Undergraduate Research Program

Assessment Case Study: University of Delaware's Undergraduate Research Program

Conrado M. Gempesaw II (gempesaw@udel.edu)

Joan S. Bennett (jbennett@udel.edu)

Andrew L. Zydney (zydney@engr.psu.edu)

Karen W. Bauer (kbauer@udel.edu)

UD Program's Purpose and Design

Students learn through research apprenticeships with faculty

- Open to students in every major department and class.
- About 600-700 students per year participate.
- Involvement lasts typically 1-3 years; summers important.
- Students gain increasing independence and responsibility.
- Students present work at symposia and poster sessions
- Seniors in university thesis program prepare research proposals, present work-in-progress to peers, give an oral defense of their theses.

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Faculty Mentors

About 2/3 of UD faculty provide undergraduate research opportunities

- Over 90% in engineering, physical, and life sciences
- Over 80% in social, behavioral, economic sciences
- Over 60% in humanities
- Over 55% in arts
- Over 50% in mathematical sciences

Faculty in Coordinating & Advising Roles

Departmental Undergraduate Research Advisors

One faculty member in each of 35 departments or research centers serves as departmental UR advisor and liaison with UR Program staff.

Board of Senior Thesis Readers

20 faculty members facilitate the University-wide senior thesis program and serve as outside readers on thesis committees.

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Undergraduate Research Program Services

- Solicit UR opportunities from faculty and publicize.
- Help departments & other units to develop UR opportunities.
- Directly advise about 300 students per year.
- Provide funds for UR project supplies and expenses.
- Provide summer and winter term UR scholarships.
- Arrange summer UR residence and enrichment programming.
- Coordinate University-wide senior thesis program.
- Mount poster sessions and symposia for UR presentations.

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Program Staff:

- Faculty coordinator
- Professional coordinator
- Administrative assistant
- Graduate assistant

Program Facility:

- Student reading & computing room/presentation practice space
- Conference room
- Staff offices and workroom

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Why Assess? Why Now (1997)?

Funds for large-scale study potentially available

- NSF RAIRE competition

Visibility desirable

- We anticipated the results would be strongly positive.
- It would benefit our own institution and higher education to demonstrate and analyze accomplishment.

Stakeholders' Influence on Assessment Design

NSF requested a *summative* assessment:

- Answers to our research questions must be of interest to the general public and the U.S. Congress
- Studies should yield assessment models adaptable for use by other research universities

UD would also like *formative* information:

- What could we learn from these studies that would benefit our own future student and faculty program participants?
- Could we also possibly contribute new methods of assessment (conduct research *on* assessment)?

Challenges to Be Met

- Articulation of, and agreement upon, the research questions
- Researching possible methods and instruments
- Organizing existing sources of data (e.g., creating an alumni data base from paper files)
- Securing staff to help with data gathering and specialized analyses
- Obtaining subjects' participation, esp. longitudinally
- Finding enough time to complete the studies

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Program Factors Influencing Assessment Design

Age of program

- Alumni available
- 20 years of student and faculty evaluations available

Central administration support

- Institutional research expertise available

Faculty support

- Faculty readily called into service

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Role of Advisory Board

- Adds unique perspectives on undergraduate research experience
- Assists with writing / obtaining grants
- Provides oversight of assessment efforts
- Acts as liaison with faculty as a whole
- Adds leverage with administration
- Increases dissemination of results

UD Advisory Board

- **Joan Bennett** – Director, UR Program, English
- **Karen Bauer** -- Asst Dir., Institutional Research, Psychology
- **Michael Vaughn** -- Asst. Dean, Student Affairs, Engineering
- **Dianne Kukich** -- Editor, Composite Center

- **Chemical Engineering**
  - Andrew Zydney
  - Roy McCullough
- **Physics**
  - George Watson
  - Harry Shipman
- **Chemistry / Biology**
  - Hal White
  - Deborah Allen
- **Math/Science Education**
  - Barbara Duch

Perspectives on UG Research

- Director of University's Undergraduate Research Program
- Faculty who actively involve undergraduates in their research programs
- Faculty with non-traditional approaches to incorporating research in the classroom
- Asst Dean for Student Affairs
- Others (?)

Grant Writing

- Strong Advisory Board looked impressive to funding agencies
- Well-defined role of Advisory Board strengthened overall proposal
- Faculty provided critical input into proposal based on personal experiences
- Editorial Assistant provided hands-on assistance with actual grant preparation

Oversight of Assessment

- Are we asking the right questions?
- Are we using assessment tools that will give useful (and believable) results?
- What correlations should be explored?
- What confounding factors need to be examined?
- How do we interpret the data?
- What conclusions can we draw and defend?

Liaison to Community

- Critical for effective communication of results to broader faculty
- Provided "believability" to faculty and administration
- Assisted in preparation of papers and presentation of results
- Increased visibility of assessment effort both on- and off-campus

Conclusions

- Strong Advisory Board is critical to overall success of assessment activities
- Composition of Advisory Board should be based on goals of assessment effort and identification of key constituencies
- Active participation of Advisory Board requires strong leadership (and persistence) from director of assessment effort

First Steps for UD Assessment Official

- Become familiar with nuances of Undergraduate Research Program, its faculty and its students
- Think, plan, develop preliminary methodology skeleton
- Collaborate with Advisory Board
  - Discuss what was to be measured
  - Articulate major issues, questions
  - Discuss potential measures and methods

Major Questions That Emerged

Does participation in undergraduate research:

- Sharpen ability to think critically, creatively, synthetically?
- Develop problem-solving, leadership, teamwork abilities?
- Increase intellectual curiosity and desire to learn?

Do alumni perceive benefits of UR in same ways as current students?

What motivates faculty to participate; what are the obstacles?

What educational outcomes do faculty perceive for students who participate in research?

How Did We Come to the Chosen Method and Measures?

- Clear to me that no one measure would answer the questions
- Important to have non-UR comparison group
- Important that subjects be unaware of the studies' connection to undergraduate research
- Important to examine data from multiple perspectives- alums, faculty, current students

Value of Multiple Measures

- Some constructs such as cognitive growth are hard to measure
- Academic and psychosocial behavior change are easier but still tough to separate from extraneous factors
- Multiple measures enabled us to look at different educational outcomes affected by UR

Non-UR Comparison

- Important to examine the value-added of UR over and above regular curriculum
- Can help identify where the UR program is meeting its goals, objectives
- Can help serve as a gauge for subgroup findings – gender, major, honors
- Non-UR comparison meant larger sample size needed

Value of a Longitudinal Study

- Resource intensive– but the best way to study student change over time
- Examine individual student growth over time
- Eliminate bias that can be made when comparing students in cross-sectional analyses
- Examine similarities and differences between self-report and objective measures
- Help examine appropriateness of some standardized measures (e.g., critical thinking and reasoning)

Important to Consider Use of Resources

- Comparison group = larger sample
- Large sample = statistical power
- Larger sample = impracticality of more qualitative examination through individual interviews
- High attrition rate would threaten generalizability of study, so follow-up is important
- Larger sample = more personnel time to follow up with nonrespondents

Value of Multiple Perspectives

- Faculty study enabled us to examine levels of UR involvement and what faculty think students learn
- Also enabled us to better understand why faculty participate; in what ways they benefit
- Alumni have the advantage of distance and seeing how educational experiences helped with career or graduate school
- Students can accurately describe their perceptions of their own academic experiences
- Multiple perspectives help tell a robust story

Assessment of the University of Delaware's Undergraduate Research Program

Four Major Components

I. Content Analysis
- previous years' *formative* evaluations
- science and engineering sophomores

II. Alumni Survey
- all majors: UR and non-UR

III. Faculty Survey
- all science and engineering departments

IV. 4-Year Longitudinal Study: Class of 2000
- UR and non-UR science and engineering students

I. Content Analysis of Previous Years' URP Evaluations

- Used formative evaluations of the Science and Engineering Scholars Program
  - free-form letters (1-4 pages each) originally written at end of sophomore summer
  - included students from 22 science and engineering majors
- Randomly selected 183 samples of letters completed annually between 1985-1995
- Created categories to examine students' perceptions of learning, satisfaction

Content Categories: Perceived Learning

- Increased technical skills……96%
- Increased independence……57%
- Insight into graduate school……..45%
- Teamwork learned and valued……43%
- Learned to work with obstacles and ambiguities……..37%
- Learned to think creatively/synthetically……..32%
- Increased desire to learn……32%
- Self-confidence gained……..28%
- Communication skills improved……24%
- Understanding "knowledge"……..24%

Content Categories: Comparison to Course Work

N of letters in which this content category was mentioned:

154/183 (84%)

- Learned more through research: 113 (73%)
- Learned as much through research: 39 (25%)
- Learned more through courses: 2 (1%)

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Content analysis web posting:

University of Delaware's

RAIRE web site

www.udel.edu/RAIRE/

II. Alumni Survey

- Alumni survey containing a large set of questions about the undergraduate experience. Survey completed in spring 1998.
  - Responses from 986 UD alumni
  - Graduating classes of 1982 through 1997
- Respondents from 75 different majors:
  - 59% science or engineering
  - 41% arts, humanities or social science
- Responses fell into three groups related to UR:
  - 418 had been undergraduate researchers served by the URP
  - 213 had conducted UR but had not received URP services
  - 355 had not engaged in undergraduate research

Alumni Survey Results (selected):

- Growth in 8 general cognitive and behavioral skills greater for UR than non-UR alums
  - Carry out research
  - Develop intellectual curiosity
  - Acquire information independently
  - Understand scientific findings
  - Analyze literature critically
  - Speak effectively
  - Act as a leader
  - Possess clear career goals
- Growth in 3 factors greater for URP than non-UR alums
  - Science, math, logic, problem-solving
  - Literature, language, mastery of contexts
  - Personal initiative and communication

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Alumni Survey Results (selected)-2:

- Education beyond the baccalaureate
  - URP alums were about twice as likely to pursue doctoral degrees
- Employment
  - Compared to URP alums, about 1/3 more non-UR alums were employed in a career not related to major

Alumni Survey Results (selected)-3:

- Alumni ratings for benefit of UR involvement:
  - High benefit perceived for even one research semester.
  - Higher benefits perceived by alums who had devoted greater amount of time to research
  - Very highest ratings given by alums who had completed a senior thesis through the URP
- Involvement in non-research out-of-classroom activities:
  - UR alums participated in co-curricular activities and on-campus employment at the same or greater rate than non-UR alumni
  - Internships related to major also rated as highly beneficial by both UR and non-UR alums

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Alumni survey publications:

Bauer, K.W. and Bennett, J.S. 2002. Alumni perceptions used to assess the undergraduate research experience. *Journal of Higher Education.* (in press)

Zydney, A.L., Bennett, J.S., Shahid, A. and Bauer, K.W. 2002. Impact of undergraduate research experience in engineering. *Journal of Engineering Education.* 91(2):151-157. [engineering data considered separately]

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III. Faculty Survey

- A survey of 155 science and engineering faculty was completed in fall of 1999.
- Over 90% of UD faculty in these fields participate regularly in UR.
- Objective was to examine:
  - Motivation of faculty to participate in UR
  - Accommodations faculty make to facilitate UR
  - Faculty perceptions of student learning through UR (compared to alumni perceptions)

Faculty Survey Results: Motivation

- Desire to influence career of talented young students
  - 75% said "important" or "very important" motivator
  - Another 20% said "moderately important" motivator
- Students' contribution to faculty member's research
  - 50% said "important" or "very important"
  - 78% said students influenced their own thinking about research
- Students' contribution to faculty member's quality of life
  - 41% said "important" or "very important"
- Undergraduates' contribution to graduate students' education
  - 39% said "important" or "very important" (primarily in engineering)

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Faculty Survey Results: Accommodations made

- 46% reported structuring to accommodate undergrads
  - These faculty took more undergrads (avg. 7.95 over 5 years compared to avg. 6.77 for those who made no adjustments)
  - 91% of these faculty had graduate students helping
- Accommodations fell into four categories:
  - Create smaller problems
  - Assign exploratory problems
  - Integrate undergrads into existing lab/project framework
  - Designate money/time for undergraduates

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Faculty Survey Results: Student skills gained-1

- Highest-rated skills (by 77-80% of respondents):
  - Develop intellectual curiosity
  - Think logically about complex materials
  - Understand scientific findings
- Also highly rated (by 63-69% of respondents):
  - Synthesize/use information from diverse sources
  - Solve problems independently
  - Approach problems creatively
  - Maintain openness to new ideas
  - Work as part of a team

Faculty Survey Results: Student Skills Gained-2

- Faculty perceptions of student skills gained generally agreed with alumni perceptions.
- Faculty who made accommodations for undergraduates perceived much larger gains in the higher order skills.
- Faculty who supervised undergraduates for two or more years rated gains significantly higher in 9 of 11 skills.
- No correlation was found between number of hours per week spent supervising students and skill gains perceived.
- Faculty for whom quality of life was a strong motivator perceived higher educational gains for their students.

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Faculty Survey Results: Graduate students

- Most faculty (73%) believed that graduate students who helped to mentor UR students gained valuable teaching experience and greater mastery of their subjects.
- Faculty with larger numbers of graduate students also had larger numbers of undergraduate researchers.
- Thus, institutional support for graduate students—when combined with a strongly institutionalized undergraduate research program—could be leveraged to improve undergraduate educational experience.

Faculty Survey: Some Conclusions

- Departmental/college encouragement was not a primary motivator and had no correlation with perceive skill gains; therefore, the institution's most effective role appeared to be indirect:
  - Providing student recruitment/advisement network as well as support services and funds for both students and faculty
- Since both length of students' research commitment and accommodations made by faculty correlated strongly with student gains, the institution should:
  - facilitate long-term student involvement; facilitate faculty's efforts to adapt their research operation to include undergraduates

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Faculty survey publication:

Zydney, A.L., Bennett, J.S., Shahid, A. and Bauer, K.W. 2002. Faculty perspectives regarding the undergraduate research experience in science and engineering. *Journal of Engineering Education.* 91(3):291-297.

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IV. UDAES: UD Academic Experience Study-- Longitudinal Study of Science and Engineering Majors, 1997-2000

Goals:

- Capture currently enrolled students
- Ensure the impossibility of respondent bias
- Measure change in skills gained over time
- Maintain comparison groups for all measurements
- Compare results from several types of instruments

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Longitudinal Study Design and Participants

From baselines on tests established in the freshman or sophomore year, charted annual differences among ~200 science and engineering majors in order to examine correlations between extent of undergraduate research experience and:

-- academic effort

-- gains in scientific skills

-- growth in critical thinking for both closed and open-ended problems

Looked for any possible role played by students' personality in differences found

Longitudinal Study Instruments

- No existing standard instrument can objectively measure the cognitive and behavioral gains that self-report, alumni perception, and faculty observation find in undergraduates who participate in research.
- To have established reliability in the instruments used for our study, we decided not to invent our own instruments.
- Instead, we ***combined*** three standard instruments—measuring (1) college student academic behaviors and gains (CSEQ, a self-report instrument), (2) logical thinking (WGCTA), and (3) personality characteristics (NEO-FFI)—with a reliable instrument still under development that attempts to measure (4) "reflective judgment" or epistemological sophistication (RCI).
- UDAES' goal was to test this combination as a viable method for longitudinal study of learning achieved through undergraduate research.

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Select Preliminary Longitudinal Study Results - 1

- **Personality:** Although overall, students decreased in neuroticism and increased in openness to experience, no significant differences were found between UR and non-UR students
- **CSEQ:** UR students perceived greater increases for themselves than did non-UR students in

  -- academic effort (this self-reported information was also reflected in students' course registrations)

  -- scientific and technological skills

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Select Preliminary Longitudinal Results - 2

- **WGCTA:** Biological/Physical Sciences/Chemical Engineering majors with intensive research involvement showed larger increase over 4 years in critical thinking (logic) than did non-research students in these majors.
- **RCI:** (1) Biological/Social Science majors with intensive research involvement showed larger increase in reflective judgment over 3 years than did majors in these subjects with a smaller amount of research or no research experience.

  (2) Women with intensive research involvement showed higher gains in reflective judgment over 3 years than women with a smaller amount of research or no research experience.

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Longitudinal Study--Some Limitations

- Sample size (limited number of analyses with statistical power)
- Only one institution; only science and engineering students (limited ability to generalize)
- Epistemological test dilemmas needed with scientific/technological content (possible limit in ability to engage interest of some students)

Longitudinal Study: Some Preliminary Recommendations

- Conduct similar studies at institutions where there is a larger N overall and especially a larger N of high-achieving students who do not do research.
- Develop a new paper/pencil self-report inventory of general cognitive and psycho-social skills to replace the lengthy CSEQ.
- Add a general test of motivation in the first and final years.
- Eliminate WGCTA, and administer RCI using new test dilemmas with content appropriate to students' disciplinary interest.

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Longitudinal study publication:

Article is in preparation.

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Impact of Assessment -- 1

- Improvements in UG research programs
  - Confirmed emphasis on early involvement
  - Increased participation in Senior Thesis
  - Greater recognition of role of graduate students
- Increased participation of students and faculty in UG research
- Added support for PBL and other efforts to infuse research throughout UG experience

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Impact of Assessment -- 2

- Development of new/expanded UG research programs at the University of Delaware
  - New NSF REU sites in ChE and CE
  - Delaware Biotechnology Institute
  - McNair, HHMI, others
- Increased funding for UG research experiences at UD

Impact of Assessment -- 3

- Increased visibility of UG research at UD
- Leadership role for UD in national discussions of UG research and assessment
- Enhancement of University reputation
- Benefits for student recruiting
  - Prospective undergraduates
  - New graduate students via REU sites