

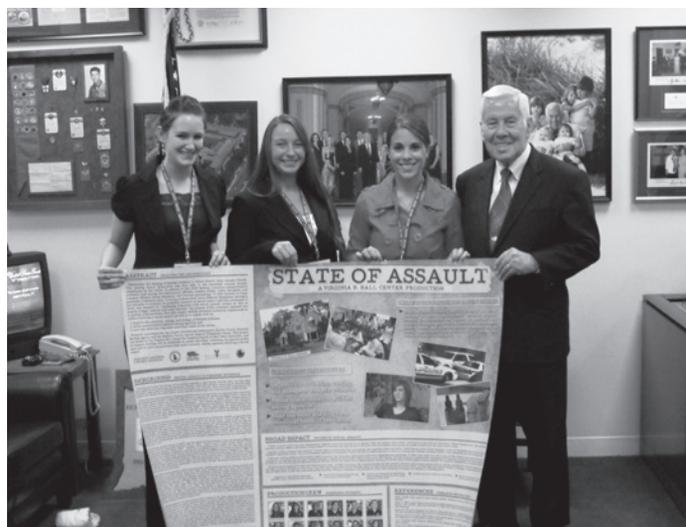
Transformative Undergraduate Research: Students as the Authors of and Authorities on Their Own Education

An important component of our university's strategic plan is to offer interdisciplinary scholarly opportunities to all students within the next few academic years. To this end, I sought and received internal funding from the university's Virginia B. Ball Center for Creative Inquiry (www.bsu.edu/vbc/) for an exciting student-developed project spanning seven majors and three colleges at Ball State, as well as two community partners and three dozen other collaborators off-campus. The title of this immersive-learning research was "State of Assault." Twelve individually recruited students developed and produced a 30-minute documentary poignantly addressing current problems in dealing with the physical and emotional needs of adult victims of sexual assault, as well as the backlog of forensic evidence (e.g., rape kits) awaiting processing in crime laboratories nationwide.

The documentary told the story through the eyes of two survivors of sexual assault. The problems and proposed solutions were well researched by student teams, and the documentary was showcased on regional public television in December 2008. It was subsequently nominated for three regional Emmy Awards this year from the National Academy of Television Arts and Sciences, and won an Emmy for editing in the non-news category in September. In leading students through this immersive-learning experience, I found four elements vital to the success of interdisciplinary undergraduate research. If addressed proactively, these can produce the most rewarding interdisciplinary experience possible.

Rethinking Conventional Teaching Through Research

Prior to writing the proposal for this interdisciplinary experience, I—probably like most other faculty members at Ball State and similar institutions—had limited experience with research or teaching students from outside my department. Although I had continually revised my microbiology classes and labs, the thought of implementing bold, nontraditional approaches such as multi-, inter-, or transdisciplinary research on real-world challenges (Graybill, Dooling, Shandas, Withey, Greve, Simon, 2006) was not something I had considered or even thought possible. Likewise, my research in food safety was moving



Students Erin Slack, Kendra Phillips, and Megan Smith (left to right) pose with Sen. Richard Lugar of Indiana as they visit elected officials on Capitol Hill during the CUR "Posters on the Hill" event.

along a fairly standard track, involving some collaboration with industry and colleagues outside my university over the years.

But once I discovered that one aspect of the molecular toolbox used in our lab for real-time characterization of bacterial food pathogens could also be a sensitive tool with great promise in molecular forensics, I established a network of colleagues outside of my comfort zone in bacteriology, in areas such as criminal justice, forensic nursing, law enforcement, and sociology. This fairly recent transition has forever changed the way in which I conduct research and run my classes. It has provided a myriad of additional avenues in professional development for myself and, more importantly, for my students. My current laboratory-based microbiology courses are now being taught, or are being redesigned, to reflect a "teaching-through-research" approach more consistent with immersive-learning ideals (Prince, Felder, Brent, 2007).

The "State of Assault" project, in particular, was designed and completed through research-based engagement of students, rather than through the traditional research-led approach (Healey, 2005). In the latter model, the curriculum is built around the content, which is selected and presented based on the instructor's previously established knowledge base. This

approach typically utilizes existing personnel and traditional means for disseminating information to students. However, the research-based engagement of students in the project allowed them to essentially create their own roadmap for how the week-to-week progress would unfold, as well as how the story would be presented in the resulting documentary to best convey their research findings to a large audience.

The transferability of this immersive-learning/teaching model to real-world applications varies according to the disciplines involved, but in all cases, the students are connected to the community at some level in order to see their efforts come to fruition in the form of a tangible outcome or product (see bullet points below). Partnerships with industry, healthcare institutions, or a corporate entity provide a conduit for student-generated ideas to become reality, while allowing each participant (including faculty) to cultivate professional contacts for future employment, internship opportunities, or continued research collaborations.

From an idea initially centered on a laboratory procedure—real-time RNA detection in cells for differentiation of human body fluids in forensic specimens—the initial project proposal grew to include a more victim-centered approach. In discussions with colleagues regarding the backlog of DNA evidence and the need for novel laboratory methods to alleviate this problem, the direct issue of how this affects the victims immediately became important. The time delay associated with the evidence backlog obligates local law-enforcement agencies to store evidence (sometimes improperly) for extended periods, which may compromise the quality of the specimens and adversely affect the outcome of legal proceedings. Moreover, in talking to criminal justice practitioners and forensic nurses, it became clear that, in many cases, sexual-assault victims do not receive adequate emotional support as the reporting process is carried out.

Two questions soon became priorities: First, how could health-care practitioners, law enforcement, and legal advocates better meet the emotional needs of sexual-assault victims during the process of developing evidence? Experts such as sexual-assault nurse examiners and victim's advocates are only available in some communities to treat assault victims' emotional needs (see Campbell, 2009 for an excellent review of programs training sexual-assault nurse examiners). Moreover, funding for training such experts is problematic for many smaller cities or rural areas (<http://www.sane-sart.com/>). Secondly, how

could state governments successfully reduce or eliminate the large backlog of sexual-assault evidence awaiting processing (Counterterrorism and Forensic Science Research Unit, 2004)?

To help answer these questions, I created a seminar course that followed the criteria for immersive learning at Ball State University and would:

- carry academic credit;
- engage participants in an active-learning process that was student-driven but guided by a faculty mentor;
- produce a tangible outcome or product (in our case, a 30-minute documentary DVD);
- involve students working in interdisciplinary teams;
- include community partners and create an impact on the larger community as well as on the student participants;
- focus on student learning outcomes; and
- help students define a career path or make connections to a profession or industry.

Through the successful completion of our project, I am able to offer four elements for success that I feel are not atypical for implementing immersive-learning/interdisciplinary research experiences with undergraduates. These embody strategies that maximize a positive and productive learning environment for students, while still offering them the independence to explore their own creativity and achieve the project's goals.

First Element for Success: Recruit for Both Short- and Long-term Success

The success of any interdisciplinary undergraduate research depends directly on the careful selection of students, since each will bring to the team a unique perspective on the problems and questions to be addressed. Through one-on-one interviews with prospective students and/or written essays relating to their understanding of the project's broad impact, one may objectively gauge some of these characteristics. Actually, however, I have found that student recruitment is a subjective process. I tried to keep in mind the importance of not only selecting students who could contribute to our project's success, but also those who would gain the most through their participation. In so doing, I was able to give priority to students' experiences and aspirations, rather than relying on traditional screening by grade-point averages, recommendation letters, etc., which became ancillary means of recruitment.



Students listen to John McKillip explain the proper use of a micropipette, while another student films the action during their participation in a DNA fingerprinting exercise for the “State of Assault” project (photo courtesy of Laura Huffman, Virginia Ball Center for Creative Inquiry at BSU)



Students from John McKillip’s interdisciplinary immersive-learning class gather to test lighting and sound for an interview with a sexual-assault nurse examiner at the Ball State School of Nursing (photo courtesy of Laura Huffman, Virginia Ball Center for Creative Inquiry at BSU)

In other words, each student was (in person) able to justify to me why and how they could contribute to our final set of research objectives, as well as what they sought to gain from others on the team. This approach (Hartline, Poston, 2009) eventually allowed me to select twelve undergraduates majoring in seven fields across three colleges; they ranged in age from 19 to 44. And while no recruitment method is foolproof, I feel that this design let students know immediately that the research project’s success relied directly on their expertise and hard work.

Second Element for Success: Macromanagement

In a way, my role was very much that of a co-learner. However, as the project coordinator, I set out from the beginning to establish amicable group dynamics, but balanced with progress toward our stated objectives. Three working groups were created, each comprised of four students possessing skills and personal demeanors suited to the tasks of their specific team. The research team surveyed the literature to formulate pertinent interview questions for experts in forensics and criminal justice, as well as for the sexual-assault victims to be featured in our film. This team also ended up writing and submitting an abstract for the annual “Posters on the Hill” event sponsored by CUR. Their abstract was accepted, allowing members of the research team to travel to Washington, D.C. last May (see accompanying photos). The interview team consisted of stu-

dents majoring in telecommunications, nursing, and women’s studies, with technical expertise (sound, lighting, equipment), or a history dealing with victims of domestic abuse. The coordination team was responsible for arranging and scheduling interviews and other off-campus activities, as well as planning our capstone showcase at the end of the semester, when the final version of the film premiered and was simulcast on public television.

By mentoring the teams through weekly group meetings, I was able to offer guidance while empowering the students to make the day-to-day project decisions on their own. By providing students with opportunities to connect with professionals in varied disciplines on campus and, especially, off campus, each was challenged to be more accountable and productive than he or she would otherwise be in a traditional classroom environment (Person, Brew, 2002). Virtually all students soon established a repertoire of community contacts in a variety of professional disciplines, providing a mutually beneficial arrangement during the project’s development. Weekly one-on-one meetings with each student and collection of students’ journal entries were also part of my management and assessment plan, since students’ performance varied markedly. Differences of opinion on how to accomplish defined project goals and philosophical disagreements among students in resolving internal problems were monitored closely through these individual meetings with students. I implemented several interventions during the semester, including changing students

on two of the teams in an effort to streamline group dynamics (Younglove-Webb, Gray, Abdalla, Thurow, 1999).

Third Element for Success: Cultivate Students' Professional Development

As the project coordinator, my goal was to enable students to complete a high-quality, 30-minute documentary on the problems and solutions associated with sexual-assault casework. However, equally important to me was that this immersive-learning experience also be an exercise in practical professional development for every student. To that end, we spent the first hour of each day for the first three-and-a-half weeks reading and discussing the principles outlined in a leadership-development book (Maxwell 1999) and how those ideals could be applied during and after the completion of our documentary.

These discussions were augmented with speakers on other practical topics directly relating to our film's success. For example, students were exposed to forums on developing interviewing skills, seminars on victimology and psychotrauma, an interactive digital tutorial on procedures used by sexual-assault nurse examiners, digital editing of film, storyboarding the documentary, and procedures for obtaining informed consent for the use of human subjects in research from the director of our university's institutional review board (IRB). Every student had to complete these modules, and the research team successfully wrote and submitted (through IRBNet) a protocol for use of human subjects that was approved by our IRB so that they could proceed with interviews of sexual-assault victims. These steps resulted in all twelve students receiving NIH certification to work with human subjects.

This blend of topics also afforded each working group the opportunity to mentor others in the class on the technical knowledge or expertise needed as the film developed. For example, telecommunications students assisted other majors on use of editing software, provided instructions on how to capture film and log tape, and use of the hand-held digital video camera for completion of our metafilm. Thus, all twelve students had their turn at completing these jobs. Likewise, the two biology majors in the group assisted the rest of the class during a day we spent in the molecular biology laboratory performing a DNA fingerprinting experiment, which involved restriction enzyme digestion, agarose gel electrophoresis, and digital photodocumentation of our DNA banding patterns.

By semester's end, each discipline represented by the varied majors had shared with the others its specific lexicon and technical jargon to at least the level of "working familiarity." In addition to the three telecommunications majors who were part of the project, two additional students were recruited to write the musical score for our film, although they were not officially enrolled in the project.

Emotional support for students was necessitated by the seriousness of our subject matter. The director of our university's counseling services visited our class and explained the expertise offered by the office and the staff specialties, as well as providing some general guidelines to assist students in dealing directly with sexual-assault victims. This was particularly important, as more than one member of our group had themselves been victimized.

In these ways I tried to address as many aspects of students' professional development as possible in order to maximize active student learning, scholarly engagement, and productivity (Hunter, Laursen, Seymour, 2007; Ryser, Halset, Thien, 2009). Achieving the goals of our research plan could only be successful if each member of the student teams was being appropriately and realistically challenged, and was mutually respectful of each other and of our off-campus collaborators and community sponsors. I tried to emphasize that it is not just getting there that matters; how you get there also defines your character, leadership potential, and by extension, your professional success.

Fourth Element of Success: Leverage Immediate Impact into Long-term Sustainability

The momentum immediately following our final showcasing of the documentary was fueled by the students' excitement over having the project completed, being able to screen the film to the public in an open forum, and broadcasting it on public television (www.stateofassault.com). However, the impact of the research efforts must persist far beyond the initial splash created by the final, tangible project outcome. Any worthwhile research endeavor should allow any of the willing and able participants multiple opportunities to locate and capitalize on related research opportunities after the initial project ends. These opportunities usually come about when the research results are presented in a professional venue, such as at con-

ferences or in publications, providing the needed exposure to scientific and lay audiences. Our project was no exception to this, and since the project's completion, the documentary and/or the poster prepared by our research team has been shown at regional conferences. These have included the Indiana Branch Meeting of the American Society for Microbiology (IBASM), the Butler University Undergraduate Research Conference, our BSU Student Research Symposium, and Spring 2009 BSU Women's Week (all with students as presenters). The highlight of all of these presentations was the opportunity for me to take three members of the research team to Washington, D.C., for the CUR "Posters on the Hill" event last spring. Students met with two Congressmen and Sen. Richard Lugar (R-IN) to discuss the project's social-policy implications, as well as the interdisciplinary-research experience itself and what it meant for their academic careers.

As the project coordinator, my role is to now use the momentum built by the project's exposure as "preliminary data" of sorts to write additional grant proposals supporting interdisciplinary undergraduate research. At the same time, I am continuing to seek the marketing and distribution of our film through my connections with one of our project's community partners, Holly Renz, a registered nurse who directs a local sexual-assault treatment center. Ball State, like many institutions similar in size and scope, offers internal funding opportunities for innovative research projects, but several federal and other external agencies support such efforts as well (Temple, Ronnenberg, 2009).

Sustaining student research projects, as well as teaching my regular course load and conducting my own research, is becoming easier as I acclimate to the idea of integrating my teaching with research, rather than perceiving these areas as mutually exclusive. If a faculty mentor/principal investigator approaches teaching and research from a student-centered perspective, being good at one will make him or her better at the other. Chapter 20 of the latest publication by CUR (Abraha, Kanis, 2009) presents a very thoughtful overview of maintaining a dynamic undergraduate research program that meets the technical, theoretical, and developmental needs of students, while also allowing original contributions to the respective disciplines.

Summation

The participation of undergraduate students in original research encourages them to pursue careers that address current complex scientific or societal problems (Russell, Hancock, McCullough, 2007). For a subset of the undergraduate participants in "State of Assault," the CUR "Posters on the Hill" was an invaluable capstone experience for their research efforts because it allowed them to see first-hand the social and political importance of their work. Making traditional undergraduate research interdisciplinary allows the experience to be more transformative in terms of its impact on students, and it also maximizes the resulting societal implications. Several inquisitive minds blend into a single creative effort to solve a problem well outside the grasp of a single investigator (Cech, Rubin, 2004).

Undergraduates (or any student research team for that matter) from diverse majors, with differing approaches to solving problems, and spanning a wide age range will disagree from time to time on a variety of issues. It is vital to the success of the project that this negative energy be neutralized or immediately shunted back into the project in a way that achieves positive results, so that students grasp the notion that the research objectives and the end results of their efforts far overshadow their own selfish whims or capricious temperaments. Results matter. How the students learn to work with each other to obtain these results matters even more. Lifelong-learning includes building strong and positive collaborations through interdisciplinary efforts that cannot be replicated in a traditional classroom (Campbell, Skoog, 2004). Students' subsequent success will be built upon their ability to cultivate these professional relationships through creative inquiry and positive, character-based leadership qualities. These are the ideals consistent with a fruitful and rewarding career in research.

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References

Abraha A, Kanis DR. Growing a vibrant research program with non-traditional students: Strategic use of time and energy. In: Boyd, M & Wesemann, J, eds. *Broadening Participation in Undergraduate Research: Fostering Excellence and Enhancing the Impact*. Washington, D.C. Council on Undergraduate Research: Chapter 20.

Campbell A, Skoog G. Preparing undergraduate women for science careers. *J Coll Sci Teach*. 2004;33:24-26.

Campbell R. The psychological impact of rape victims' experiences with the legal, medical, and mental health systems. *Amer. Psychologist*. 2008;63:702-717.

Cech TR, Rubin GM. Nurturing interdisciplinary research. *Nat Struc Mol Biol*. 2004;11:1166-1169.

Counterterrorism and Forensic Science Research Unit. Automating the forensic analysis of nuclear DNA: The FBI's research and development initiative. *Foren Sci Commun*. 2004;6:1-4.

Graybill JK, Dooling S, Shandas V, Withey J, Greve A, Simon GL. A rough guide to indisciplinaryity: Graduate student perspectives. *BioScience*. 2006;56:757-763.

Hartline BK, Poston ME. 2009. The mandate for broadening participation: Developing the best minds and solutions. In: Boyd M & Wesemann J, eds. *Broadening Participation in Undergraduate Research: Fostering Excellence and Enhancing the Impact*. Washington, D.C. Council on Undergraduate Research: Chapter 1.

Hunter A-B, Laursen SL, Seymour E. Becoming a scientist: The role of undergraduate research in students' cognitive, personal, and professional development. *Sci Ed*. 2007;91:36-74.

Healey M. Linking research and teaching to benefit student learning. *J Geog High Ed*. 2005;29:183-201.

Maxwell J. *The 21 Indispensable Qualities of a Leader: Becoming the Person Others Will Want to Follow*. Thomas Nelson Publishers, Nashville, TN, 1999.

Pearson M, Brew A. Research training and supervision development. *Stud High Ed*. 2002;27:135-150.

Prince MJ, Felder RM, Brent R. Does faculty research improve undergraduate teaching? An analysis of existing and potential synergies. *J Eng Ed*. 2007;96:283-294.

Russell SH, Hancock MP, McCullough J. Benefits of undergraduate research experiences. *Science*. 2007;316:548-549.

Ryser L, Halseth G, Thien D. Strategies and intervening factors influencing student social interaction and experiential learning in an interdisciplinary team. *Res High Ed* 2009;50:248-267.

Temple GG, Ronnenberg SGC. Resources for broadening participation in undergraduate research. In: Boyd M & Wesemann J, eds. *Broadening Participation in Undergraduate Research: Fostering Excellence and Enhancing the Impact*. Washington, D.C. Council on Undergraduate Research: Appendix.

Younglove-Webb J, Gra B, Abdalla CW, Thurow AP. The dynamics of multidisciplinary research teams in academia. *Rev High Ed*. 1999;22:425-440.

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