fields were surprised by the long team discussions to reach consensus about approaches to content areas. Similarly, participants from different disciplines varied in their comfort with open-ended assignments.

Gender and cultural issues. Awareness of sexism in STEM was a theme that echoed throughout the responses of the participants. For some, a better understanding of sexism helped them acknowledge the need to continue to do this type of research. Additionally, students reported learning of the statistics on non-completion, common sources of discouragement that women report, and the disproportionate progression of women in science. Participants also reported gaining assertive communication skills; in fact, one participant felt that the project had helped her express discomfort in her own doctoral program. Additional learning outcomes included recognition of gendered communication, micro-aggressions, and hidden assumptions behind jokes.

Creating instructional materials. Questionnaire responses indicated that participation in the project resulted in improved written communication skills. Some participants expressed that they had learned how to write and deliver material to a STEM audience (i.e., outside their own department or discipline). Participants also reported learning about the complexity of creating online materials, to program web pages, and to integrate ideas of interdisciplinary team members to develop materials.

Psychological topics. Responses indicated that participants increased their knowledge of psychological research that undergirds the development of *Career*WISE content and research design. Some of these participants gained a deeper understanding of content areas they were already familiar with, while others learned content that was entirely new to them. Some of the psychological content areas mentioned were resiliency, self-efficacy, emotional styles, and communication skills. Exposure to psychological topics was helpful in contributing to participants' research and educational goals outside the project.

Engineering education. Overall, participants reported a better understanding of the research gaps in graduate STEM education and a better awareness of the difficulties faced by women in STEM. Participants reported gaining knowledge about the importance of an academic advisor in helping a student navigate a PhD program, the cultures of different departments and programs, and the nature of research lab settings.

Benefits to students

Application of skills. Responses indicated that participants were able to apply knowledge gained during participation in the interdisciplinary project to a variety of situations outside the project. Specifically, participants noted that they applied both written and oral communication skills in their daily and academic life; in difficult situations, they also used problem-solving skills.

Professional networking. Overall, participants felt that professional networking was supported through being on the *Career*WISE team. Students who reported improving their networking skills cited the opportunity to meet faculty and professionals from other universities by attending professional conferences and the project's annual advisory board meeting. Additionally, participation in CW increased some participants' awareness of different professional networks and influenced some students' decision to join. Finally, participants reported an increased confidence in networking with professional colleagues.

Challenges Faced

When asked to report any challenges faced while working on the *Career*WISE project, participants referred to negotiating the differences in work and communication styles across disciplines. Other difficulties included administrative aspects of managing an interdisciplinary team such as scheduling and learning to compromise when making decisions. Personal challenges, particularly working outside zones of comfort or expertise were also noted.

Future Interdisciplinary Work

All participants reported that they would join an interdisciplinary team in the future. Some of the factors contributing to a future decision included the specific roles and expectations of the project, the faculty or program leader, the disciplinary composition, and the availability of office space, job security and publishing opportunities. The type of research and the fit with the personal research agenda were also cited as important considerations.

Final Impressions.

When asked to make additional comments, some participants noted that employment on this particular project had exceeded their expectations and that the project was beneficial for professional development because it provided students with the opportunity to publish, conduct research and present at conferences. Some participants noted that the project's current organization allows for the presentation of ideas and a safe environment for people to disagree with each other if necessary.

Discussion and Conclusions

Results from the questionnaires provide preliminary findings about student experiences while working on a large interdisciplinary project. Participants reported the benefit of learning about other disciplines through interactions with team members as well as learning to communicate more effectively both in networking settings and within their own department. This supports the view that interdisciplinary work may increase students' ability to apply knowledge across different contexts. Not surprisingly, students reported learning content that pertained to the topics addressed by *Career*WISE research: gender issues in STEM, psychological topics, and engineering education. On the other hand, participants typically reported unique outcomes related to their personal and professional growth. This finding may indicate that student background plays a role in both the specific professional development and learning that takes place in an interdisciplinary project setting.

Overall, the study indicated that the participants enjoyed working on the interdisciplinary project and learned useful skills that they may not have learned outside of an interdisciplinary environment. The interpersonal and technical skills learned while on the project will be useful as participants transition into academic and professional positions. Also, the benefits of working on a large, interdisciplinary project will help them collaborate with colleagues in different units and departments, and the challenges faced will prepare them to problem-solve difficult situations in the future.

The findings of the preliminary study may serve as a model for future interdisciplinary team developers, particularly those teams looking to integrate students and faculty members across STEM and social science disciplines. Additionally, as learning outcomes and experiences of student team members continue to be studied, it will be important to look at other interdisciplinary projects as well. With additional studies, students' experiences in *Career*WISE can be compared to the experiences graduate students have in other types of interdisciplinary experiences. Specific questions to investigate in the future include: how does interdisciplinary work impact retention, and how does the background of students on an interdisciplinary team impact their specific professional growth trajectory while on the team.

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Appendix A

***Career*WISE: An Interdisciplinary Experience for Graduate Students**

Questions for Team Members

The following questions will be used to help us better understand the experiences of students and faculty members who work on a large, interdisciplinary research team. Please respond to the questions below with as much detail as possible. You can submit your answers to assigned drop box in the *Career*WISE office, send the survey via internal mail to mail code 0211 . Thank you in advance for your time.

- Are you currently employed or volunteering on the *Career*WISE project?

- If so, how long have you been (or were you) involved with *Career*WISE?
    - 0 – 12 months
    - 12.1 months to 24 months
    - 24.1 months to 36 months
    - More than 36 months

- Please describe how each of the following affected your contributions to the project, what you learned, and the quality of your experience.

    - Your role in the project (e.g., team leader, team member, RA, volunteer)
    - Your length of time with the project
    - Your particular assignments and activities

- Since its inception, *Career*WISE has consisted of students and faculty members from a variety of disciplines, including engineering, physical sciences, communication, educational technology, counseling psychology, educational psychology, arts media and engineering, curriculum studies and educational leadership and policy studies. Please reflect on your time as a team member on the project, including the composition of students and faculty members, and tell us what you have gained from interacting with these people.

- Please describe any challenges you have experienced while working with people from different disciplines on this project.

- For each of the following, describe what you have learned (knowledge and skills) through participating in the *Career*WISE project, how you have applied what you have learned in settings outside of *Career*WISE, and how you do, or plan to, use this learning in your career
    - Interdisciplinary teams
    - Disciplinary cultures
    - Gender issues in educational and career settings
    - Creating instructional materials for online

- Of the skills and knowledge you have learned, how have you applied them in settings outside of *Career*WISE? Please be as specific as possible

- One of the objectives of the research held in *Career*WISE is to identify the reasons behind the attrition rates of women in PhD programs in STEM areas as well as to create and evaluate a web-based intervention tool aimed at increasing self-efficacy and resiliency toward persisting in their programs. Based on your involvement on the project, please describe what, if any, information you have learned related to gender and cultural issues while working on the *Career*WISE team.

- Next, please describe what, if anything, you have learned related to:

    - Psychological topics
    - Engineering education
    - Professional networking

- If the opportunity to be part of a large interdisciplinary team such as *Career*WISE presents itself in the future, please rate your likelihood of joining the team?

Definitely would not join				Definitely would join
1	2	3	4	5

- Please describe what factors would go into your decision when choosing to work on an interdisciplinary team in the future.

- Please make any other comments you think might be helpful in understanding how *Career*WISE has benefitted and/or challenged you personally or professionally