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Fall 2015 | Volume 36, Number 1

ETHICS AND THE RESPONSIBLE CONDUCT OF UNDERGRADUATE RESEARCH

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A Web Supplement for Using *COEUR* to Assess Undergraduate Research: A Three-Stage Model for Institutional Assessment

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CUR Quarterly
COUNCIL ON UNDERGRADUATE RESEARCH

Volume 36, Number 1

Publisher
CUR National Office
Council on Undergraduate Research
734 15th Street NW, Suite 550
Washington, DC 20005-1013
Phone: 202-783-4810
Fax: 202-783-4811
www.cur.org

Design
Design and Prepress Production
SliceWorks
Gaithersburg, MD
www.slice-works.com

Production and Mailing
The Sheridan Press
Hanover, PA
www.sheridan.com

The *Council on Undergraduate Research Quarterly* is published in the Fall, Winter, Spring, and Summer by the Council on Undergraduate Research.

The mission of the Council on Undergraduate Research is to support and promote high-quality undergraduate student-faculty collaborative research and scholarship.

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For CUR members, the *CUR Quarterly* is delivered as a benefit of membership. For other individuals, the annual subscription rate is $42. For libraries, the subscription rate is $87 annually.

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ISSN 1072-5830

Council on Undergraduate Research
734 15th Street NW, Suite 550
Washington, DC, 20005-1013

Cover Photo: Students at a poster session at the University of Illinois at Urbana-Champaign.

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Cooperative Learning and Assessment of Ethics Sessions in a Summer Undergraduate Research Program

In 2010, the U.S. National Science Foundation (NSF) began requiring instruction in research integrity for all students, including undergraduates, who are supported on NSF research grants. Since then, administrators of undergraduate research programs have taken increased interest in providing instruction in research ethics and, specifically, in the responsible conduct of research (RCR).

In social-science programs, advanced undergraduates typically learn about responsible conduct of research in a course on research methods (Punch 2013; Ware and Brewer 2013). In engineering programs, undergraduates learn about professional ethics instead of the responsible conduct of research (Alfredo and Hart 2011). In the natural sciences, little is known about the instruction that undergraduates typically receive in appropriate research practices (Heitman and Bulger 2005), although some instructors have taken the initiative in integrating coverage of responsible research conduct into undergraduate courses and curricula (Fisher and Levinger 2008).

Undergraduate programs in computer science have generally included significant attention to ethical issues in the discipline. Since 1987, the guidelines of the Computer Sciences Accreditation Board have required undergraduate programs in computer science to provide a substantial amount of instruction on social, ethical, and legal issues in computing (Huff and Martin 1995). Curriculum recommendations developed by the Association for Computing Machinery and the Computer Society of the Institute of Electrical and Electronics Engineers have also emphasized instruction in social, ethical, and professional issues (Tucker 1991). These accreditation guidelines and curricular recommendations have significantly influenced the content of all computer science programs. By 1995, about 300 courses on computer ethics were offered in the United States (Crawford 1995). In a random survey of 700 computer science programs in 2005, out of 251 respondents, 172 programs included instruction in computer ethics in required courses (Spradling et al. 2008).

Standard textbooks on ethics in computing (for example, Johnson 2009; Quinn 2005; Tavani 2004) address issues in professional ethics and social ethics, including intellectual property, privacy of individual data on the Internet, malicious software, software risks, and hacking. They neglect ethical issues in computing research, however (Wright 2006).

In this article, we describe the design and assessment of sessions on research ethics and computer ethics in a summer research program for undergraduates. We collected assessment data at the beginning and end of the summer program.

Ethics Sessions

In the summers of 2009, 2010, 2011, and 2012, the Information Trust Institute at the University of Illinois at Urbana-Champaign hosted a summer undergraduate research program focused on reliable and secure computing. This eight- to ten-week program was supported by a grant from the NSF Research Experiences for Undergraduates (REU) Sites program. Most students were majoring in computer science, computer engineering, or another technical discipline. The number of summer students varied from 21 to 26. Each summer, ten domestic students were supported by this NSF grant, a few domestic students were supported through a different REU site grant, and the remaining students, who were international, were supported by other funds.

Each summer's format included six weekly sessions on ethics in the responsible conduct of research (RCR) and in the development and use of information technology. The sessions addressed topics such as authorship standards, plagiarism, mentoring relationships, conflict of interest, privacy of personal data, professional responsibility for software quality, accuracy of computational models, and the social impacts of computers. We chose these topics for their relevance to the students' research projects. We omitted standard RCR topics that were not relevant to these students, such as the responsibilities of peer reviewers and the protection of human and animal subjects. Even the traditional RCR topics of fabrication, falsification, and data management were not relevant for many projects that involved the development of software or the mathematical analysis of algorithms.

To address the ethical topics we focused on, we selected fictional but realistic short cases (scenarios) from a variety of sources (Table 1).

Table 1: Ethics Cases Used in 2009 Summer Program

Week	Topics	Cases and sources
1	Authorship, plagiarism	"Case 1" (Penslar 1995, 31-32); "The Charlie West Case" (Bebeau 1995, 30-31)
2	Mentoring, conflict of interest	"A Question of Mentoring Bias" (Online Ethics Center for Engineering and Science 2006a); "The Endless Dissertation" (Online Ethics Center for Engineering and Science 2006b); "A Conflict of Commitment" (Committee on Science, Engineering and Public Policy 2009, 45)
3	Professional responsibility, software quality, confidentiality of intellectual property	"Software Risks" (Anderson et al. 1993, 102-104); two short cases (see text)
4	Privacy	"Privacy" (Anderson et al. 1993, 100); "Using an Internet Search Engine to Locate a Friend" (Tavani 2004, 137-138); "Toysmart.com" (Tavani 2004, 145); Loyalty Cards [Discussion Questions 40, 41] (Quinn 2005, 238)
5	Social impacts of computers	"Data Mining at the XYZ Bank" (Tavani 2004, 132); "Hacker Ethic" (Tavani 2004, 158); Anonymity in a Political Election [Discussion Question 3] (Tavani 2004, 172); Violent Computer Games [Exercise 10.23] (Baase 2003, 433); Internet Filtering [Exercise 10.29] (Baase 2003, 434)
6	Ethics in computational modeling	"A Sonar Story" (Kijowski 2011, 90-92); "Looking for the Bright Side" (Kijowski 2011, 93-94); "Low Impact" (Kijowski 2011, 96-98)

For example, the following are two short cases that author Loui wrote and used in the third week of the summer program:

> In the early 1980s, Atomic Energy of Canada Limited (AECL) manufactured and sold a cancer radiation treatment machine called the Therac-25, which relied on computer software to control its operation. Between 1985 and 1987, the Therac-25 caused the deaths of three patients and serious injuries to three others. Who was responsible for the accidents? The operators who administered the massive radiation overdoses, which produced severe burns? The software developers who wrote and tested the control software? The manufacturer, AECL? A non-AECL system engineer who noticed the absence of backup hardware safety mechanisms?
>
> You designed the embedded system software for the engines that Galactic Motors hopes to use in future all-electric automobiles. Six months ago, you left Galactic for a managerial position with Forge Motor Company, a direct competitor. After a restructuring, however, Forge's vice president asks you to lead a design team to develop the control software for Forge's planned electric autos. The vice president hints that Forge is interested in the design concepts that you previously developed at Galactic Motors. How should you respond? For what reasons?

During the first summer program, we noticed that some of the students' research projects raised questions about individual privacy. To make the privacy issues immediately relevant to students, in 2010, 2011, and 2012, we replaced one of the privacy cases by short cases involving the privacy of human subjects in Internet-based research on social networking:

> A Facebook user has consented to participating as a subject in your research study of social networking. She reveals information not only about herself and her friends, but also her friends' friends. Under what circumstances can you publish research results about their social interactions?
>
> You are collecting a large amount of data from a social networking site. As you collect the data, you scrupulously replace actual names with numerical codes. Nevertheless, from the anonymous data, it is possible to infer the identities of individuals associated with their data. Under what circumstances can you publish your study?

In 2011 and 2012, we replaced the session on ethics in computational modeling by a showing and discussion of the 36-minute movie *Henry's Daughters*. This movie highlights ethical issues in a dramatized case in which engineers design an intelligent transportation system with autonomous vehicles (Loui et al. 2010). In ethics presentations for other REU site programs in the summers of 2013 and 2014, after the Information Trust Institute's REU grant had ended, we replaced some of the cases with short videos developed at the University of Nebraska—Lincoln (National Center for Professional and Research Ethics 2014). Each of these videos is less than four minutes long. We substituted the video cases for text cases because we expected that students would find

video cases more interesting and memorable. Our expectations were confirmed in the program-evaluation surveys at the end of each summer (not reported here).

The ethics sessions used active learning methods, specifically, collaborative and cooperative learning (Barkley, Major, and Cross 2005; Millis and Cottell 1997). We chose active learning through small-group discussion because, as McKeachie and Svinicki have said, "Discussion methods are superior to lectures in student retention of information after the end of a course; in transfer of knowledge to new situations; in development of problem solving, thinking, or attitude change; and in motivation for further learning" (McKeachie and Svinicki 2006, 58).

After a lunch provided by the program, in each 60-minute ethics session the students were randomly divided into small groups of four to six students. Each group simultaneously read and discussed the same case for about ten minutes. Then author Loui led a discussion of this case with the entire cohort. He asked different groups to respond to questions about the case for about ten minutes. The questions usually asked students to identify the ethical issues and to suggest what the characters in the case should do next, for what reasons. Then the session moved on to another case, again with simultaneous discussions in small groups followed by a discussion with the entire cohort. One session was organized differently: Each small group took responsibility for reading and answering questions about one of five cases dealing with the social impacts of computers. For the first ten minutes, all five groups read and discussed their case simultaneously. Then Loui interacted with each group in turn to discuss that case, while other groups listened.

At the beginning of the first ethics session of the summer program, we presented a general approach to ethical problems (Figure 1) that was inspired by the seven-step guide for ethical decision making developed by Davis (1997). Our general approach uses everyday language because, with limited time in a summer REU program, students need guidance in thinking about ethics issues without having to learn philosophical jargon (Schachter 2003).

Each student received a copy of the booklet *On Being a Scientist* (Committee on Science, Engineering and Public Policy 2009), which provides a basic overview of responsible conduct of research, the Association for Computing Machinery code of ethics (ACM 2014), and a book chapter on ethics for computing professionals (Johnson and Miller 2004). Students were not tested on these readings, however, and they were not assigned any other ethics homework.

Figure 1. A General Approach to Ethical Problems

1. Identify the affected parties, their interests (rights, expectations, desires), and their responsibilities. Determine what additional information is needed.
2. Consider alternative actions by the main actors, and imagine possible consequences.
3. Evaluate actions and consequences according to basic ethical values—honesty, fairness, trust, civility, respect, kindness, etc. —or the following tests:
   - **Harm test:** Do the benefits outweigh the harms, short term and long term?
   - **Reversibility test:** Would this choice still look good if I traded places?
   - **Common practice test:** What if everyone behaved in this way?
   - **Legality test:** Would this choice violate a law or a policy of my employer?
   - **Colleague test:** What would professional colleagues say?
   - **Wise relative test:** What would my wise old aunt or uncle do?
   - **Mirror test:** Would I feel proud of myself when I look into the mirror?
   - **Publicity test:** How would this choice look on the front page of a newspaper?

As learning outcomes, through the ethics sessions, we expected students to learn to identify the ethical problems or dilemmas, recognize the people affected and understand their perspectives, identify a comprehensive list of actions, and provide a justified action to resolve the ethical problem or dilemma.

Assessment

To assess the effectiveness of the ethics sessions in 2009 and 2010, we adopted the two-case method of Kraus (2008). We administered initial and final assessments, in which students analyzed two short cases. Case A highlighted ethical issues in information technology, and case B raised ethical issues in conducting research. The texts of these cases appear in the appendix.

One group of half the students received case A for the initial assessment at the beginning of the summer and case B for the final assessment at the end of the summer. The other group of students received case B initially and case A at the end. The domestic students and international students were equally divided between the two groups.

For each assessment, students were expected to take 30 to 60 minutes, working individually, without consulting any references. There was no limit on the lengths of students' responses. Students typed their responses into text documents

and sent the documents to one of the summer-program coordinators, who removed identifying information before printing the responses.

The learning outcomes were assessed by the rubric shown in Table 2, which follows our general approach to ethical problems shown above; Sindelar et al. (2003) developed a similar rubric for scoring student responses to ethics cases. To state the problem and check the facts, students had to identify the ethical issues in the case. To identify relevant factors, students had to identify who were the persons affected by the case. To develop a list of options and test the options, students had to identify the actions that the characters in the case could take. To make a choice, students had to justify their chosen action with appropriate reasons.

The students' responses from 2009 were scored by one author (Loui) using a rubric similar to the one in Table 2.

Table 2. Scoring Rubric for Assessment Case Responses

	Fair (1 pt)	Good (2 pts)	Excellent (3 pts)
Ethical Issues	Identified at least 1 ethical issue relevant to the case	Identified at least 2 ethical issues relevant to the case	Identified at least 3 ethical issues relevant to the case
Who is affected by this case?	Considered 1 or more affected parties mentioned in case without their perspectives	Considered 1, 2 or 3 affected parties mentioned in case and their perspectives	Considered at least 4 affected parties (or at least 3 affected parties, including at least 1 party not mentioned in the case) and their perspectives
Actions	Identified 1 or 2 practical actions to be executed	Identified 3 practical actions to be executed	Made a comprehensive list of at least 4 practical actions to be executed
What actions should they choose and why?	Provided a solution without argumentation	Provided a reasonable, realistic solution with argumentation	Provided a thorough, reasonable, realistic solution with argumentation and discussion of drawbacks, which led to a consensus

There was one minor difference in the rubrics used in 2009 and 2010. The 2009 rubric scores ranged from zero to two, whereas the 2010 rubric scores ranged from one to three. This difference was accounted for in the analysis of the 2009 data below by transforming the scores to correspond to the scores in the 2010 rubric.

Both authors scored the 2010 students' responses using the following procedure. We independently scored students' responses using a common rubric. There were four questions in the assessment pertaining to the case. The student's answer to each question was scored from one to three points. We compared our scores and discussed differences. After discussion and reconciliation, the combined scores differed by at most one point. We aggregated our independent scores to obtain a cumulative score for each student. As a result, a student could have obtained a maximum score of 24 points. Only after scoring did we learn which responses were initial assessments and which were final assessments.

In the summer of 2009, we had initial and final responses for seventeen students. In the summer of 2010, we had initial and final responses for eight students.

Because the numbers of students were small in both 2009 and 2010, we used the Mann-Whitney U test for independent samples to analyze the differences between the initial and final responses. The Mann-Whitney U test was appropriate because the data did not pass the Shapiro-Wilk normality test or a test of homoscedasticity. We aggregated the 2009 and 2010 data by case. Using the aggregated data, we compared the initial scores for case A with the final scores with case A; we used the same approach for case B. As noted above, the maximum score for any particular student, scored on the rubric shown in Table 2, was 24.

As shown in Table 3, the Mann-Whitney U test for independent samples signed-ranks showed that 2009 and 2010 case A initial scores (median: 16.5) did not differ significantly from the case A final scores (median: 18), $Z = 0.05$, $p = 0.98$. That is, in the two summers, we found no significant differences between the initial and final scores for case A. As shown in Table 3, the Mann-Whitney U test for independent samples signed-ranks showed that 2009 and 2010 case B initial scores (median: 16) did not differ significantly from the case B final scores (median: 16), $Z = 0.35$, $p = 0.74$. That is, in the two summers, we found no significant differences between the initial and final scores for case B.

Table 3. Results of Cases A & B

	Ranks			Test Statistics[a]	
	n	Mean Rank	Sum of Ranks	pre-post	
Scores on Case A					
Initial Ranks	14	12.9	181	Mann-Whitney U	78
Final Ranks	11	13.1	144	Wilcoxon W	144
Total	25			*Z*	0.05
				p (2-tailed)	0.98
Scores on Case B					
Initial Ranks	11	12.4	136.5	Mann-Whitney U	70.5
Final Ranks	14	13.5	188.5	Wilcoxon W	188.5
Total	25			*Z*	-0.35
				p (2-tailed)	0.74

*a. Grouping variable: Initial Scores

We suspect that there was essentially no difference in the initial and final scores because the content of the ethics sessions was not formally reinforced outside of the sessions through additional academic work. In addition, the ethics sessions might not have added significantly to the knowledge and skills of the students who had previously taken computer ethics courses that were required in their undergraduate computer science programs. On the post-test, the students may not have been motivated to complete the assessment to the best of their abilities. At the end of the summer, because the students may have focused on finishing their projects, they may have put only minimum effort into the post-test. For example, several students who earned low scores (less than half the possible points) on the post-test submitted one-line answers. Finally, our intended learning outcomes may have been too ambitious, and thus the assessment task was too difficult. As a consequence, students might have been unable to demonstrate what they had learned.

If the undergraduate research program had continued for additional summers, we could have either increased the attention to ethics, through homework and other academic activities, or reduced our expectations for learning outcomes. In addition, to complement the quantitative analysis, we could have conducted a detailed qualitative analysis of the students' responses to the assessment cases. With a qualitative analysis, we could have classified the different ways in which students thought about ethical issues, identified their conceptual difficulties, found strengths and deficiencies in their case responses, and described how their ethical reasoning developed over the course of the summer.

Conclusions

We have described how we integrated a series of sessions on ethics into a summer undergraduate research program at the Information Trust Institute (ITI). Other undergraduate research programs can implement a similar series of sessions that highlight ethics issues relevant to the programs' themes, using a cooperative learning pedagogy. As in the ITI sessions, students can learn about these issues by discussing short cases in small groups. Relevant cases can be found online at the Online Ethics Center for Engineering and Science (http://onlineethics.org) and at the National Center for Professional and Research Ethics (http://nationalethicscenter.org).

We believe that our assessment method can also be applied broadly. This method uses two short cases as pre- and post-tests. Students' responses to the cases are scored according to a simple common rubric. Using this assessment method, undergraduate research programs can assess the effectiveness of their series of ethics sessions in achieving the intended learning outcomes. As our experience suggests, however, even when the ethics sessions are taught with appropriate pedagogies, and when the assessments are aligned with the learning objectives, students might not demonstrate improved skills in analyzing ethics cases.

Acknowledgments

Keri Frederick and Roseanna Marie Dorsey gathered students' assessment submissions and made them anonymous. Karrie Karahalios shared her short cases on privacy in Internet-based research on social networking. This work was supported by the National Science Foundation under Grant CNS-0851957. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation or the University of Illinois.

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Appendix:

Case A

Analyze the case below *individually*. Do not consult other students. Do not consult any references.

At Colossus Corporation, vice president Kelly Kim has become concerned about the productivity of Colossus's office workers. According to personnel evaluation reports that Kelly has read, too many workers spend too much time using the Internet during office hours for personal tasks such as shopping on amazon.com and playing online games such as *World of Warcraft*. Kelly also worries that the office workers might divulge Colossus's proprietary information when they interact with customers.

Kelly asks Chris Patel, a software engineer in Colossus's information technology department, to monitor the Web accesses and the information transmitted by the office workers. To analyze this voluminous amount of data, Chris recommends that Colossus purchase a data mining program from Chris's domestic partner Robin Finelli. An independent software contractor, Robin had developed this program while previously employed by Banana Computers, without the awareness of anyone at Banana Computers.

Please answer all of the following questions. There is no limit on the length of your response; use as much space as you wish.

- What ethical issues does this case raise?
- Who is affected by this case? What are their perspectives on the case?
- What actions might the characters consider to resolve the ethical issues?
- Among these actions, which should the characters choose? For what reasons?

Case B

Analyze the case below individually. Do not consult other students. Do not consult any references.

The executive editor of the *Journal of Wondrous Technology Research* asks Professor Randy Gonzales to review a manuscript from the laboratory of Professor Morgan Nelson. Examining the manuscript, Randy discovers that although the theoretical ideas are novel and promising, the manuscript has numerous flaws: the literature review is incomplete, the description of the experimental method is internally inconsistent, the illustrations lack labels, and the statistical analysis is incorrect. Randy plans to refer the manuscript to a third-year doctoral student, Dana Wong, to enable Dana to learn from the manuscript's mistakes, and to give Dana experience in reviewing a manuscript, an important professional duty. In addition, Randy thinks that two theoretical ideas in the Nelson manuscript might help Dana overcome some obstacles that have blocked Dana's research progress for the last three months. One idea indicates that Dana's current approach is likely to be fruitless, and a second idea suggests a different path for Dana to take. Randy had previously speculated that the theoretical ideas might be true.

Please answer all of the following questions. There is no limit on the length of your response; use as much space as you wish.

- What ethical issues does this case raise?
- Who is affected by this case? What are their perspectives on the case?
- What actions might the characters consider to resolve the ethical issues?
- Among these actions, which should the characters choose? For what reasons?

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A Web Supplement to Using *COEUR* to Assess Undergraduate Research: A Three-Stage Model for Institutional Assessment

	Campus Constituency				
COEUR Outcome	Administration	UR Office	Committees	Faculty	Students
1.0 Campus mission and culture					
1.1 Institutional commitment	Interview				
1.1.1 Clear statements of alignment of UR with college mission, strategic plan	Audit				
1.1.2 Support for UR	Interview				
1.1.2.1 Resources for faculty and student UR	Audit				
1.1.2.2 Recognition for faculty and student UR	Interview				
1.1.3 Involvement of other constituencies	Audit				
1.1.3.1 Student affairs	Interview				
1.1.3.2 Physical plant	Interview				
1.1.3.3 Human resources/student payroll	Interview				
1.1.3.4 Business office	Interview				
1.1.3.5 Institutional advancement	Interview				
1.1.3.6 Public relations	Interview				
1.2 Scholarly faculty	Audit				
1.2.1 Faculty members current and active scholars	Audit				
1.2.2 Teacher-scholar model				Survey	
1.3 Faculty commitment				Survey	
1.3.1 Committed to UR				Survey	
1.3.2 Value UR				Survey	
1.3.3 Create UR opportunities				Survey	
1.4 Broad disciplinary participation		Interview		Survey	
1.4.1 UR across broad disciplines		Interview			
1.4.2 Faculty-mentored UR opportunities available for all students		Audit			Survey
1.5 Accessible opportunities for undergraduates		Interview			Survey
1.5.1 Available at all class ranks					Survey
1.5.2 Available for all students regardless of GPA	Audit				Survey
1.6 Integration with other engaging and high-impact opportunities		Interview			
1.6.1 Integrated and coordinated with other high-impact practices		Interview			
1.6.1.1 Honors		Interview		Survey	Survey
1.6.1.2 First-year program		Interview			Survey
1.6.1.3 Service learning		Interview			

1.6.1.4 Study abroad	Interview	Interview			
1.6.1.5 Leadership programs		Interview			
1.6.1.6 Career center	Interview				
1.6.1.7 Residential life	Interview				
1.6.1.8 General education	Audit				
2.0 Administrative support					
2.1 Internal budgetary support	Interview	Interview	Focus Group	Survey	
2.1.1 Budget allocations for UR	Audit	Interview		Survey	
2.1.1.1 Departments		Interview	Focus Group	Survey	
2.1.1.2 Programs		Interview	Focus Group	Survey	
2.1.1.3 Individuals		Interview	Focus Group	Survey	Survey
2.1.2 Human resources for UR for all disciplines				Survey	Survey
2.1.3 External funds		Interview		Survey	
2.1.3.1 Matching		Interview		Survey	
2.1.3.2 Long-term equipment/infrastructure maintenance				Survey	
2.2 Startup funding	Audit			Survey	
2.2.1 Startup funding commensurate with institutional expectations for scholarship and undergraduate student participation in faculty research	Interview			Survey	
2.2.2 New faculty get the startup funds to allow them to be effective in research	Interview			Survey	
2.2.3 Startup packages include appropriate time for beginning research program	Interview				
2.2.4 Startup funding sufficient to establish track record to be able to compete for external funding	Audit				
2.3 Faculty load credit for supervising undergraduate research	Audit			Survey	
2.3.1 Faculty time for UR protected	Interview	Interview		Survey	
2.3.2 Compensation through teaching load credit for UR or reassigned time	Audit			Survey	
2.3.3 Rotating load credit among faculty within departments				Survey	
2.3.4 Offering small-enrollment courses to teach research team	Audit				
2.4 Reassigned time for research-related tasks	Audit			Survey	
2.4.1 Grant writing	Audit				
2.4.2 Writing articles or books	Audit				
2.4.3 Coordinate research-related committees (IRB)	Audit				
2.4.4 Administering multi-faculty projects	Audit				
2.5 Undergraduate research administrative support		Audit			
2.5.1 Undergraduate research program office		Audit			
2.5.1.1 Central office of undergraduate research		Audit			
2.5.1.2 On-campus research symposia		Audit			
2.5.1.3 Summer research		Audit			

2.5.1.4 Student workshops		Audit			
2.5.1.5 Mentorship training		Audit			
2.5.1.6 Disbursement of funds for student travel		Audit			
2.5.1.7 Summer research assistantships		Audit			
2.5.1.8 Program director		Interview			
2.5.1.8.1 Funded through institution (not external, soft money)		Audit			
2.5.1.8.2 Located appropriately in institutional hierarchy		Interview			
2.5.1.8.3 Appropriate professional credentials		Audit			
2.5.1.8.4 Support for continuing professional development		Audit			
2.5.1.9 Coordinator of UR (our model)		Interview			
2.5.1.9.1 Central advocate		Interview			
2.5.1.9.2 Coordinates		Interview			
2.5.1.9.3 Faculty member with reassigned time		Audit			
2.5.1.9.4 Campus advisory board		Audit			
2.5.1.1 Space for UR center		Audit			
2.5.1.1.1 Adequate space with high student and faculty visibility		Audit			
2.5.1.1.2 Access to meeting rooms		Audit			
2.5.1.1.3 Highly visible affordable space available for research symposia/ celebrations		Audit			
2.5.1.1.4 Office for faculty coordinator		Audit			
2.5.1.2 Infrastructure support for UR center		Audit			
2.5.1.2.1 Funding for routine office expenses (includes computer and software)		Audit			
2.5.1.2.2 Workshops and events funding		Audit			
2.5.1.2.3 Funding for professional development of coordinator		Audit			
2.5.1.2.4 CUR membership	Audit				
2.5.1.2.5 Publicity (internal outreach to students, faculty, and for broader audience)	Audit				
2.5.1.2.6 External publicity with campus PR	Audit				
2.6 Travel and other student funding		Audit			
2.6.1 Provide sufficient funds for faculty and students to present research		Audit			
2.6.2 Travel to a minimum of one professional meeting or conference each year	Audit				
2.6.3 Provide funding for faculty to travel with undergraduates to conferences	Audit				
2.6.4 Encourage individual faculty who might not otherwise attend, such as student-centered conferences		Audit			
2.6.5 Small equipment, supply, and travel grants		Audit		Survey	
2.6.6 Help students initiate their research				Survey	

2.7 Research grants office	Interview				
2.7.1 Keep track of and alert faculty to funding opportunities	Interview				
2.7.2 Office of sponsored research will also manage the grant application process, including electronic submissions with the appropriate institutional certifications, and will assist faculty with post-award administration	Interview				
2.7.3 Make faculty aware of funding opportunities for including undergraduates	Interview				
2.7.4 Assist undergraduates in grant proposals that require institutional consent and support	Interview				
2.7.5 Alternative: Designate a knowledgeable person to be responsible for acting as the institutional representative for grant submissions	Interview				
2.7.5.1 Must be given sufficient reassigned time to perform this job well	Interview				
3.0 Research infrastructure					
3.1 Space		Interview		Survey	Survey
3.1.1 Adequate		Interview		Survey	Survey
3.1.2 Dedicated				Survey	Survey
3.1.3 Accessible				Survey	Survey
3.1.4 Not just classrooms and teaching laboratories	Audit			Survey	Survey
3.1.5 Number of square feet of research lab per faculty/student	Audit				
3.1.5.1 Dedicated desktop space				Survey	
3.1.5.1.1 Lighting	Audit				
3.1.5.1.2 Safety	Audit				
3.1.5.1.3 Ventilation	Audit				
3.1.5.1.4 Climate control	Audit				
3.1.6 Private space				Survey	
3.1.6.1 Confidential interviews				Survey	
3.1.6.2 Focus groups				Survey	
3.1.6.3 Observational studies				Survey	
3.1.7 Conference/meeting space		Interview		Survey	
3.1.8 Data and supplies secure				Survey	
3.2 Instrumentation and equipment				Survey	Survey
3.2.1 On-campus access to appropriate equipment				Survey	Survey
3.2.2 Department and institutional plans for equipment acquisition and maintenance and replacement	Audit				
3.2.3 Small colleges may share equipment elsewhere				Survey	
3.3 Library resources	Interview			Survey	Survey
3.3.1 Adequate	Interview			Survey	Survey
3.3.1.1 Primary literature access	Interview			Survey	
3.3.1.2 Acquisition plan	Interview				

3.3.1.3 Interlibrary loan	Audit				
3.3.1.4 Disciplinary search tools				Survey	Survey
3.3.1.5 Electronic access	Audit			Survey	Survey
3.3.1.6 Information literacy and research training	Audit				
3.4 Computational resources	Audit				
3.4.1 Hardware	Audit			Survey	
3.4.2 Operating system	Audit				
3.4.3 Software	Audit			Survey	Survey
3.4.4 High speed computing network	Audit				
3.5 Other research resources	Audit				
3.5.1 Museums	Audit				
3.5.2 Archives	Audit				
3.5.3 Samples	Audit				
3.5.4 Artifacts	Audit				
3.6 Research oversight structures	Interview	Interview			
3.6.1 IRB	Audit				
3.6.2 IACUC	Audit				
3.6.3 Oversight for research ethics training (humans and animals)	Audit			Survey	Survey
3.7 Support, administrative and technical staff		Interview			
3.7.1 Laboratory and studio support staff		Interview			
3.7.2 Instrument technicians	Audit	Interview			
3.7.3 Supplies inventories and ordering		Interview			
3.7.4 Research preparation		Interview			
3.7.5 Computer		Interview			
3.7.6 Curating					
4.0 Professional development opportunities					
4.1 Research leaves	Audit	Interview			
4.1.1 Sabbaticals	Audit	Interview	Focus Group		
4.1.2 Leaves for junior faculty	Audit		Focus Group		
4.2 Research training opportunities		Interview	Focus Group	Survey	
4.2.1 Workshops			Focus Group	Survey	
4.2.2 Mini-conferences	Audit				
4.2.3 Short courses	Audit				
4.2.4 Research training “camps”	Audit				
4.3 Non-research-related professional development			Focus Group		
4.3.1 Career and professional development conferences and workshops			Focus Group	Survey	
4.3.1.1 Pedagogy for UR			Focus Group	Survey	
4.3.1.2 Diversity training	Audit				

4.3.1.2 Assess UR		Interview			
4.4 Mentorship training			Focus Group		
4.4.1 Faculty				Survey	
4.4.1.1 Ongoing faculty mentorship training	Audit		Focus Group		
4.4.1.2 Orientation sessions for mentors		Interview			
4.4.1.3 Professional development meetings on mentorship		Interview			
4.4.1.4 Personal development plans	Audit				
4.4.1.5 Junior faculty mentored by senior faculty	Audit		Focus Group		
4.4.2 Graduate students and postdoctoral fellows (not relevant for us)					
5.0 Recognition					
5.1 Promotion and tenure guidelines	Audit	Interview			
5.1.1 Described in promotion and tenure guidelines for faculty	Audit				
5.1.2 Clear what it is and how it counts	Audit			Survey	
5.2 Salary review		Interview			
5.2.1 Merit pay and salary reviews	Audit				
5.3 Campus awards	Audit				
5.3.1 Public awards for excellence in UR	Audit				
5.3.2 Departmental student UR awards	Audit				
5.3.3 E.G. faculty mentoring awards	Audit				
5.3.3.1 Outstanding thesis	Audit				
5.3.3.2 Prize winning student publication	Audit				
5.3.3.3 Outstanding poster	Audit				
5.4 Prominent publicity for research accomplishments	Audit				
5.4.1 UR prominent on institution website	Audit				
5.4.2 Print and electronic publications	Audit				
5.4.3 Students encouraged to apply for prestigious scholarships, fellowships & awards					Survey
5.4.4 Awards publicized widely	Audit				
6.0 External funding					
6.1 Faculty research funding	Audit	Interview		Survey	
6.1.1 Faculty members seek and receive external funding	Audit			Survey	
6.1.1.1 UR	Audit				
6.1.1.2 Research technicians				Survey	
6.1.1.3 Graduate students					
6.1.1.4 Equipment				Survey	
6.1.1.5 Infrastructure				Survey	
6.1.2 Specific UR grants				Survey	

6.1.2.1 RUI				Survey	
6.1.2.2 REU				Survey	
6.1.2.3 AREA				Survey	
6.1.2.4 Private				Survey	
6.2 Institutional funding for research	Audit	Interview			
7.0 Dissemination					
7.1 Peer-reviewed publication, exhibition, or performance	Audit			Survey	Survey
7.1.1 Peer-reviewed (not undergraduates) publication, exhibition or performance	Audit			Survey	
7.1.2 Student co-authorship				Survey	
7.2 Presentation at professional meetings				Survey	Survey
7.2.1 Institutional funding for student presentations	Audit	Interview			Survey
7.2.2 Mentoring on how to present	Audit				
7.3 Student research conference	Audit	Interview	Focus Group	Survey	Survey
7.3.1 NCUR		Interview			Survey
7.3.2 Disciplinary conference				Survey	Survey
7.4 On-campus symposia				Survey	Survey
7.4.1 Undergraduate research celebration	Audit	Interview	Focus Group	Survey	Survey
7.4.2 Promote broad attendance	Audit				
7.4.3 Workshops for writing abstracts, making presentations or posters, delivering a talk	Audit				
8.0 Student centered issues					
8.1 Opportunities for early and sustained research involvement	Audit				Survey
8.2 Establishing and communicating expectations				Survey	Survey
8.2.1 Level of work, number of hours, length of research commitment				Survey	Survey
8.3 Developmentally appropriate expectations and intellectual ownership			Focus Group		
8.3.1 Students should be able to develop through the stages of research ownership and a clear campus policy should exist on shared publication credit	Audit				
8.4 Community of student scholars	Audit				
8.4.1 Sufficient number of students doing research so that they can support each other, become peer mentors and be involved in research groups though seminars, etc.	Audit				Survey
8.5 Peer mentoring/teamwork opportunities				Survey	Survey
8.5.1 The terms critical mass and peer mentorship in multi-level teams with each team member having responsibility for a specific part of the project				Survey	
8.6 Expanding and integrating student research opportunities with other engaging experiences		Interview	Focus Group		

8.6.1 Multi-disciplinary, multiple mentors, community based research, service learning, entrepreneurial applications, policy implications, articulation beyond the academic community	Audit	Interview			
8.7 Faculty mentor availability				Survey	Survey
8.7.1 Research methods, scaffolding, integration, courses, special topics		Interview	Focus Group		
9.0 Curriculum					
9.1 Research supportive curriculum	Audit				
9.1.1 Content	Audit				
9.1.2 Integration of research and teaching			Focus Group	Survey	
9.1.3 Course scheduling and managing faculty teaching loads		Interview		Survey	
9.1.3.1 Faculty time to mentor student research, blocks of time for supervision, 9 contact hours/week is limit	Audit	Interview		Survey	
9.2 Additional training opportunities and workshops for undergraduates	Audit	Interview			Survey
9.2.1 Ethical responsibilities				Survey	Survey
9.2.2 Professional skills workshops	Audit				
9.2.2.1 Writing	Audit				
9.2.2.2 Speaking	Audit				
9.2.2.3 Posters	Audit				
9.3 Student course credit for research	Audit				
9.4 Requiring undergraduate research	Audit				
10.1 Research-supportive teaching calendar	Audit				
10.1.1 No courses in the summer so that research can be done in the summer	Audit				
102. Faculty compensation	Audit				
10.2.1 For summer research with students and competitive with other summer opportunities					Survey
10.3 Student compensation for summer research	Audit				
10.3.1 Summer research above minimum wage; typical 10-week stipend $3500 to $5000	Audit				
10.4 Student housing and access to facilities and student services	Audit				
10.4.1 Summer research--inexpensive, attractive, access to services (some at no cost)				Survey	Survey
10.5 Student programming in summer	Audit	Interview			
10.5.1 Summer research community common activities		Interview			
10.6 Summer research symposia	Audit				
10.7 Coordination among multiple programs		Interview			
10.8 Hosting visiting students		Interview			
11.0 Assessment of student learning					
11.1 Program assessment and evaluation	Audit	Interview	Focus Group		
11.1.1 Satisfaction				Survey	Survey

11.1.2 Sustainable method of student demographic, engagement and retention data	Audit	Interview			
11.1.3 Sustainable method of tracking faculty engagement (e.g., co-authored publications)	Audit				
11.1.4 Tracking external funding	Audit				
11.1.5 Post-graduation student outcomes	Audit				
11.1.6 Assessment resources	Audit				
12.0 Strategic planning					
12.1 Identify UR goals and scale up successful programs	Audit	Interview			
12.2 Resources for new programs	Audit	Interview			

UNDERGRADUATE RESEARCH Highlights

Brant JA, Massi DM, Holzwarth NAW, MacNeil JH, Douvalis AP, Bakas T, Martin SW, Gross MD, Aitken JA. Fast Lithium Ion Conduction in Li2SnS3: Synthesis, Physicochemical Characterization and Electronic Structure. *Chemistry of Materials*. 2015; 27: 189-196. (Duquesne University)

In this paper it was demonstrated, for the first time, that Li_2SnS_3 acts as a fast Li^+ ion conductor and possesses high thermal and environmental stability, making it a promising new solid-state electrolyte for lithium ion batteries. Jennifer A. Aitken is an associate professor in the Department of Chemistry and Biochemistry at Duquesne University. Danielle Massi graduated from Duquesne University with her BS in chemistry in May of 2012. She received her masters of education with a concentration in secondary chemistry from Cabrini College in December of 2014 and is now teaching chemistry and physics at Merion Mercy Academy in Merion Station, PA. This project was supported by the National Science Foundation under Grant no. DMR-1201729.

Fetcie K, Jacob B, Saavedra D. The Failed Zero Forcing Number of a Graph. *Involve, a Journal of Mathematics*. 2015; 8: 1:99-117. (Rochester Institute of Technology)

Zero forcing is a dynamical system on a graph (or network) that has applications in minimum rank problems and quantum mechanics. Conventionally, researchers have studied the minimum number of starting locations necessary to fill an entire graph. We introduced and investigated a new concept, called the failed zero forcing number, that is the maximum number of starting locations that fail to fill the entire graph. Bonnie Jacob is an assistant professor of mathematics at the National Technical Institute for the Deaf, a college of the Rochester Institute of Technology. Daniel Saavedra is a packaging-science major at the Rochester Institute of Technology. Katherine Fetcie recently graduated from the Rochester Institute of Technology with a bachelors degree in environmental sustainability, health and safety. She will begin a graduate degree in environmental toxicology in the fall at NYU.

Smolyaninova VN, Yost B, Zander K, Osofsky MS, Kim H, Saha S, Greene RL, Smolyaninov II. Experimental Demonstration of Superconducting Critical Temperature Increase in Electromagnetic Metamaterials. *Scientific Reports*. 2014; 4: 7321. (Towson University)

A recent proposal that the metamaterial approach to dielectric response engineering may increase the critical temperature of a composite superconductor-dielectric metamaterial has been tested in experiments with compressed mixtures of tin and barium titanate nanoparticles of varying composition. An increase in the critical temperature on the order of 5 percent compared to bulk tin has been observed for a 40 percent volume fraction of barium titanate nanoparticles. Vera Smolyaninova is a professor of physics at Towson University. Kathryn Zander, a physics major at Towson, participated in the research for independent study credit. Zander graduated from Towson University this spring and is planning to apply to graduate school. This research was supported in part by undergraduate research grants awarded to Zander and by NSF grant DMR-1104676 to Towson.

Wei-Ting C, Caleb HM, Elizabeth CD. Growth and Microstructure-Dependent Hardness of Directionally Solidified WC–W2C Eutectoid Ceramics. *Journal of the American Ceramic Society*. 2015; 98: 3. (North Carolina State University)

The research investigated the tungsten carbide (WC) based refractory ceramics typically used to manufacture high-performance cutting tools in an attempt improve their mechanical properties, using laser surface processing. The research involved using known eutectoid compositions between the WC and W2C phases to produce two-phase lamellar microstructures that together boost the mechanical properties beyond the limits of each of the individual phases. Using laser surface processing, the scale of the eutectoid lamellar microstructure could be controlled to examine the size dependence of the microstructure. It was found that the indentation hardness of material increased with decreasing lamellar spacing. An indentation hardness of 28.5 GPa was achieved with the smallest interlamellar spacing, the highest hardness value reported in the WC system. Elizabeth Dickey is a professor and director of graduate programs in the Department of Material Science and Engineering, as well as director of the Center of Dielectrics and Piezoelectrics and associate director of the Analytical Instrumentation Facility at North Carolina State University. Caleb Meredith took part in the research as an undergraduate from 2012 to 2014 while studying in the Department of Material Science and Engineering at North Carolina State. He is currently working as a researcher at a green-technology startup company in Raleigh, North Carolina. The research was supported by National Science Foundation grant CMMI-1139792.

Lee MD, Bingham KN, Mitchell TY, Meredith JL, Rawlings JS. Calcium Mobilization is Both Required and Sufficient for Initiating Chromatin Decondensation during Activation of Peripheral T-cells. *Molecular Immunology*. 2015; 63:2: 540-549. (Furman University)

This study examined the mechanism of activation-induced chromatin decondensation in peripheral T lymphocytes, focusing on the role of calcium in the process. This study shows that the mobilization of intracellular calcium is both required and sufficient to initiate chromatin decondensation. Furthermore, the decondensation was shown to be independent of the action of NFAT. Jason Rawlings is an assistant professor of biology. Kellie Bingham is currently enrolled at the Medical University of South Carolina. Megan Lee and Taylor Mitchell will both attend the University of South Carolina School of Medicine – Greenville. Jenna Meredith will attend the Mercer University School of Medicine. The research was supported by grants from the NIH (5 P20 RR016461 and 8 P20 GM103499), the NSF (EPS-0903795), and an HHMI USE award. Further support was provided by Furman University.

Guest L, Schap D. Rationales Concerning the Treatment of Federal Income Taxes in Personal Injury and Wrongful Death Litigation in the State Courts. *Journal of Legal Economics*. 2014; 21:1: 85-117. (College of the Holy Cross)

Awards of damages in certain tort cases are exempt from federal income taxes. Some state courts adjust awards in recognition of the tax advantage, while others do not. Based on a comprehensive survey of judicial reasoning in the various state courts, the study categorizes the varied rationales for the differing tax treatments and rationales as to whether juries ought to be instructed in the matter of taxes. David Schap is professor of economics. Lauren Guest is a 2013 graduate of Holy Cross and worked on the project as a research assistant during the summers of 2012 and 2013, as well as during directed research courses in fall semester 2012 and spring semester 2013. Guest now works for the software startup company Trio Health, whose software tracks patient data for various chronic diseases. A grant from the May and Stanley Smith Charitable Trust supported the summer research in 2012, and the Office of the Dean at Holy Cross funded the summer 2013 research.

John P, Pineno O. Biological Significance in Human Causal Learning. *Psi Chi Journal of Psychological Research*. 2015; 1. (Hofstra University)

The present study was conducted to assess the influence of fear-inducing cues on human causal learning, specifically on a learning-reversal procedure followed by spontaneous recovery. The study found that spontaneous recovery was stronger with high-fear cues than with low-fear cues. This research has implications for the clinical treatment of fears. Oskar Pineno is an associate professor of psychology. Prescilla John is currently at Columbia University and is seeking to enroll in a doctoral program in clinical psychology.

Eriani G, Karam J, Jacinto J, Morris Richard E and Geslain R. MIST, a Novel Approach to Reveal Hidden Substrate Specificity in Aminoacyl-tRNA Synthetases. *Plos one*. 2015. accepted May 15, 2015. (College of Charleston)

This work describes a new technical and conceptual approach named MIST (Microarray Identification of Shifted tRNAs) designed to study the formation of complexes between transfer RNA and aminoacyl-tRNA synthetases (tRNA/AARS), two essential components of the cellular translation machinery. MIST combines electrophoretic mobility-shift assays with microarray analyses. Our results reveal important new trends in tRNA/AARS complex formation and potential deep physiological implications. Renaud Geslain is an assistant professor of biology. Joseph Karam and Jomel Jacinto co-developed this project in 2014 during their senior year at the College of Charleston, as part of their independent-study project. Karam is currently enrolled in a masters-of-science program in biomedical sciences at the Medical University of South Carolina with a focus on biochemistry and molecular biology. Jacinto is currently a first-year osteopathic medical student at the Edward Via College of Osteopathic Medicine in Spartanburg, SC. This research was supported by a Faculty Research Development grant to Geslain from the College of Charleston.

Carpi, A., Fostier, A.H., Santos, J.C., Gittings, M., Orta, O.R. Mercury Emissions from Soil Following the Loss of Forest Cover in the United States and Brazil. *Atmospheric Environment*. 2014; 96: 423-429. (John Jay College, CUNY)

This article explores the role that deforestation plays in the global mercury cycle. Mercury, a toxic and persistent pollutant, is emitted by a number of anthropogenic and natural sources. While previous research had identified the role that forest fires play in the release of mercury into the environment, this is the first study to show that mercury continues to be emitted into the atmosphere by soil surfaces post-deforestation. This article thus provides an important link in the chain of research examining and catalyzing a reduction in mercury use. Anthony Carpi is a professor of environmental chemistry. Olivia Orta is a first-generation college student who conducted undergraduate research with professor Carpi

through John Jay's PRISM research program and continued to work with him after graduating with her bachelor's degree. During this post-graduate training period, she took the lead on data analysis for the study, gathering, normalizing, and graphing hundreds of hours of data collected in the field. She conducted all statistical analyses for the study and contributed substantively to the writing of the manuscript. She is now in her third year as a doctoral student in epidemiology at the Harvard School of Public Health. Funding for the study was provided by a Fulbright Scholarship from the Fulbright program of the U.S. Department of State and by the São Paulo Research Foundation (FAPESP).

Bell KM, Higgins L. The Impact of Childhood Emotional Abuse and Experiential Avoidance on Maladaptive Problem Solving and Intimate Partner Violence. *Behavioral Sciences*. 2015; 5: 154-175. (Capital University)

The purpose of the study was to examine the joint influences of experiential avoidance and social problem solving on the link between childhood emotional abuse (CEA) and intimate partner violence (IPV). As part of a larger study, 232 women recruited from the community completed measures assessing childhood emotional, physical, and sexual abuse, experiential avoidance, maladaptive social problem solving, and IPV perpetration and victimization. Findings suggest that CEA may lead some women to avoid unwanted internal experiences, which may adversely impact their ability to effectively solve problems in social situations and increase their risk of violence by intimate partners. Kathryn Bell is an associate professor of psychology. Lorrin Higgins conducted this secondary-data analysis project in order to gain research experience prior to applying to graduate school. She began the project in spring 2013 and presented the findings at the annual convention of the Association for the Advancement of Behavioral and Cognitive Therapies in November 2013 in Nashville, TN. Higgins graduated from Capital University in May 2015 and plans to apply to graduate school in clinical psychology. Initial data collection was funded by Northern Illinois University with support from the Center for Family Violence and Sexual Assault. Travel to present findings was partially supported by Capital University.

Calicchia, S. "Play That Funky Music" or Not: How Music Affects the Environmental Self-Regulation of High-Ability Academic Writers. *Young Scholars in Writing*. 2014; 11: 62-72. (Utah State University)

Successful writing, achieved by self-regulated writers, depends not only upon focus and content, but also upon the writing environment, including the physical and social setting, which varies greatly among writers. Just as musical tastes differ among individuals, there are strong preferences regarding the role of music in a writing setting. To better understand the environmental self-regulation of writers, a group of twelve high-achieving writers with a range of musical interests was selected, including nine professors and three undergraduate students across three academic fields. The results suggest that musical background impacts a writer's preferred setting, and academic writers should strongly consider this impact when establishing a successful writing environment. Sara Calicchia conducted this research during her sophomore year as an independent-study project in an honors English class. Calicchia has since graduated and currently works as a clinical research assistant at Ambry Genetics in Aliso Viejo, CA. Joyce Kinkead, the student's research mentor, is a professor of English. No funding was required for this project.

Basu, P., Dixon, D., Varghese, S., Varghese, G., Varghese, G., Maier, C. Detection of Estrogenic and Anti-estrogenic Activities of Dietary Plant Extracts by In Vitro Reporter Assays. *The FASEB Journal: The Journal of the Federation of the American Societies for Experimental Biology*. 2015; 29: 1. (Texas Woman's University)

This study aimed to establish the estrogenic agonism and antagonism of some dietary plants in the Ericaceae, Moraceae, Rosaceae, and Vitaceae families of plants. A steroid-regulated transcription system in Saccharomyces cerevisiae containing a human estrogen receptor alpha expression plasmid and a ß galactosidase gene reporter plasmid was employed in this study. Estrogenic activities of plant extracts were detected by assessing their effects on estrogen receptor mediated transactivation of the reporter gene as compared to estradiol. This study reports for the first time anti-estrogenic activities of the above plant extracts, and it may lead to detection of new more potent phytoestrogens for possible chemopreventive effects and cancer treatments. Camelia Maier is an associate professor of biology. Paramita Basu, Dinu Dixon, Sherin Varghese, Gladys Varghese, and Gladwin Varghese are all undergraduate students in biology at Texas Woman's University. This research was funded, in part, by the Texas Woman's University Undergraduate Research Microgrant Program.