# Curriculum Improvement in Practice-based Biology Programs Using Student E-Portfolios: A Progress Report

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## PROJECT OVERVIEW

This project began with the ambitious goal of assessing student learning in our biology/biochemistry undergraduate curriculum that incorporates traditional academic coursework; experiential education, including but not limited to experiences in Northeastern University's flagship Cooperative Education Program (Co-op); and the informal education that comes with student life. Our assessment method for this project includes expert review of student work according to well-defined rubrics with performance-based standards of measurable progress toward proficiency in desired learning goals. To facilitate the assessment process, we developed a web-based portfolio system that allows students to archive their work and present it in different views for different audiences, and a web-based performance evaluation process for use by employers of Northeastern students.

## IMPLEMENTATION OF ASSESSMENT TOOLS

*Rubric Development*

For students to assess their own work and for reviewers to provide independent assessment, with the long range goal of curriculum improvement, we developed a scoring rubric that clearly identifies learning objectives and criteria as well as measurable performance-based levels of execution. The rubric development team included three employers, two academic faculty members, a co-op faculty member, an instructional designer, a graduate from the Northeastern biology program, and a graduate research assistant. Two of the employers were scientists working in the biotechnology industry, and the third was a human resource management specialist, also working in biotechnology. We included employer representatives on the team because we are particularly interested in their point of view. From previous surveys we had learned that our employers value "soft skills" such as dependability, ability to work effectively on a team, and effective communication, more highly than success in academic courses.

Over the past ten years, the Biology faculty at Northeastern University has engaged in several curriculum change initiatives, and for each of these efforts, a major task was the development of learning goals for the curriculum. The results were remarkably similar each time, leading the faculty to agree that future efforts should focus on assessment of student performance rather than defining learning goals. After collecting and analyzing information from all the initiatives, the rubric development team agreed on 21 measures, or criteria, grouped into five major learning objectives. Our aim was to develop a rubric that would translate the learning objectives of the program into behavioral measures of proficiency gleaned from student "artifacts" - examples of student work such as lab reports, evaluations of student performance on co-op experiences, research papers, slide presentations, and study abroad reports deposited into student portfolios.

*Software Development*

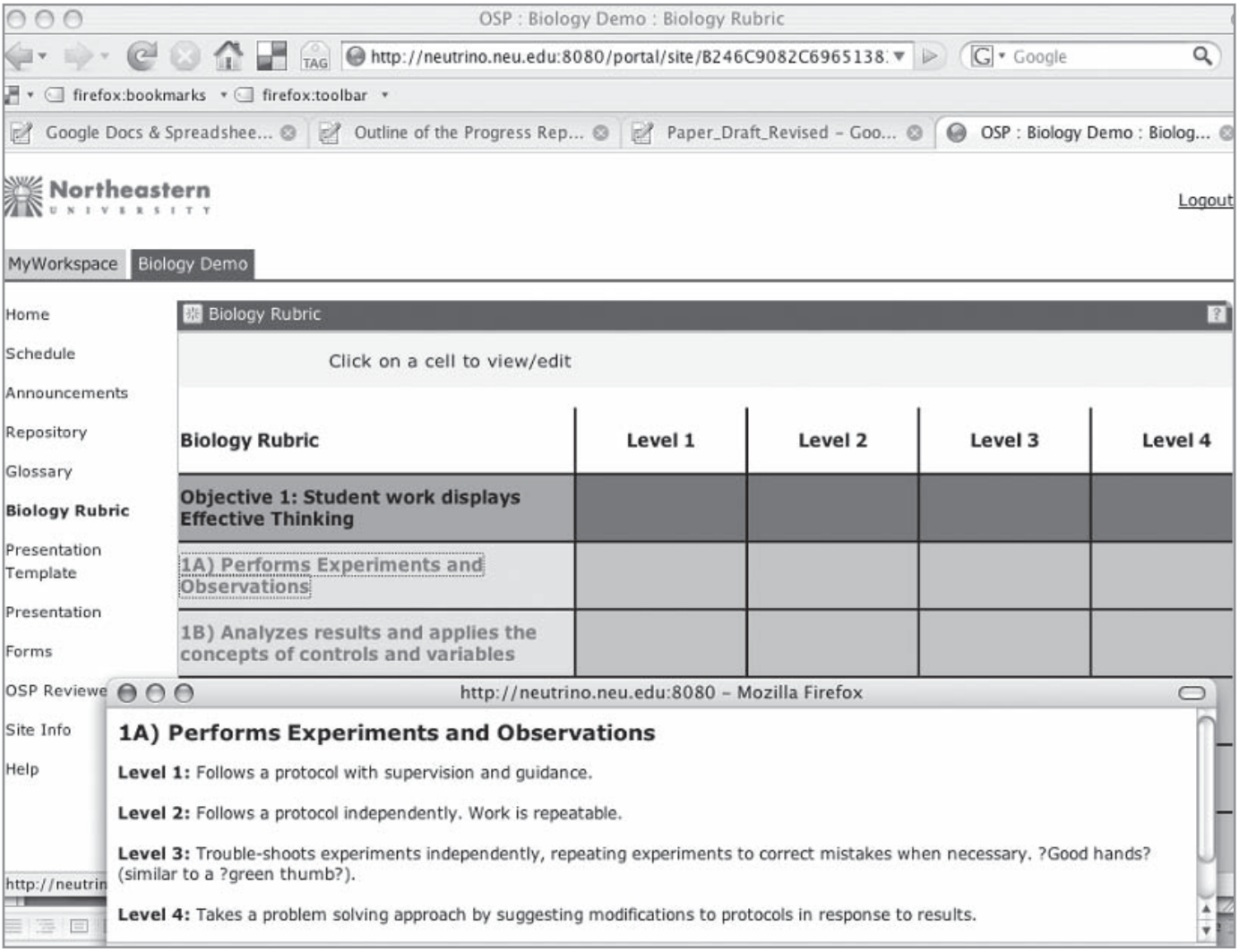
We selected the Open Source Portfolio (OSP) as our software platform for several reasons: 1) it offers features that fit well with curriculum assessment goals through the use of a rubric table; 2) it has the flexibility to

allow the student to choose different views for different audiences; and 3) we thought that using open source software would provide flexibility in customizing the solution and also provide an opportunity to assess the open source tool for wider adoption by the university. Finally, the software itself was free (although the effort required for configuration and development was significant).

The OSP 2.0.1 system used by students in this project has three primary components: a Repository, the Biology Rubric, and Presentations. The Repository is a personal storage area, with access restricted to the individual user (student). Items in the Repository may be organized in any way the user chooses using folders. Users may upload any type of file (e.g., documents, slide presentations, spreadsheets, images, movies, and pdf files).

OSP includes a matrix tool that allowed us to enter the Curriculum Assessment Biology Rubric described above. The five main objectives and associated criteria are listed in the left-hand column of the matrix. Each criterion is followed, horizontally, by four boxes representing levels of performance. When a user clicks on a criterion (e.g., "Performs experiments and observations"), a pop-up window displays the descriptions for each performance level (referred to as "expectations" by OSP) (See Figure 1).

**Figure 1. Online Screen Shot – Rubric/Student Interface**



To place an artifact in the Rubric, the student selects a file that provides evidence of meeting a specific criterion and uses the level descriptions to evaluate his/her level of performance for that criterion. The student then clicks on the appropriate rubric cell and associates the file (or files) with that cell. OSP provides a "wizard" to guide the student through a reflection process about their entry. The wizard asks the student to respond to three questions: What evidence demonstrates that you have met this expectation? Explain how your evidence demonstrates this expectation? and, How has your understanding of these criteria changed as a result of your having created the above evidence? The student's Rubric is visible to the student who created it and the instructors, but not to other students or reviewers.

OSP allows students to share their work through Presentations created using presentation templates. We created two presentation templates, written in xslt and xml, for this implementation: a Rubric Presentation and a Resume Presentation. The Rubric Presentation simply displays whatever content a student completes in his/her rubric by listing each criterion for which the student has made an entry, associated files, and the student's reflection. Rubric Presentations are updated automatically by the system to reflect any changes the students make to their rubric table. Students can choose to share these presentations with instructors, other students, and/or individuals outside the system. The Resume Presentation displays information about academic and experiential education, work history, and references. For each major section, a student may attach sample files from the repository, or links to material elsewhere on the internet. Like the Rubric presentation, the student can choose to share the resume with instructors, students, and/or individuals outside the system. The goal here was to create an *enhanced electronic resume* that the student is able to share when applying for a job or graduate school. We believe this can provide a strong motivation for student participation.

*Web-Based Performance Evaluation - Co-op Education*

For most biology/biochemistry students at Northeastern, the major source of experiential education is participation in the Cooperative Education Program (Co-op). Students earn experiential learning credit upon satisfactory completion of the three components of the Co-op learning process: preparation, activity, and reflection. During the activity component of the program, students typically spend six months in a planned career-related work experience where they have the opportunity to apply critical concepts and skills learned in class. While they are on Co-op, students are supervised and mentored by professionals in their field. Employers are expected to complete a performance evaluation for each student.

The Co-op student performance evaluation process provides employers with an effective method to assess the performance of Co-op students across multiple attributes (e.g., writing abilities, oral presentation skills, quality of overall performance). It requires active participation by students and by employers at each of three time points during the six month work experience: Goal Setting during the initial 2 weeks of employment (learning and performance goals); a Mid-Term Evaluation; and a Final Evaluation.

Early in this project, we realized that few students placed artifacts into the biology rubric that related to their experiential education. This is a serious problem for the process of assessment and curriculum improvement. In discussions, we realized that the major artifact from the Co-op experience would be the employer evaluation of student performance at the end of the Co-op period, and that this artifact was not readily available for placement into the rubric because it was handwritten.

In response, we initiated a side project using a web application to process employer evaluations. This application was designed to produce a pdf document that simulates the University-approved standard paper evaluation form. In keeping with the integrated learning model adopted by the university, our goal was to provide at least three opportunities for formal communication and feedback between the student and the supervisor during the six month Co-op period.

## PRELIMINARY RESULTS/DISCUSSION

*OSP Reporting Tool*

The greatest limitation of the OSP 2.0 software in meeting the goals of this project was a lack of tools for reporting and analyzing data across the rubric table rather than student by student. Since OSP maintains all the data in an accessible SQL database, we were able to write a web tool that: 1) Displays the number of artifacts submitted for each level of each criterion; 2) Allows an administrator to access all the artifacts submitted for a specific criterion and performance level and then assign artifacts for review; 3) Allows reviewers to access assigned artifacts and enter an evaluation level and comments; and 4) Allows an administrator to view reviewers' evaluations and comments.

*Student Self-Assessment with Portfolio System*

The students in this study were enrolled in the Biology Department "Capstone" course, developed with the explicit goal of helping students integrate and assess the concepts and skills learned from the entire curriculum, including both experiential and classroom-based components. This course is a graduation requirement for all biology/biochemistry majors. Students in each of two successive classes (spring 2006 and fall 2006) were asked to deposit at least five artifacts into the rubric table, as a whole, but were given no further instruction about which of the 21 criteria should be selected. We collected more than 500 student artifacts with accompanying reflections and self-assessments. The results from the two offerings of the capstone class were remarkably similar. Table 1 shows the distribution of artifact placement report for the fall 2006 Capstone class (N=50).

Collectively, each class addressed all criteria, but the pattern of responses is clearly not uniform. For example, we had anticipated that artifacts generated as the result of experiential education such as the Co-op program would be placed within Objective #3. Since we have now implemented the web-based performance evaluation system we expect that students in future Capstone classes will place their final evaluations (in pdf format) into their ePortfolios under this objective.

**Table 1. Summary Results: Distribution of Student Artifacts**

| | PERFORMANCE LEVEL | | | | |
|---|---|---|---|---|---|
| **Objectives and Criteria** | 1 | 2 | 3 | 4 | TOTAL |
| **Objective 1: Student work displays effective thinking** | | | | | |
| 1A) Performs Experiments and Observations | 0 | 21 | 12 | 7 | 40 |
| 1B) Analyzes results and applies the concepts of controls and variables | 0 | 10 | 16 | 3 | 29 |
| 1C) Relates biological structure and function | 2 | 0 | 6 | 4 | 12 |
| 1D) Uses an evolutionary perspective | 0 | 0 | 2 | 1 | 3 |
| 1E) Critically assesses the hypotheses, assumptions, and conclusions of others, including those from popular and scientific literature | 1 | 6 | 8 | 14 | 29 |

| | | | | | |
|---|---|---|---|---|---|
| **Objective 2: Student work displays effective communication** | | | | | |
| 2A) Connects primary lit and results from experiments/field observations | 2 | 1 | 10 | 5 | 18 |
| 2B) Presents organized experimental data | 0 | 6 | 11 | 7 | 24 |
| 2C) Writes clearly and concisely | 0 | 5 | 21 | 8 | 34 |
| 2D) Demonstrates effective oral presentation skills | 0 | 3 | 9 | 14 | 26 |
| 2E) Participates and contributes when working with others | 0 | 3 | 4 | 6 | 13 |
| **Objective 3: Student work displays a professional presence** | | | | | |
| 3A) Demonstrates time management skills | 0 | 2 | 3 | 2 | 7 |
| 3B) Displays reliability | 0 | 0 | 0 | 2 | 2 |
| 3C) Projects a professional attitude | 0 | 2 | 6 | 4 | 12 |
| 3D) Exhibits responsible and competent judgment | 0 | 2 | 4 | 1 | 7 |
| **Objective 4: Student work reflects an understanding of the social & cultural context** | | | | | |
| 4A) Considers historical, philosophical, economic, and governmental/political realities when making judgments | 0 | 4 | 11 | 5 | 20 |
| 4B) Considers consequences of development and advancement | 0 | 0 | 5 | 0 | 5 |
| 4C) Considers information in international and multicultural contexts | 0 | 2 | 1 | 0 | 3 |
| 4D) Collects, records, and interprets data responsibly | 0 | 3 | 10 | 1 | 14 |
| 4E) Identifies, analyzes, and justifies positions on ethical issues | 0 | 2 | 11 | 0 | 13 |
| **Objective 5: Student work reflects an integrated educational experience** | | | | | |
| 5A) Reflects on undergraduate experiences through writing | 4 | 4 | 7 | 7 | 22 |
| 5B) Connects ideas and experiences across disciplines and settings | 0 | 3 | 7 | 11 | 21 |
| **Total Number of Student Artifacts: 354** | | | | | |

*Student Reactions to Rubric/OSP Project*

Students were asked to comment anonymously on the portfolio assignment. Two thirds of those who commented found the assignment useful; however, many expressed doubt that it would ever be useful in finding a job. Several students commented that they were impressed by how much work they had produced. Others were quite frustrated that they had not been told about the portfolio assignment earlier in their academic career, feeling it was unfair that they were now expected to produce old material (particularly since they had experienced numerous problems with computer upgrades and disk crashes during their college careers). From our point of view, the difficulties were more imagined than real since all students were able to produce at least 5 artifacts of their work. Nevertheless, we take this concern seriously and have started encouraging students to save their work earlier in their academic careers using the new campus-wide remote electronic repository system called "Myfiles" (Northeastern's implementation of Xythostm).

*Expert Review of Student Artifacts*

To assess the need for curriculum improvement, the next step in this project was to bring together a panel of expert reviewers to evaluate the artifacts that were placed into the Biology Rubric. To date, we have completed a preliminary pilot study in which three Northeastern University biology department faculty members and two employers (scientists at the Ph.D. level) participated. The primary goal of this pilot was to obtain data about inter-rater reliability. Reviewers were asked to rate individual student artifacts and reflections, according to the criteria and performance levels set by the rubric. We were encouraged that reviewers reported that they found the web-based review process using the rubric to be straightforward.

Seven of the eight artifacts selected for the pilot study represented artifacts placed into Objectives 1 and 2, because most of the artifacts rated by students fell within these two objectives. We also selected one artifact representing Objective 3. We deliberately selected artifacts with student ratings of 3 or 4 because we wished to have reviewers rate examples of students' "best" work. Finally, we decided that each artifact would be rated by at least two different reviewers and we selected two artifacts to be rated by all reviewers.

**Table 2. Pilot Study – Student Artifacts: Expert Review vs. Student Self Evaluation**

| | Student Self Evaluation | Reviewer 1 | Reviewer 2 | Reviewer 3 | Reviewer 4 | Reviewer 5 |
|---|---|---|---|---|---|---|
| **Objective 1: Student work displays effective thinking** | | | | | | |
| *1A) Performs experiments and observations* | | | | | | |
| Student Artifact 1 | 4 | 4 | | | 4 | |
| Student Artifact 2 | 3 | | | 1 | | 2 |
| Student Artifact 3 | 3 | 3 | 3 | 2 | 3 | 2 |
| Student Artifact 4 | 3 | | 4 | 3 | | |
| **Objective 2: Student work displays effective communication** | | | | | | |
| *2C) Writes clearly and concisely* | | | | | | |
| Student Artifact 5 | 3 | 2 | 2 | 2 | 2 | 2 |
| Student Artifact 6 | 3 | 4 | | | | 3 |
| Student Artifact 7 | 3 | | 3 | | 2 | |
| **Objective 3: Student Work displays a professional presence** | | | | | | |
| *3C) Projects a professional attitiude* | | | | | | |
| Student Artifact 8 | 3 | 2 | 2 | 2 | 2 | 2 |

Table 2 shows the distribution of the artifacts among the reviewers and performance levels. The student self-evaluation ratings are included for comparison. These results suggested that inter-rater reliability was strong enough for us to proceed to a large-scale study.

**Figure 2. Distribution of Expert Reviewer Ratings independent of Objectives or Criteria**

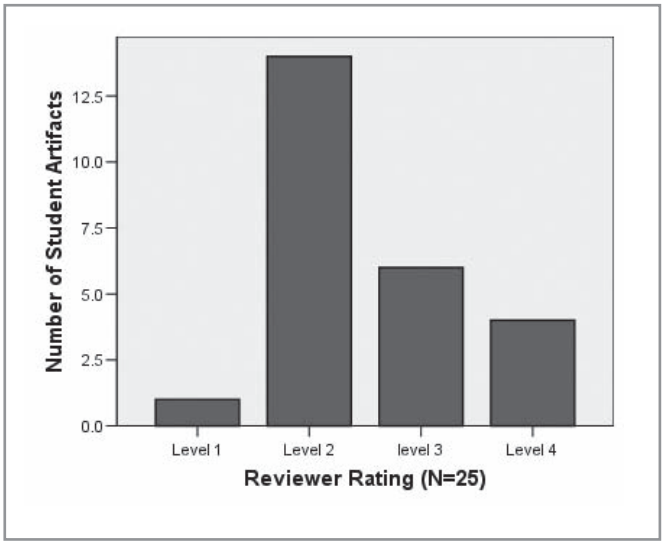



Figure 2 displays the overall distribution of performance ratings assigned by reviewers, independent of rubric objectives or specific criteria. Clearly, the expert reviewers had higher standards than the students. Although we do not intend to compare student ratings with expert reviewer ratings as a formal part of this project, we anticipated that student self-assessment ratings would be higher than those of the expert reviewers and were not surprised with this finding. Before this pilot we had some concerns that the distribution of expert ratings would not use the whole scale. So far that does not seem to be the case.

*Web-Based Co-op Employer Performance Evaluation*

The web-based performance evaluation process has resulted in many advantages for students and employers. It provides a centralized repository accessible to students and employers. It is available to students for use in building electronic portfolios to share with others (e.g. prospective employers), eliminates hand-written paper forms, and eliminates the possibility of lost or misplaced forms.

**Table 3. Participation in Web-Based Performance Evaluation Process**

| | Spring 2006 | | Fall 2006 | |
|---|---|---|---|---|
| | Percent Compliance | Number of Students | Percent Compliance | Number of Students |
| **Goal Setting** | 10% | 8 | 45% | 39 |
| **Mid Term Evaluation** | 10% | 8 | 43% | 37 |
| **Final Evaluation*** | 84% | 69 | 92% | 80 |
| *[* Submitted within 30 days of end of Co-op Period]* | | | | |

Interestingly, we have seen tremendous improvement in employer compliance in the submission of completed evaluations, as well as a substantial improvement in the time it takes for employers to submit completed evaluations after the Co-op period ends. As Table 3 shows, the return rate of final evaluations within 30 days of the end of the Co-op period was 84 percent for the spring 2006 Co-op period and 92 percent for the fall 2006 period. In prior years, it was not possible to document compliance with all three phases of the performance evaluation, but anecdotal reports suggest that it was spotty at best. The dramatic improvement in fall 2006 participation rates compared with the spring 2006 rates for Goal Setting and Mid-Term Evaluations lends support to the anecdotal reports and suggests that participation will improve as the users become more comfortable with the system. With paper forms, even with frequent reminders to the student and denial of credit for non-compliance, the typical rate for submission of the final evaluation form within 30 days of the end of the Co-op period was less than 50 percent.

**Table 4. Co-op Employer Ratings - 10 Attributes (N=158 Students)**

| Attribute | Not Meeting Standard | Approaching Standard | Meets Standard | Exceeds Standard |
|---|---|---|---|---|
| Job Performance Level | 0 | 9 | 51 | 99 |
| Verbal Communication | 0 | 4 | 73 | 81 |
| Written Communication | 0 | 11 | 78 | 68 |
| Problem Solving Skills | 0 | 11 | 84 | 62 |
| Interpersonal Skills | 0 | 3 | 46 | 110 |
| Use of Technology | 0 | 4 | 96 | 57 |
| Professional Ethics | 0 | 0 | 77 | 82 |
| Professional Behavior | 2 | 8 | 69 | 80 |
| Work Ethics | 0 | 12 | 44 | 103 |
| Level of Supervision | 1 | 6 | 52 | 100 |

With the implementation of web-based performance evaluation, we are able to easily assess student performance data across ten attributes, which were previously identified by Co-op employers as key indicators of workplace success. The combined results of the spring and fall 2006 Co-op terms are presented in Table 4. It seems apparent from the pattern of responses that Coop Employers are very satisfied, in general, with the level of performance provided by Co-op Students.

**Figure 3. Co-op Employer Ratings – Select Attributes**

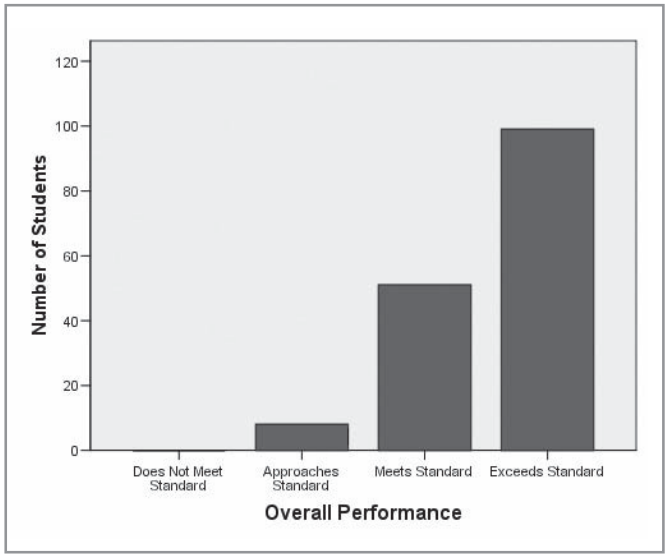



*Figure 3A*

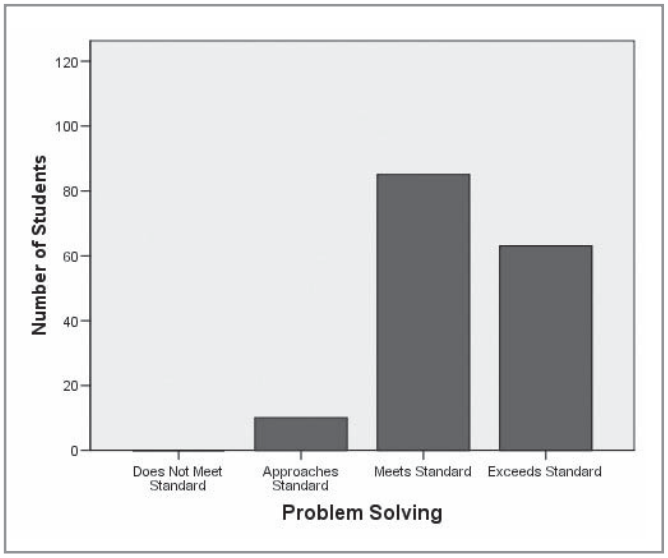



*Figure 3B*

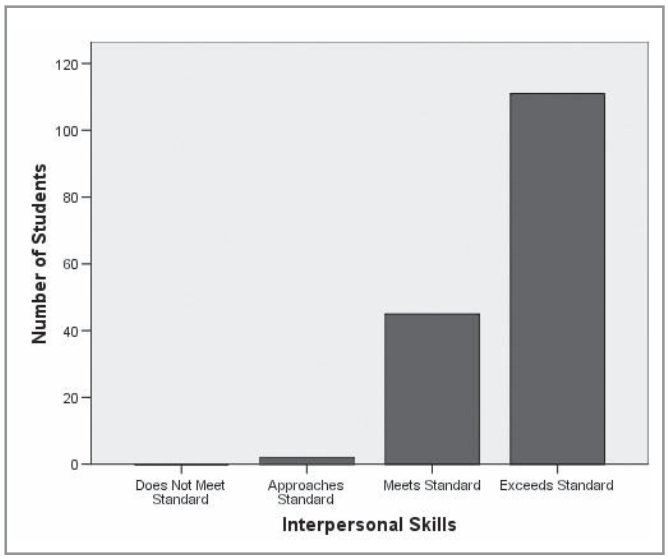



*Figure 3C*

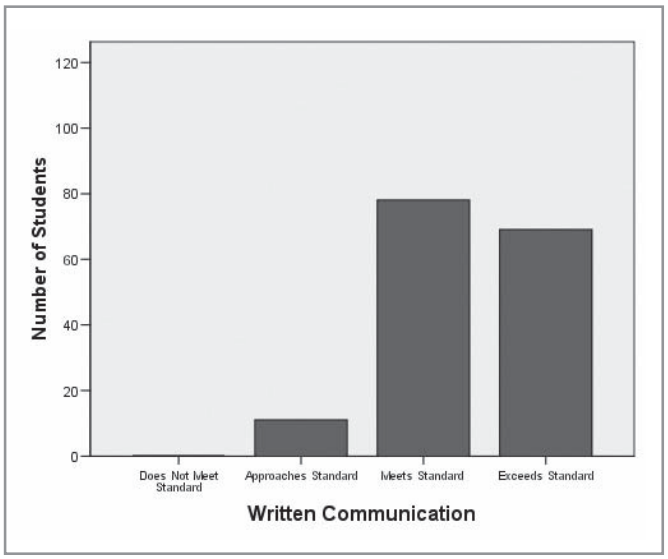



*Figure 3D*

However, further observation of these results, as shown in Figure 3, indicates that employers do evaluate students with deliberation, not just "sing their praises" indiscriminately. Although most students are rated as exceeding the standard for overall performance and interpersonal skills, they did not score as well in such areas as written communication and problem solving. Chi Square analysis, comparing employer scores for written communication and problem solving, using overall student scores as expected values, demonstrated that these differences were statistically significant ( written communication: Chi Square= 24.89, 2 df; p<.001; problem solving: Chi Square= 36.42, 2 df; p<.001. Chi Square analysis comparing employer scores for interpersonal relationships against scores for overall performance indicated no significant differences, as was expected.)

## LONG TERM GOALS

*Rubric Assessment*

The success of our initial pilot has given us the confidence to scale up the expert review of student artifacts. We have increased the number of expert reviewers and the number of artifacts for each reviewer. We

will continue to look at measures of inter-rater reliability as well as intra-rater reliability among the artifact ratings. We continue to see this review as a formative tool for curriculum improvement rather than as a graduation requirement for students.

An emphasis on writing in subject classes has become an important part of the new university-wide core curriculum implementation at Northeastern University. The Biology Department has designated certain courses as writing intensive and has agreed to make a major effort to develop writing assignments for the laboratory component of these courses. Results from our expert review will inform these efforts and, in turn, we will use the student portfolio/expert review system to assess the results.

*Co-op Employer Evaluation*

Although the current web-based process has resulted in substantial improvement in employer participation and provided better access to evaluation data, there is an opportunity to focus future work in this area on developing performance-based criteria for the work attributes that are important to employers.

*Student Reflection*

As the project progressed, the importance of the reflection process became apparent. The OSP architecture permits students to reflect upon their work when the work is placed into the Rubric. Students in the spring 2006 class struggled with this assignment, because they were not quite sure what was expected. For the fall 2006 class, we provided written guidelines for student reflection. We observed that students were able to complete this assignment with less difficulty. Because some of the student artifacts did not represent recent work, we began looking at the potential benefits of students reflecting upon their work as it is finished. Therefore, we plan to encourage faculty to require students to write a reflection piece on major assignments when they are completed and to store their work and reflections in the Myfiles repository. This effort will certainly facilitate portfolio building in subsequent years. We hope it will also help to create an atmosphere in which students value their past work and realize that it is worth saving after the semester is over and they have received a grade.

When students return from Co-op, they have individual meetings with their Co-op Faculty Coordinators, providing an opportunity to compare and contrast employer performance evaluations and student self evaluations, and discuss them from the perspective of academic and career goals. Student are expected to prepare post-meeting written reflections about what was discussed at the meeting and during his/her Co-op experience, after which, all three documents are deposited in the Myfiles repository. We expect that this process will lead to more artifacts from experiential education being included in future e-portfolios.

*Implications for Student Learning and Curriculum Development*

Student electronic portfolios that are managed using a powerful database can provide a wealth of data on student learning in various settings. Using expert review of student artifacts as an assessment tool we have just begun to process data we have collected over the course of a single academic year. We have already identified and acted on the need for more communication with Co-op employers and we can extend the web-based employer evaluation system to students in other experiential education settings. The Biology Department will use the methods developed in this project to assess the changes in instruction required by the new core curriculum that will start at Northeastern University for students entering in fall 2007.

*For those who would like to have "hands-on" demonstration of our instance of the OSP Portfolio System, we have a live demo site you may visit http://neutrino.neu.edu:8080/portal. (Log in with user id "biology". The password is "demo". After the site opens, click on the "Biology Demo" tab.)*