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CUR Focus

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Using Electronic Portfolios to Measure Student Gains from Mentored Research

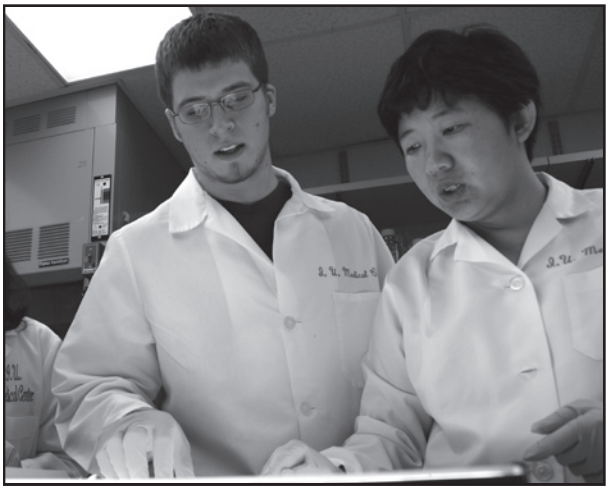
The Assessment Rational and the NSF Electronic Portfolio (ePortfolio)

The cumulative personal and professional benefits of completing an undergraduate research experience project are varied, interwoven, complex and, in some cases, not easily measured. Nonetheless, prior work has shown that students who are involved in undergraduate research: (1) gain self-confidence (Ferrari, Jason, 1996; Campbell, Skoog 2004; Houlden, Raja, Collier, Clark, Waugh, 2004), (2) are more likely to complete their undergraduate education (Nagda, Gregerman, Jonides, von Hippel, Lerner, 1998; Ishiyama, 2001), and (3) are more likely to go onto graduate school compared to students who do not have a research experience (Kremer, Bringle, 1990; Chandra, Stoecklin, Harmon, 1998; Alexander, Foertsch, Daffinrud, Tapia, 2000; Foertsch, Alexander, Penberthy, 2000; Ishiyama, 2001; Bauer, Bennett 2003). Descriptive studies suggest students gain intellectually as a result of an undergraduate research experience (Hakim 1998; Kardash, 2000; Hathaway, Nagda, Gregerman, 2002). A few well-designed assessment studies show that students involved in undergraduate research *self report* intellectual gain from such experiences (Ishiyama, 2002; Seymour, Hunter, Laursen, Deantoni, 2004; Lopatto, 2004; Russell, Hancock, McCullough, 2007). Nevertheless, there are few objective assessment tools for measuring the effects of undergraduate research experiences on student learning, and attempts to conduct objective assessments have rarely been attempted.

Descriptive studies suggest student-faculty interactions during an undergraduate research experience play a key role in enhancing student confidence (Blackburn, Cameron, Chapman, 1981; Jacobi, 1991; Koch, Johnson, 2000), student retention, and academic growth (Pascarella, Terenzini, 1991; Astin, 1993; Tinto, 1998). In 2005 and 2006, the Faculty Survey of Student Engagement (FSSE) and the National Survey of Student Engagement (NSSE) sampled over 29,000 faculty and more than 65,500 seniors at 209 four-year colleges and universities. These surveys could not match student/mentor collaborators, but taken together, indicated a positive relationship between student engagement in "educationally purposeful activities", such as research participation, and outcomes including critical thinking, grades, and "deep learning" (Kuh, Chen, Laird, 2007) Deep learning is defined as "learning that encourages students to process information in ways that help them make qualitative distinctions about the merits of data-based claims or the persuasiveness of logic-based arguments" (Kuh *et al,* 2007, pg. 40). Contemplating the "value added" by undergraduate research, one hopes that in addition to gaining self-confidence and increasing persistence and graduation rates, it also promotes student intellectual growth.

In addition to the dearth of objective studies documenting student intellectual gains, studies that objectively examine the role mentoring plays in the undergraduate research experience are lacking. We suspect the quantity and quality of mentoring students receive during research projects varies considerably depending on the students' academic disciplines, the environment they work in, and characteristics of individual mentors. Studies have shown that students mentored by a faculty member were more satisfied with their research experience than those mentored by someone other than a faculty member (Shellito, Shea, Weissmann, Mueller-Solger, Davis, 2001). The recent NSSE and FSSE studies, surprisingly, show that the amount of time the faculty member spends doing research does not seem to affect the probability students will participate in research, collectively, at an institution. Rather, the higher the value faculty members at an institution place on this activity the more likely students will report greater progress in key learning outcomes (Kuh *et al*, 2007). Such studies do not fully answer questions about skills students gain, nor do surveys of student satisfaction with faculty mentoring speak fully to student learning, to exactly which components of the research environment bring about intellectual growth, or to which of these different components might be most crucial.

The NSF funded ePortfolio Project is a collaboration among several institutions. The project goal is to develop a more objective, evidence-based approach, than is currently available through surveys and standardized tests, to gain insight into student learning that takes place in a mentored research experience. To measure student intellectual growth the NSF ePortfolio Project has developed an evaluation tool to examine student research products before and after a research experi-



Human Biology Students in their Freshman year gather data from the field for their Level 4, open-ended research.

ence. The tool for this task is embedded in a learning portfolio, which documents *and* promotes learning (see Cambridge, Cambridge, Yancey, 2008 for numerous examples). A learning portfolio pulls together three domains: documentation (of research products); collaboration (the faculty/student research collaboration); and reflection (on the collaborative project that produces the products) (Zubizarreta, 2004). The Inter/National Coalition for Electronic Portfolio Research (http://ncepr.org/) provides a resource of projects from over 50 colleges and universities that document the connection between student learning and development, and the use of electronic portfolios. In this NSF project students set up electronic portfolios and add products from their research. Both students and mentors evaluate research products as matched pairs. The criteria used in the ePortfolio (ePort) to assess student intellectual growth are derived from the first three of IUPUI's Principles of Undergraduate Learning (PULs): (1) core communication and quantitative skills, (2) critical thinking, and (3) integration and application of knowledge (The IUPUI PULs, 2008). The American Association of Colleges and Universities (AAC&U) calls these "Essential Learning Outcomes" (AAC&U, 2007, listed on pg. 12). In the ePort, students and mentors access an evaluation tool, the "NSF Electronic Rubric", in order to assess skills reflected in research products that students have placed in their portfolios. At the end of the research project students respond to a mentoring survey to identify elements within the research environment and characteristics of the mentoring relationship that may have influenced their skills development. Both the research mentor and the student also fill out demographic surveys to help determine mentor/student characteristics that may influence the mentor/student collaboration and acquisition of skills. Reflections will ultimately provide further information about the collaborative experience. Note that data collected from both the mentor and the student can be quantified, stored in a database, retrieved, and matched between student and mentor.

Development and Evolution of the NSF Electronic Rubric (The Research Project Evaluation Tool)

The NSF Electronic Rubric is an undergraduate research assessment instrument, which has been constructed in an iterative fashion, for use across disciplines and with multiple undergraduate research products. Initially the primary objective was to design an evaluation tool to grade undergraduate research experiences, at first focused for use in the STEM disciplines, but then more broadly targeted for use across all disciplines. Eventually the objective was modified to *develop a rubric for rating research products*. Measurement challenges associated with rubric construction raise some basic questions: (1) What is a rubric and how is it defined in the literature? (2) How are rubrics developed and what do they look like? (3) Are there advantages or disadvantages to using rubrics? (4) Have relevant analytic rubrics, as envisioned for use in the NSF ePort, already been developed? If so, what do they look like? (5) Is it feasible to develop an analytic rubric across disciplines and multiple undergraduate research products? (6) Are there practical alternative approaches to the initial objective? And finally, (7) Are there recognizable criteria by which undergraduate research projects can be evaluated, and do those criteria reflect the selected learning outcomes of the PULs?

Definitions and Usefulness of Rubrics

Two definitions of "rubric" are useful in building a tool to evaluate undergraduates' research experiences and related products. A rubric:

- is a tool for assessing instruction and performance according to predetermined expectations and criteria (Taggert, Phifer, Nixon, Wood, 1998); and

- articulates in writing the various criteria and standards that a faculty member uses to evaluate student work. It translates informed professional judgment into numerical ratings on a scale. Something is always lost in the translation, but the advantage is that these ratings can now be communicated and compared (Walvoord, 2004).

Discussions about rubric-related resources across disciplines frame rubrics as authentic assessment tools (for example, Taggert *et al*, 1998; and Walvoord, 2004) that facilitate a student's thinking about criteria upon which work (including research products) may be evaluated. Additionally, rubrics make students aware of the criteria prior to receiving instruction and assessment.

Rubrics may be analytic or holistic, and task specific or general. *Analytic* rubrics provide specific feedback along several dimensions. Scoring is more consistent and provides more detailed feedback than *holistic* rubrics, but analytic rubrics are more time consuming. Conversely, holistic rubrics are useful for quick snapshots of student achievement, often providing a single score based on overall impressions of student performance on a task. They do not provide detailed information, and it may be difficult to provide one overall score. *Task specific* rubrics are used to assess knowledge when scoring consistency is extremely important, whereas *general* rubrics are used for assessing reasoning, skills, and products when all students are not doing the same task (Schreyer Institute for Teaching Excellence, 2008).

Alternate Approaches and Frameworks for Assessment

Initially the NSF ePortfolio project collaborators envisioned using an analytic rubric and attempted to construct a *task specific* rubric matrix. The matrix would be based upon three PULs that permeate the undergraduate curriculum and apply to undergraduate research activity. However, this type of rubric is very detailed and thus its specificity does not lend itself well to rating multiple types of research products from a range of disciplines. The overriding challenge associated with an analytic rubric for undergraduate research activities is that research mentors determine *specific* expectations for students with respect to their research project. In the NSF ePort the initial objective of rating diverse research products across disciplines intentionally required defining these expectations broadly. Analytic rubric construction requires making *specific* a *conceptual framework* that falls under the authority of each mentor and would require securing measurement criteria from all participants for each project. Because analytic rubrics are implicitly tied to single products or artifacts and therefore cannot be used across various disciplines or with multiple products, the NSF ePortfolio Project focused on the use of a holistic-generalized evaluation tool.

Identification and Evolution of Evaluation Criteria

The Intel International Science and Engineering Fair (Intel-ISEF) is the world's largest pre-college science competition. It provides an opportunity for young scientists from around the world to share ideas, showcase cutting-edge science projects, and compete for awards and scholarships (Society for Science and the Public, 2009). Criteria employed by Intel-ISEF to judge competitions were ultimately incorporated into the rubric-like ePort evaluation instrument. To construct a judging/scoring worksheet for student research projects, the University of New Mexico adapted assessment material from the Bay Area Science & Engineering Fair, BASEF-2002, which had originally adapted its judging criteria from those of the Intel's Science Fair (University of New Mexico Judging Rubric for Student Research Projects, 2004; see the judging form for BASEF 2002, http://hwhsef.mcmaster.ca/2002/judging/JudgingHandout2.doc). Using this adaptive approach the NSF ePortfolio Project built on the foundations of all three instruments and evolved five research themes: (1) design, innovation and/or solution; (2) thoroughness; (3) presentation; (4) approach and/or methodology; and (5) originality, in addition to learning outcomes associated with the PULs. Furthermore, there are elements associated with each of the themes that allow research mentors and students to rate the amount of evidence found in a product resulting from student undergraduate research.

The NSF ePort Evaluation Tool Design

The NSF ePort evaluation tool allows students and mentors to evaluate research skills on the basis of evidence they can recognize in products that are placed in the electronic portfolio. The tool asks evaluators to select the type of project approach from three choices: (1) *experimental approach*, an investigation proposed or undertaken to test one or more hypotheses; (2)

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non-experimental approach, a collection and analysis of data that is descriptive, observational, and/or showing evidence of a correlation or pattern of interest; and (3) *innovation or creative work*, the development and/or evaluation of models, innovations, or creative works. Evaluators must also consider at what level of originality a student is working and whether a project is being planned, executed or in completion. The type of product is selected from among the following choices: (1) abstract; (2) annotated bibliography; (3) lab report; (4) poster; (5) PowerPoint slides; (6) PowerPoint slides with narration; (7) research paper; and (8) scholarly works, as well a write-in category.

Integrating the NSF Evaluation Tool into the Electronic Portfolio

Once a hard-copy version of the evaluation instrument was developed it had to be integrated into a web-based electronic portfolio and made accessible to students at multiple universities for the NSF research project. The campus chose to utilize the Sakai ePortfolio. Originally conceived as a free alternative to commercial learning management software, the Sakai software is now in use in over 160 universities, colleges and schools throughout the world. Based on the "open source" development concept, the Sakai code can be deployed free of charge; moreover, institutions can suggest and develop additional software functionality, which in turn is added to the core programming infrastructure. The Sakai ePortfolio benefits from this community-based, open source approach, as new functionality is constantly under development (Open Source Portfolios, http://osportfolio.org).

As a founding member of Sakai, Indiana University -- and especially IUPUI -- plays a critical role in developing and implementing functional requirements to the ePort software. Over the last eighteen months, IUPUI has centered its ePort development on tools that allow for the direct gathering and assessment of student work. Specifically, the ePort "Matrix" tool illustrated on the web at http://crl.iupui.edu/NSFePortfolioProject/matrix.html allows for the visual presentation of student progress. The Matrix tool further enables both formative and summative assessment as it facilitates document workflow between the student and faculty mentor.

The NSF evaluation tool and other associated surveys were fairly complex. However, original ePort software was unable to gather and report anything but the most basic data. This challenge was met by using existing commercial survey software to construct the tools and surveys. Currently the project employs Checkbox, survey software distributed by Prezza Technologies. Students and mentors must link to the evaluation tool and surveys from a URL inside the portfolio until data gathering and reporting tools embedded in the ePort can be further developed. Student and mentor responses are stored in the survey tool's database until they are downloaded and transferred to ACCESS for additional analysis.

A range of data reporting functions that can be accessed directly from the ePort software are now under development.

Once implemented, reports will allow for the querying of data across various Matrix cell/column/row combinations. Some of the quantitative, objective information gathered from student electronic portfolios is ultimately available to the institutions who may also be constructing institutional portfolios (iPorts) for assessment, as is the case at IUPUI (IUPUI Institutional Portfolio; http://www.iport.iupui.edu).

Selected information about the project and tools that were constructed can be viewed by accessing the following URLs:

- Overview of the NSF project: http://crl.iupui.edu/NSFePortfolioProject/NSFproject.html
- The NSF Undergraduate Research Product Evaluation Tool:
- http://surveycentral.uc.iupui.edu/nsfevalcur.aspx
- The NSF Undergraduate Research Survey Regarding the Mentoring Experience: http://surveycentral.uc.iupui.edu/nsfmentoringcur.aspx

Further development of the NSF research portfolio will improve and refine elements that complement the NSF evaluation tool including the introduction to the NSF project, instructions for using the site, relevant resources, and communication tools, as well as a robust set of prompts for self reflection related to the research and mentoring experience. The centerpiece of the site is a matrix consisting of cells where students can upload examples of products representing work from their pre- and post- undergraduate research experience. From this matrix students access the evaluation tool, a demographic survey, a survey regarding their relationship with their mentor, and several opportunities to provide reflective feedback. Mentors also can access and evaluate student work through this matrix. The tool also can assess students' research experiences over time since they can store work from the beginning and the end of projects as well as over the course of their undergraduate careers from early research participation until graduation.

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