ASSESSMENT OF STUDENT LEARNING DURING A COMPLEX MULTI-YEAR, MULTI-DISCIPLINARY PROJECT: A MODEL FROM TRINITY UNIVERSITY

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TRINITY UNIVERSITY

PROJECT BACKGROUND

Rigorous assessment of student learning has become increasingly important in college education. While many formative and summative assessment methods are available, choosing the right tools for the job is crucial. We provide an assessment model that we have integrated throughout a multi-year, multi-disciplinary, NSF-funded project at Trinity University in San Antonio, Texas.

Trinity is a small, liberal arts college with strong teaching and research traditions, where faculty pride themselves on their ability to engage students in the classroom, in the lab, and in the field. It has become clear that students with the ability to work across classic disciplinary boundaries, thinking outside their own discipline's paradigm, will be better prepared for success in an increasingly interdisciplinary world and workplace. In addition, popular conceptions of the scientific method both in the media and at the elementary and secondary levels have resulted in widely-held misunderstandings of the way that scientists work, something that we have frequently observed at all curricular levels.

To address these challenges, we designed a multi-year project that most directly involves the departments of Geosciences and Chemistry, and has involved the departments of Art and Art History, Classical Studies, and Environmental Studies. We carefully crafted overarching project goals (see PROJECT GOALS) that we hoped would best impact student learning and provide seeds for future improvements across STEM disciplines and beyond at Trinity. We found it more difficult, however, to develop an assessment program that could provide us with rich data for project assessment.

The assessment design process included a rigorous discussion of how to best assess student learning and overall project success at both formative and summative stages. Our desire was to construct an assessment framework that worked from the micro- to the macro-scale, providing us data for individual student learning, curricular/pedagogical efficacy for impacted courses, the strength of cross-disciplinary interaction, and overall project effectiveness. As we near the end of this NSF funded initiative (NSF-DUE #0942949), we think that our assessment framework has proven remarkably effective, providing us data that we have used to improve student learning at all curricular levels.

PROJECT GOALS

1 To improve both science and non-science majors' understanding and appreciation of the scientific method by providing engaging, interdisciplinary learning opportunities.

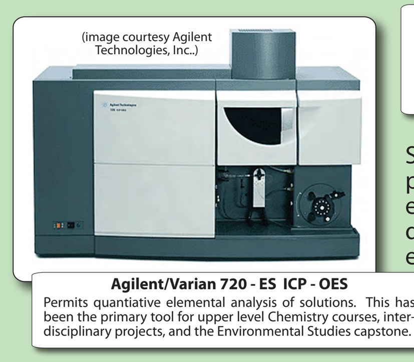
We proposed to improve both student understanding and overall attitude in these areas by modifying our existing lecture, laboratory and field pedagogy in Chemistry and Geosciences courses, with an aim to better focus on the processes of science rather than knowledge without context (Cashin and Downey, 1995; Smart and Ethington, 1995).

2 To improve the depth of understanding and application of elemental analysis methods and spectroscopies in college students at all curricular levels.

Since students construct their understanding through active participation, interpretation, and iteration (e.g., Tobin, 1990), we proposed to integrate the use of two new instruments (see figures), into curriculum across levels, from introductory to capstone courses.

Tracer III-V XRF spectrometer
Permits real-time semi-quantitative analysis of solids. (e.g., minerals, rocks, soils, metals). This has been our primary tool for introductory and upper level Geosciences courses.

(image courtesy Bruker, Inc.)



(image courtesy Agilent Technologies, Inc.)

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Permits quantiative elemental analysis of solutions. This has been the primary tool for upper level Chemistry courses, interdisciplinary projects, and the Environmental Studies capstone.

Students participate in data collection and interpretation of elemental analysis with the knowledge of instrument limitations (e.g., matrix dependence, elemental interference, X-ray emissions energies). These activities have all been designed within a scientific process framework, with the hope that all students gain a better understanding how science and scientists work.

3 To develop students' appreciation and recognition of the inherent interdisciplinary nature of many scientific problems while fostering multidisciplinary faculty interactions to form the foundation for future collaborations.

We proposed to develop new interdisciplinary activities across disciplines, focusing primarily on interactions between students in Chemistry and Geosciences courses. In addition, we proposed to initiate new undergraduate research projects that extend beyond these two departments, fostering interactions between faculty and students, emphasizing the importance of interdisciplinary research.

ASSESSMENT OF STUDENT LEARNING

Course activities

In the process of developing new activities and course materials for the classroom, lab, and field, we consciously integrated ideas realated to the scientific process (see Nature of Science diagram, right). In addition, we devised exercises and related questions that permitted us to assess learning related to project goals. We also included a range of question types (e.g., multiple choice, free response) on quizzes and exams tailored to a specific discipline, and we included more generalized questons that could be compared across disciplines. Finally, classroom interactions, including student-student (see below) and student-faculty discussion, provided information that could be used to assess the effectiveness of the activity or discussion in real time (albeit in a qualitative way).

Thus, faculty involved in project activities were constantly gathering data that they could use to revise the structure of an activity, with the goal of improving student learning. These assessment data are shown as (A) and (B) on the assessment plan.

Photo by Anthony Perez

Student surveys

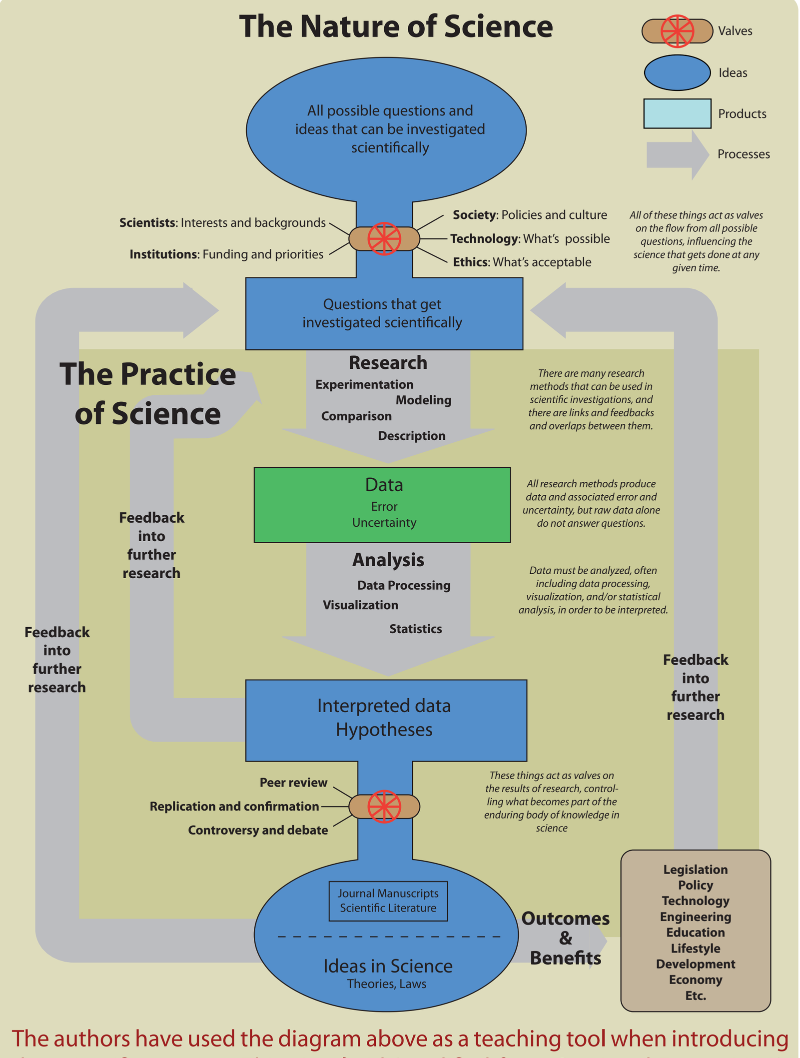
We developed pre- and post-learning questionnaires for each course impacted by the project. These are particularly effective at assessing the attainment of student-learning goals (e.g., Labarkin, 2001). Many questions varied by discipline, curricular level, and course-related goals. Additionally, we developed a set of common questions to assess student learning across disciplines and curricular levels.

While important for project evaluation, pre-learning questionnaires permit faculty to tailor students' learning opportunities to best match existing student attitudes and conceptions (Libarkin, 2001) and maximize the efficacy of student learning (Hofstein and Lunetta, 2003). As part of the process, we used proven assessment questions which target student attitudes toward science and the scientific method (e.g., Aikenhead and Ryan, 1992; Bradford, 1995; Libarkin, 2001) to best aid our efforts in evaluating student learning related to Goal 1.

Student research

Undergraduate research is a vital component of a Trinity student's education. Althought the assessment of student research results is primarily qualitative, this is an area with perhaps the most significant potential for future growth.

Student projects in the first three years have included: 1) provenance analysis of Spanish colonial pigments at the Alamo; 2) identification of now-invisible gilding on Roman statuary (1st to 3rd century A.D.) at the San Antonio Museum of Art; and 3) elemental analysis of potmarks on Aegean pottery (1400 - 1100 B.C.) for determination of provenance.



The authors have used the diagram above as a teaching tool when introducing the scientific process. This visual aid (modified from Carpi and Egger, 2012), when combined with other activities and discussion, has helped us dispell many misconceptions about the way that science and scientists work.

IMPROVING STUDENT LEARNING

What can we do better?

Although pleased with the conclusions of our summative project evaluation, we and our external evaluator have been able to identify a number of ways that we can improve student learning. These include:

1) Finding ways to improve interaction between non-science department majors and science majors, likely through shared lab experiences. We think that such activites will provide opportunitites for peer teaching, and more in-depth student-student interdisciplinary conversation.

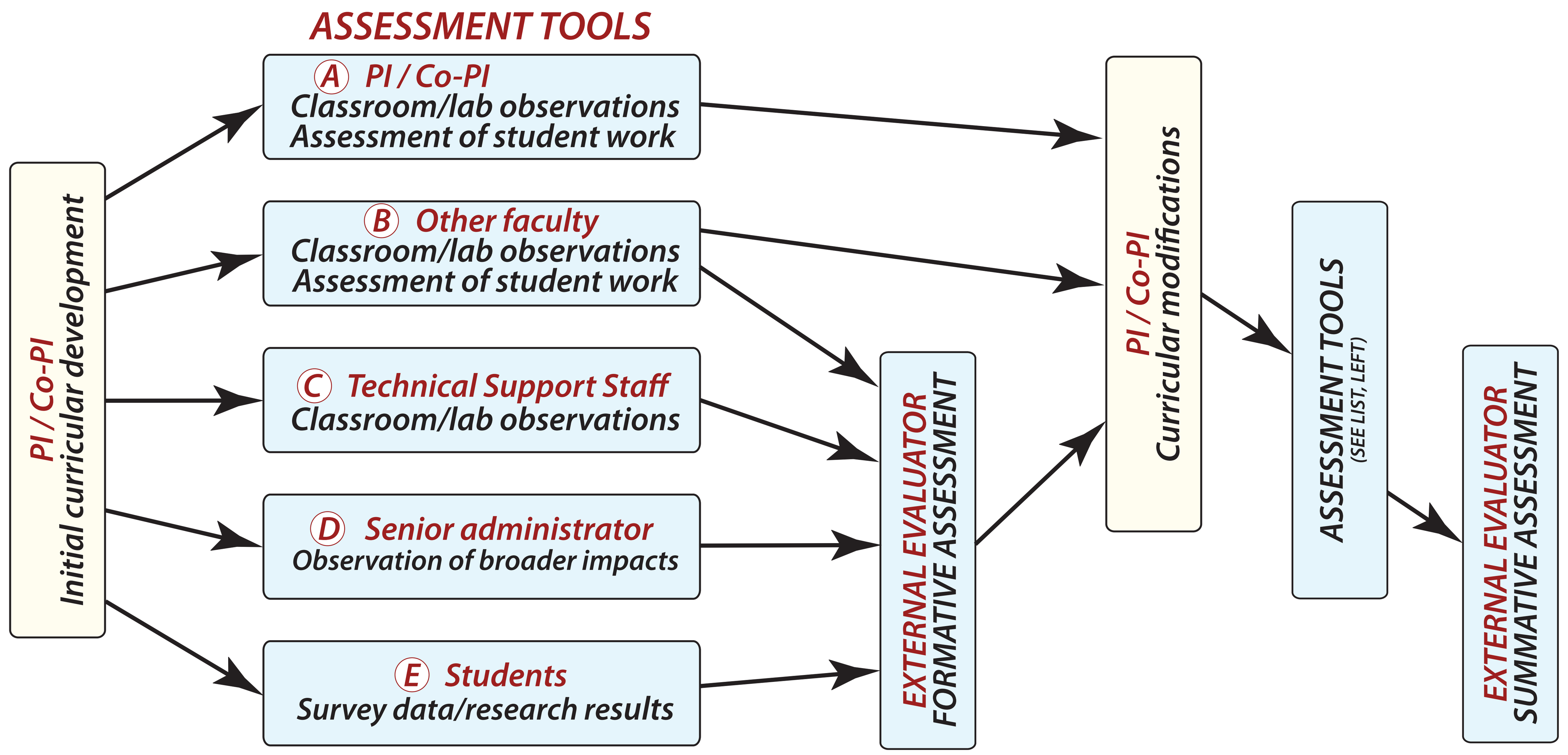
2) Finding the ideal balance between sciences skills/ knowledge and instrument use. While minimal science knowledge is required to understand basic data from insturment analysis, there are opportunities for more advanced analysis of data in the context of the way that these instruments work.

3) Increasing the time that students have to use the instruments at both introductory and advanced course levels. Students faculty, and staff all commented that this would improve overall student learning, from initial engagement to deeper analysis of scientific data.

4) **Using these instruments and ongoing grant activities to promote synergy.** Although cliche, we see obvious opportunities for ongoing project activites to provide a springboard for interaction with exisitng programs on campus, off-campus interactions, and new, related grant proposals.

PROJECT ASSESSMENT PLAN

In order to provide us the best assessment of the overall project, we decided to elicit data from a wide range of sources (see below). With a diversity of feedback mechanisms, we hoped to effectively modify existing activities/curriculum, add new activities, and evaluate our methods thoughout the project and beyond. Although the assessment framework shown below terminates with summative assessment by an external evaluator, we will continue to assess the products of the project in the future. With three years of data now available, we are confident that this structure has been effective and that this framework is easily transportable to other institutions and projects.



EXTERNAL FORMATIVE PROJECT ASSESSMENT

Assessment report structure

The external evaluator based the design of his evaluation upon the successful NSF grant proposal by Drs. Bushey and Surpless. The primary goals of his one-year formative assessment were to: 1) identify, describe, and document student, faculty, and senior administrator perceptions of student development and engagement in grant-related activities; and 2) document the early effectiveness of interdisciplinary interactions.

Pre- and post-learning Likert style questions and free response statements (see examples below) administered to students were the primary data gathering mechanism for student development and engagement. Shown as (B),(C), and (D) on the PROJECT ASSESSMENT PLAN (left), the external evaluator used interviews of faculty and staff to gather further information about student development and engagement as well as determining the effectiveness of interdisciplinary interactions.

Example statements for student survey free response:

- Good scientific data can only be interpreted in one way.
- Even when scientific investigations are performed correctly, the conclusions that scientists draw may change in the future.
- Scientific research must involve experimentation.
- What type of information can be obtained about a sample by hand-held XRF analysis?

Senior administrator perceptions

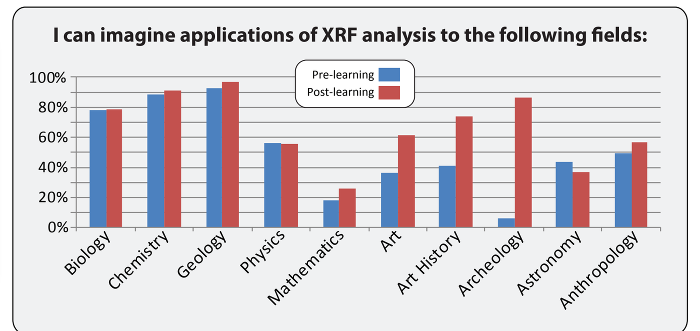
By interviewing a senior administrator who was peripherally involved in the project, the external evaluator was able to gauge the initial broader impacts of project activities across classes, departments, and at Trinity. Her most insightful observations were related to future impacts of the project on Trinity. She thought that these student-centered activities and interdisciplinary interactions would lead to a stronger Trinity education, engaging students across disciplines and fostering stronger interdisciplinary interactions in both teaching and undergraduate research. She thought these activities could provide a model for future initiatives on campus.

Faculty/staff perceptions

One faculty each from Geosciences, Chemistry, and Art (none were directly involved in the proposal process) were interviewed, and one support staff member each from Geosciences and Chemistry were interviewed to address the 2 primary goals of the external assessment report.

Student perceptions

Our external evaluator closely examined pre- and post-learning surveys that consisted mostly of Likert scale survey questions and free responses in order to determine the efficacy of grant-supported activities in promoting student engagement and learning. These responses were gathered primarily from chemistry, geology, and environmental studies classes and labs, with all class levels (i.e., first-year through senior) represented. The sample included approximately 20% science majors and 80% non-majors.

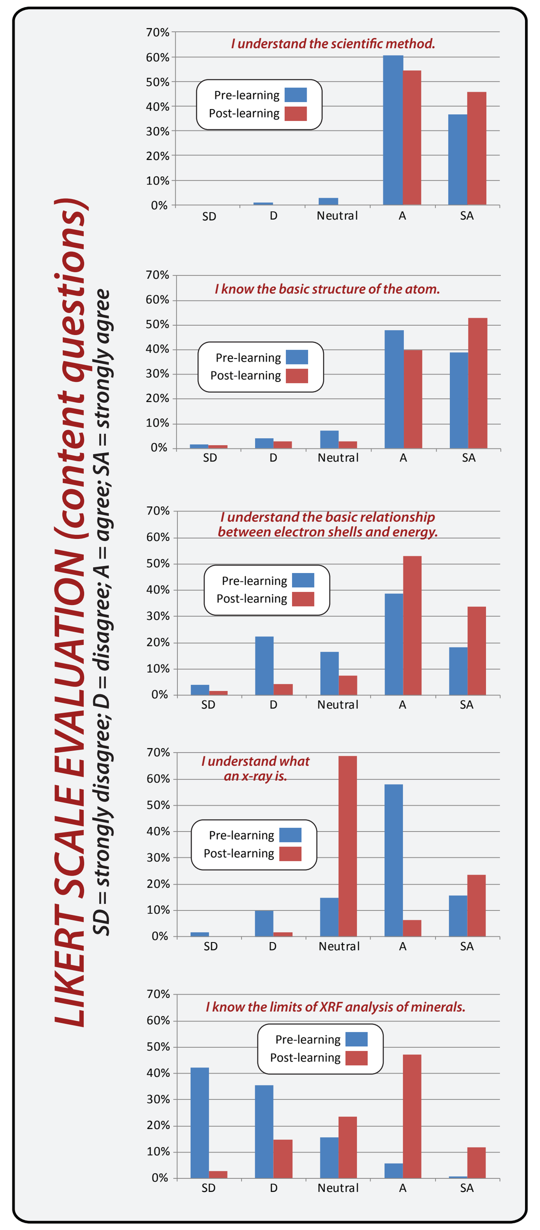


Assessment report findings

Progress toward GOAL 1: Qualitative and quantitative data suggest that grant-supported activities have more fully engaged students in the processes of science.

Progress toward GOAL 2: Based on student survey results and faculty members' professional assessment, students involved in grant-supported activities exhibit deeper understanding of elemental analysis and spectroscopy than in previous semesters.

Progress toward GOAL 3: Faculty and staff report more lab interaction and discussion between departments as a direct result of grant supported activities.



A MODEL FOR MULTI-YEAR PROJECT ASSESSMENT

As more emphasis is placed on the assessment of student learning in higher education, departments and institutions increasingly find themselves required to offer evidence of improved student learning related to courses and overall programs (e.g., Nelson et al., 2010). The assessment tools used and the frameworks for efficient and effective evaluation of learning can vary widely. Here we have provided a model that permits flexibiilty and at the same time offers opporutnities for a wide range of feedback mechanisms, through both qualitative and quantitative means, that should lead to improved student learning. Below we list what we consider to be important components of any rigorous project assessment.

1 Plan your assessment framework when the project itself is in the planning stages.

2 Maximize the number and type of assessment tools - the more data, the better!

3 Build in feedback mechanisms, including benchmark formative project evaluations.

4 Find ways to integrate assessment of project activities with existing course/institutional tools.

REFERENCES

Aikenhead, G.S., and Ryan, A.G., 1992, The development of a new instrument: "Views on science - technology– society (VOSTS): Science Education, v. 76, p. 477-491.

Bradford, C.S., 1995, Views about science – technology – science interactions held by college students in general education physics and STS courses: Science Education, v. 79, pp. 355-373.

Carpi, A., and Egger, A., 2010, The Process of Science: www.visionlearning.com, retrieved Fall 2012.

Hofstein, A. and Lunetta, V.N., 2003, The laboratory in science education: foundations for the twenty-first century: Science Education, v. 88, p. 28-54.

Libarkin, J.C., 2001, Development of an assessment of student conception of the nature of science: Journal of Geosciences Education, v. 49, pp. 435-442.

ACKNOWLEDGEMENTS

This work has been funded and supported by NSF (DUE-0942949), the Earl C. Sam's Foundation, Trinity University, the San Antonio Museum of Art, and the Daughters of the Republic of Texas, Custodian of the Alamo. Thanks also to Diane Smith, Les Bleamaster, Tony Perez, and Bruce Kaiser for aid during the execution of this initiative.