Abstract for

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Title:

"The Integration of Academia and Workplace Competencies through Systematic Development of Measurable Assessment Criteria"

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Abstract

At Northeastern University in Boston, Massachusetts, U.S.A., we are bridging the gap between classroom and field learning. Through systematic integration activities we are attempting to combine and measure what often seems to be dual competency expectations: one academic and the other industrial.

The presenters will discuss their efforts in Computer Science to develop measurable competency criteria using rubrics. These rubrics are sets of categories that define important components of work being assessed. Each category contains levels of competence with a score assigned to each level and a clear description of the criteria at each level. The rubrics are derived from the college's educational objectives (technical and non-technical,) and are based on the presenters' previous five years of assessment research.

Focus groups consisting of faculty, employers and students were called together to refine the rubrics, which are part of a move toward developing on-line portfolios. Rubric examples and the steps to create them will be presented.

Presenter

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The Integration of Academia and Workplace Competencies through Systematic Development of Measurable Assessment Criteria

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Introduction

Computer scientists create the software tools which have fostered the shift toward a knowledge-based society. Ubiquitous computer technology and its increasingly complex software, have far reaching effects, beyond the halls of academia, in which computer scientists are educated. Because of its impact on the broader society, the education of computer scientists is central to the shift to a knowledge based society.

There is a plethora of research on predicting performance and success of students majoring in computing and there are many articles written on the academic integrity and program objectives for cooperative education. However, little effort has been expanded to measure and integrate computing classroom and out-of-classroom competencies. The Department of Cooperative Education, in collaboration with the College of Computer and Information Science at Northeastern University in Boston, are trying to bridge the gap that exists between learning in the computing classroom and field learning. Through systematic integration activities, we are attempting to combine what often seems to be dual competency expectations: one academic, the other, industrial. In spite of the potential philosophical conflicts arising between industry and academia, it is nonetheless crucial to develop channels of communication. There is a breadth of new writings and research reflecting the importance of providing a seamless experience between the classroom and out-of-classroom curricula. To support our believe that outside classroom learning is important, we reference the work of George Kuh (1997). Kuh has documented "that what students do outside the classroom influences what and how much they learn (see Astin 1993; Baxter Magolda 1992; Chickering and Reisser 1993; Kuh 1993, 1995; Kuh et al.1997, 1991; Pascarella and Terenzini 1991; Terenzini, Pascarella, and Bimling 1996)".

Purpose

This paper will discuss the implementation phases of an ongoing assessment process applied within Northeastern University's College of Computer and Information Science (CCIS), where students are required to engage in alternating periods of classroom learning and outside "experiential" learning experiences (co-op). The first phase of the project was to determine, using author-developed survey instruments, where CCIS students perceived that they acquired some of their computer knowledge and/or skills (the classroom or co-op). Phase two again surveyed the students, and this time added their supervising co-op employers. Phase three surveyed students, employers and computer science faculty. Phase four saw the development of a new experiential on-line evaluation which was completed by both students and their employers. Phase five, the current phase of this project, is the development of rubrics based on college curriculum objectives. Faculty, employer, and student focus groups are involved in on going activities; the progress of this phase will be discussed later. The ultimate goal of these assessment efforts is to develop measurable criteria which can then be applied to electronic portfolios, which will be used as an overall measure of students' learning throughout the five-year curriculum.

Our current efforts to develop measurable competency outcomes are focused on the development of rubrics. These rubrics are sets of categories that define and describe the important components of the work being completed, critiqued, or assessed. Each category contains a gradation of levels of completion or competence with a score assigned to each level and a clear description of what criteria needs to be met to attain the score at each level (Rogers, 2002). A number of focus groups, consisting of academic faculty, employers and students, have been called together to develop the rubrics. These rubrics, supported by the theoretical and conceptual framework of learning theory, were derived from the college's educational objectives and are based on our previous five years of research.

Theoretical and Conceptual Framework

The investigation of student learning has been the focus of many discussions at the university level. Recently, the emphasis has been on how to improve classroom instruction using knowledge of how students learn. As a result of this dual emphasis, assessment of student learning outcomes has become a central component of curriculum development.

Although the classroom teacher may assume they have control of the teaching and student learning, the student should have control of their own learning. Wiggins (1997) states, "It's not teaching that causes learning. It's the attempts by the learner to perform that cause learning, dependent upon the quality of the feedback [what was done or not done] and opportunities to use it [feedback]." This implies that, as educators, we should be aware of how students learn and then facilitate the process. In trying to better understand and facilitate the quality of learning, we approach the student learning process by understanding the integration of the classroom and the out-of-classroom experience. Our research (during phases one two and three), shows clearly that students, faculty, and employers all believe that valuable learning takes place for the student during the experiential component of the curriculum, as well as in the more traditional classroom setting. Initially the assessment of this learning was based on self-reports and our goal is to move toward more objective criteria.

We have developed our conceptual construct using cognitive field theorist views on learning as the psychological process through which insightful behavior is developed. This process involves the ways in which each individual selectively perceives his/her physical and social environment. A learner perceives an object if it is relevant to his/her purposes. Sensing and finding meaning occur simultaneously as a result of the person's purposes. The psychological environment of a student is made up of his/her unique perceptions. The theory that learning is a relativistic process has emerged out of the Gestalt field concept (Kohler, 1971). In the psychological field, all objects modify one another reciprocally; objects have meaning only in relation to other objects, subject to the person's psychological interaction (Bigge, 1962). As the person's perception changes, the construct of the field is likewise altered.

Weinstein and Meyer, (1991) in their discussions of *Cognitive Learning Strategies and College Teaching*, emphases the importances of understanding that learners use a variety of cognitive processes to take in and process information and make it available later. Accessing information at a later date supports our belief that theory presented in the classroom may not be applicable immediately to the non-classroom learning environment until a student perceives the need. Students using knowledge learned at any undocumented time, creates the need to be able to assess those cognitive processes with methods not as appropriate as traditional classroom assessment procedures. The method to be used in the documentation of the out-of -classroom learning is the rubric structure. Providing students with a well define criteria will allow students to better document their learning outcomes and learning styles which supports our goal to facilitate a seamless curriculum encompassing the classroom and non-classroom activities.

The Context

We want to take a moment to place our current rubric development project into perspective. Although it is the fifth phase of our research in learning outcomes in CCIS, the development of the rubrics is the first task in a larger project that is being funded by the National Science Foundation in Washington, D.C. The larger project is entitled: *Curriculum Improvement in Practice Oriented Biology and Computer Science Programs Using Student Portfolios* (Kostia, Porter, Simms, Proulx, 2002)**.** This curriculum improvement project is intended to move the assessment of practice-oriented science education from indirect to direct measures of student learning. Northeastern University is a major research university with a long tradition of practice-oriented education. Through its well-established cooperative education program, most students alternate periods of full time course work with periods of full time paid employment relevant to their major. Even in on-campus settings, science education has moved beyond the traditional classroom, where instructors maintain direct oversight over students, to include new forms of lab instruction, collaborative research projects, and independent study. These other new forms of instruction as well as the cooperative education model both raise questions about what is learned in each setting, how the acquired skills can be assessed, and how this learning can be integrated into the overall curriculum.

Development of rubrics to evaluate student learning in different settings has facilitated discussions among academic faculty, co-op faculty, employer supervisors and students. Once rubrics for all learning outcomes have been created, the next task will be the design of the portfolio. The portfolio system will follow the recommendations of the rubric development teams and be piloted during the third year of the project. During the last two months of each year, the project team will review progress by consulting with curriculum committees, employer groups, student groups and an Advisory Committee formed for this project. After the final evaluation the results will be disseminated to the University Community and to the wider audience of scientists and educators.

Research Plan

The creation of rubrics has followed current practices in the area as outlined by Moskal, (2000), Herman, Aschbacher and Winters (1992), and the materials developed by many K-12 systems, including that of the Chicago Public Schools (2000). As the literature emphasizes, to develop a scoring rubric, we first identified the learning objectives to be assessed. This complex process was begun by CCIS faculty as part of a curriculum re-design. Now that the learning objectives are in place, the rubric team [Mel Simms, Mark Erickson and Viera Proulx (Computer Science faculty member)] has expanded the process by beginning to develop preliminary standards (rubrics) for levels of student performance for each of the learning objectives. The first rubrics in Computer Science are based on the "Programming" and "Communications and Learning" objectives of the college.

As part of the rubric development process, we are creating specific criteria to rate each the student on each learning objective. Students will be rated using a 5 levels model of attainment: novice, advanced beginner, competent, proficient and expert (Dreyfus & Dreyfus, 1986)

We are using focus groups consisting of students, faculty, and employers to assess and revise the first set of rubrics. Once the rubrics are completed for all learning objectives and revised with input from the focus groups, we plan to test these preliminary standards for utility by applying them to actual examples of student work in Computer Science. On the basis of this reality check, the standards will be refined and consolidated to best reflect the actual work that students create in the classroom, in field experiences, and on co-op employment. Student input is essential at this level to understand and include their perspectives on how they develop and express their learning. These activities have been and will continue to be the focus during the next two years.

Rubric Development

An example of the rubric development in Computer Science using the Programming Skills Objectives is described below. For each of the five aspects of programming, we have applied our five steps of development from novice to expert. Faculty, staff and students have provided initial input during the focus groups, and will continue to provide feedback as the rubrics are further refined. We established a point system which was applied to each component of the skill at each level. In addition, student focus groups will be asked to either provide and/or suggest possible work examples that they might apply in verifying the accomplishment of the skill. The following is a sample learning objective, programming, which was discussed in the first series of focus groups. Other skill objectives will be developed the next year.

Example-Programming Skills Learning Objective
http://www.ccs.neu.edu/teaching/Curriculum/objectives/ProgSkills/index.html

We define five aspects of programming that all students should master:

Program synthesis
- solve small "pattern" problems
- write programs about 250 lines long
- recognize common operations

Program analysis
- use abstract data types
- identify bugs in a small program and fix them
- identify the scope of an identifier
- correlate assignments with potential uses of the value assigned
- write a conditional dispatch
- formulate the post-condition of a while loop
- identify the base and recursive cases of a simple recursion
- hand simulate a small piece of code

Program design
- select appropriate structure from alternatives
- use a standard structure and adapt it
- evaluate the costs and benefits of using structures and algorithms
- use some sophisticated techniques

Program composition
- define requirements and produce specifications
- knowledge of tools and environments
- higher level programming components
- work in a team

Program assessment
- measures for assessment of programs
- apply the techniques for assessment
- certifying the program quality

Rubric Development Recommendations

Rubric Criteria	Process for Rubric Development	Student Use of Rubrics
One page in length. Limited professional jargon. Based on professional standards. Based on institutional outcomes.	Select relevant faculty. Identify concepts and supporting outcomes. Develop performance levels.	Provide clear statement of expectations. Self-assessment of performance. Goal setting. Peer evaluation of draft projects.

Specific example of a rubric: programming synthesis

For each five aspects of programming,
We apply our five steps of development from novice to expert.

Skill Level	program synthesis
Expert Context-free and situational. No longer relies on analytical principle. Demonstrates deep understanding of situation	Solves small "pattern" problems with ease. Writes excellent programs of 250 lines. Recognizes common operations and easily names these operations with little or no hesitation. 8 - 10 pts.
Proficient Context-free and situational. Begins to make decisions rather than merely following rules. Hones in on accurate region of problem.	Solves small "pattern" problems with reasonable ease. Writes good programs of 250 lines. Recognizes common operations and easily names these operations. 6 - 7 pts.
Competent Context-free and situational. More experience acquired. Senses what is missing. Sees actions in terms of long-range plans.	Able to recognize common operations. With time is able to write program. Ability in solving small "pattern problems acceptable. 4 - 5pts.
Advanced beginner Context-Free. Performance improves to a marginally acceptable level. Recognizes elements when present. Perceives similarity with prior examples.	Has some difficulty recognizing common operations. Limited difficulty in writing program. Improved ability in solving small "pattern problems. 2-3 pts.
Novice Context-Free – Recognized without reference to situation acquisition of new skill. Recognizes objective facts and features. Actions based on fact and features	Has difficulty recognizing common operations. Difficulty in writing program. Limited ability in solving small "pattern problems. 0 - 1 pts.

Five Steps of Skill Development (Dreyfus & Dreyfus, 1986) and (Benner, 1982)

As the rubric team works to arrive at the standard to be used to rate a student's ability, we will continue to grapple with the questions such as: What does a learning objective mean in behavioral terms? What are the standards by which a student would be deemed to have demonstrated satisfactory or superior ability in this area? Would multiple examples of such performance be needed? Would there need to be evidence of a student being able to do this without direct guidance from a faculty member or a co-op supervisor? Would the standards for work done in an on-campus lab be different from the standards for work done on a cooperative work assignment? To what extent, if any, does the students' data presentation need to be "independent" in contrast to being the result of multiple revisions and feedback from others?

Task Outline

- Task 1 – Creation of working groups
    - Formation of employer/faculty groups (completed)
    - Initial agreement on learning goals ((Learning goals have been developed by the faculty – employer and student feedback is being collected.)

- Task 2 – The Rubrics
    - Development of rubrics (in progress)

        - Initial development from learning goals (in progress)
        - Use of student and employer focus groups for feedback and revision (in process)
        - Continued collection of student work (to begin shortly)
        - Comparison of rubrics and student work
        - Iteration of rubric development process
- Task 2 - Database Design (year 2)
    - Design of database system to maintain portfolios
- Task 3 - Portfolio Pilot and Evaluation (year 3)
    - Testing of system with 200 students per unit
    - Evaluation of robustness of technology
    - Evaluation of a sample of materials

Findings
Participants in the first focus group for rubric development were quite positive about the process we have undertaken and are willing to keep working with the task force. Employers and faculty, for slightly different reasons, are interested in what students know and what they learn in both classroom and non-classroom settings. Participants seemed to agree that the use of a portfolio to document student learning could be valuable for students, for faculty, and for employers. One of the results of the first meeting was a better understanding on the part of the employers about the CCIS curriculum details and the skill sets of our students, which some employers had tended to underestimate prior to co-op employment.

There is a dynamic tension between the need for a specific assessment with detailed information and the employer's wishes for simplicity and ease of documentation. Employers understand that student learning is a driving force behind co-operative education, but also state that it is not their primary objective. Understandable, they desire a system that will be easy to use and relatively simple for them.

One of the most conceptually interesting but operationally complex possibilities to emerge from the focus groups would be that each student would not be rated or evaluated on all of the learning objectives at the end of their co-op term, but rather on the ones which match the skills required for their particular position. To accomplish this, once the rubrics are in place, each job could be rated according to the skills which are most likely to be used for the position and a specific set of student learning goals could be established early in the coop process. Then, if the employer and student documented only these selected goals, they would be working in depth from a smaller more manageable set of rubrics. While this is an intriguing possibility which we will pursue, it would be extremely difficult to integrate within the existing co-op information database structure and operations.

The rubric team continues to be faced with finding ways to measure students' level of mastery of such content areas as program analysis. How well do students use abstract data types? How readily can they identify bugs in a small program and fix them? Can they optimize a program and document their success at this crucial task? How well can they evaluate the benefits and costs of using particular data structures and algorithms? How much difficulty do they have in generalizing from class examples to full-scale programs?

In addition to these technical skills, CCIS's general learning objectives also include non-technical skills, effective written and oral communication, creative thinking, and ethical-professionalism. We are also in the process of developing rubrics for each of these areas.

We continue to conduct brainstorming sessions with the rubric development task force as we continue to define the expected content of the portfolios. These discussions are providing examples and guidelines that will suggest ways and materials that can be used to document and demonstrate achievement of various levels of proficiency in the learning goals of students' programs.

As we develop the rubrics, we continue to survey work supervisors, as mentioned above, to learn the strengths and weaknesses of students on the job. These surveys are being used to improve the rubric development, but it continues to be difficult to receive feedback from employers in a timely enough manner to use this information to better integrate students' strengths and weaknesses into the courses students take immediately after their co-op assignments. We still struggle to provide the academic faculty with timely information before the portfolios are ready for faculty review. For the moment we continue to refine the rubric development process.

Summary

Our effort in developing rubrics is the first stage of a larger project intended to move the assessment of practice-oriented education in computer science from indirect to direct measures of student learning. Rubrics for other learning outcomes will be completed during the 2003-2004 academic year. This paper has reported on the progress in rubric development in the computer science portion of the total project. The larger project is the creation of a carefully crafted portfolio as a vehicle through which students will present direct evidence of attainment of program learning goals. The creation and maintenance of a performance-based portfolio is intended to become an active part of computer and information science and biology students' learning experiences at Northeastern University. The completed project will provide our students with a forum to present what they know. Last but not least, we'd like to say that even though the portfolio is a large portion of our student learning assessment process we also incorporate other traditional experiential assessment tools such as: reflective seminars, on-line surveys and evaluations. Through the development of rubrics and usage of the electronic portfolio we hope to provide the students, employers and faculty the widest range of examples of the student learning and accomplishments. The development of this latest stage of assessment (the rubrics) continues to improve the communications network connecting academic faculty, co-op faculty, employers, students which will foster further academic and co-op integration.

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