Developing Assessment Tools for Identifying "Where Do Computer Science Students Learn and Use Computing Skills – Classroom and/or Workplace?"

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Abstract – In a comprehensive degree program which combines in-class learning with professional development, there is concern about the significance and validity of experiences gained outside of the classroom. The Department of Cooperative Education at Northeastern University, in collaboration with the College of Computer and Information Science, has continued to refine its assessment of whether computer science students acquire their computing and professional skills in the classroom and/or workplace. The foundation of this assessment was derived from the College of Computer and Information Science's Educational Objectives. These educational objectives fall into the following two content areas: Technical Objectives and General Learning Objectives.

In refining the assessment and documentation of the practice-oriented component of the curriculum, the faculty members who oversee the experiential learning process in the college developed and implemented the following four sets of assessment instruments:

1. The student version of the instrument was designed to determine where computer science students learn and use 52 identified skills.

2. An employer/technical supervisor version of the instrument was developed to survey their perceptions of co-op students' skills, level of proficiency, whether each skill is obtainable through the company's co-op assignment, and the importance of the skill.

3. A third instrument was deployed early in 2001 to reassess the perceptions of computer science faculty members.

4. The fourth assessment instrument, deployed in early 2002, combined the student and employer evaluation of the experiential learning period.

This paper discusses the development of the four instruments and outlines some of the implications for future assessments. The implementation of this ongoing assessment project has improved the communication bridges between academic faculty and cooperative education (co-op) faculty. It has also led to a conceptual shift in the relationship between the academic and the co-op portions of the curriculum.

Introduction

Assessing student learning both within the classroom and outside of the classroom is a matter of increasing concern to practice-oriented and cooperative ("co-op") educators. Educational administrations require the development of elaborate procedures to verify learning outcomes. The Association for Computing Machinery's (ACM) Computing Curricula 1991 [13] suggest requirements to aid educators in the standardization of learning objectives and in the development of appropriate assessment tools be esablished. Developing such tools has been an ongoing project at Northeastern University for a number of years.

Assessment methodologies and goals have shifted significantly over time as research has revealed new details of the learning process. Traditionally in computer science, the classroom teacher has controlled the assessment process through activities such as regular testing and various programming exercises. It has more recently become recognized at the college level that student learning not only occurs during classroom-directed activities but also during activities outside the classroom. Wiggins [15] 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 and opportunities to use it [feedback]." This implies that educators should be aware of how students learn, and then facilitate the process. Weinstein and Meyer, [16] in their discussions of *Cognitive Learning Strategies and College Teaching*, emphasize the importance of understanding that learners use a variety of cognitive processes to take in and process information for later availability and use. The process whereby students access information at a later date supports the belief that theory presented in the classroom may not be immediately applicable to the non-classroom learning environment until a student perceives the need. The fact that students use knowledge learned in the classroom during undocumented outside time creates a need to assess those cognitive processes with methods other than traditional classroom assessment procedures.

There is a breadth of extant writings and research which reflect the importance of providing a seamless mesh between in-classroom curricula and out of classroom experience. George Kuh [6] has asserted "that what students do outside the classroom influences what and how much they learn [1,2,4,7,8,9,10,11,12]".

This paper will discuss the implementation phases of an ongoing assessment process applied within Northeastern's 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, from 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, the latter by means of a pilot survey. Phase four (the most recent phase) saw the development of a new experiential evaluation which was completed by both students and their employers. Initial findings and results of these completed phases will be presented in the following sections.

Phase five of this ongoing project will include the development of rubrics based on college curriculum objectives. Faculty, employers, and student focus groups are currently being established; the progress of this phase will also be discussed in this paper. 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.

Background

Development of an instrument to assess students on where they acquire their computer science skills/knowledge began in the mid 1980's. Serious discussion began in the fall of 1996 when visiting professor Dr. Steven W. Rauch from the University of New Brunswick, in Canada, came to Northeastern. In collaboration with the authors of this study, initial discussion began on the philosophy and ideology of how students learn, and how they might apply the knowledge gained both in the classroom as well as during their scheduled structured work experiences.
A summary of the project evolution follows:

1996/7 First skills lists using "Skill Assessment" section in 1992 ACM publication [14] was developed.
1998 Piloted 10-page student survey list to graduating seniors.
1999 Issued a 2-page paper version of the assessment tool. Data analyzed.
2000 Results shared with college faculty in April. In June, a revised student survey was posted online and in October, an employer version of the assessment tool was posted online.
2001 In February, a faculty survey was developed and administered.
2002 (In progress) Student and employer experiential evaluation forms have been developed.
2002 (In progress) Data being collected and analyzed.

The Assessment Survey

The survey instrument contained a series of skills/knowledge areas.

For each skill/knowledge area students were asked to provide information concerning their **EXPOSURE** to the skill, their **PROFICIENCY** level and their estimation of the **IMPORTANCE** of the skill/knowledge area. Exposure, Proficiency and Importance were defined as follows:

EXPOSURE:
Where students were exposed to a skill (e.g., school or co-op or other place)
PROFICIENCY:
Self-defined level of attainment, determined as follows (students were asked not to check any proficiency level if there is NO knowledge and NO experience):

> NOVICE - having elementary knowledge of the skill/knowledge area, with SOME experience
> PROFICIENT - being competent to recognize the appropriate principle and apply the skill/knowledge. Having REASONABLE experience with the skill/knowledge area.
> EXPERT - having EXTENSIVE experience with the skill/knowledge area or the ability to connect an appropriate situation to an appropriate action without conscientious reference to an analytical principle. [5,3]

IMPORTANCE:
Self-defined value of the skill (e.g., None [not important], somewhat important, important, not sure)

The Assessment Instrument – Skill Categories

The most recent version of the assessment tool contains 18 categories and 52 measured elements of skills/knowledge. Each skill/knowledge element was assigned a number. The following is the skill/knowledge identification numbering:

Section	Skills	Skills/Knowledge Areas
See separate .pdf Appendix for numbering usage.		
I	(1-5)	Programming
II	(6-8)	Programming Languages
III	(9,10)	Discrete Structures/Theoretical
IV	(11,12)	Complexity and Algorithms
V	(13,14)	Architecture
VI	(15–18)	Operating Systems
VII	(19-20)	Computer-Human Interaction
VIII	(21-23)	Graphic, Visualization and Multimedia
IX	(24-25)	Intelligent Systems
X	(26-27)	Information Management
XI	(28-31)	Net-centric Computing/Networking
XII	(32-33)	Software Engineering/Methodology
XIII	(34-35)	Computational Science
XIV	(36-40)	Non-Technical
XV	(41-45)	Creative Thinking & Problem Solving
XVI	(46,47)	Effective Communication
XVII	(48,49)	Natural World Impact
XVIII	(50-52)	Ethical & Behavioral

Both instruments contained ten sub-divisions for each skill (*Exposure, Proficiency, Importance*); Exposure (*School, Co-op, Other*); Proficiency (*Novice, Proficient, Expert*); Importance (*None, Somewhat, Important, Not s*ure).

The first version of the student assessment tool contained 17 categories and 58 different Skills/Knowledge areas:

FINDINGS

Ranking all the skills (52) in descending order of the means, it was observed that in-class learning ranked highest among students. The highest-ranked skill/knowledge area among students was programming. Within outside-class exposure, the next-highest-ranked skill/knowledge area was practicing professionalism in the workplace, followed by troubleshooting, a skill to which students received the most exposure while on co-op. Practicing ethical behavior/values ranked high and was used mostly while on co-op.

An abbreviated list of the all the skills ranked in descending order of frequency are listed below: (See Appendix "All Skills" for complete listing):

It can be concluded that students believe many skills identified in the computer science curriculum are acquired not only in the classroom but are acquired and used on co-op. A variety of the skills taught in the classroom and used while on co-op were ranked very high on the exposure list. The survey results imply that many important technical and non-technical skills are acquired both in school and from the co-op component of the curriculum.

Students believe they do learn while on co-op. They stated that they had acquired many of their computing and professional skills both in the classroom and the workplace. Often skills introduced in one area (classroom or co-op) are utilized in the other area. The initial finds suggest that both the classroom and the co-op experience are important in providing a well-balanced curriculum.

Students' estimation of their level of proficiency is higher than the employer or faculty rating of students' level of proficiency. Both classroom and co-op experience are perceived by students to be equally important in their curriculum. Professionalism, written communication, ethical behavior are rated highly by students as skills acquired while on co-op. These are considered non-technical skills/knowledge areas in the college.

Employers rated communicating technical work clearly, problem solving, professionalism, and written communication skills high on the list of skills obtainable on co-op.

<u>Major gaps:</u>
Students stated they acquired supervisory skills while on co-op, yet the employers rated that skill area as one of the lowest. In one of the most unusual discrepancies, students believed that they gained a thorough understanding of the impact of technology on daily life on co-op, while employers disagreed. The gap between students and employers on the "understand social impact of computing" measure was 23%.

The computer science faculty provided no surprises. Faculty have a clear understanding of what is taught in the classroom and what co-op can provide. Faculty tend to assume that co-op will provide opportunities for students to use communication, practice professionalism, utilize non-technical (teaching, training, supervisory, making informed judgments), build web applications, and utilize multimedia applications.

<u>Comparing importance of the skill with place of exposure:</u> The skills were ranked in descending order of Importance. Only those skills/knowledge areas ranked as Important were selected, and cross-referenced against place of Exposure (expressed in percentage). For example, on skill number 36 (section XIV), "Written communication skills", 79% of the students said they were exposed to this skill in school; 80% said exposure on co-op, and 46% said exposure was from another unidentified source. Skill number 51 (XVIII), “Practice ethical behavior/value”, received a 67% for school exposure, 83% for co-op and 48% from other. The students believed “Practice ethical behavior/value” was an important skill and the majority expressed co-op as the major place of exposure. (See Appendix “Importance/Exposure” for complete listing.)

Comparing importance of the skill to student’s level of perceived proficiency: Skills were rated for perceived Importance (None, Somewhat, Important, Not sure). They were then listed in descending order of percentage. The rating for level of Proficiency (Novice, Proficient, Expert), also ranked in descending order, was then matched against Importance.

A possible conclusion is that if students identified a skill as important, they tended to rate their own level of proficiency as high. For example, an average of 4.3 on a 5-point scale for "Practice ethical behavior/values" identifies this skill as important. For the same skill (practice ethical behavior), students rated their proficiency level as 4.0 average (on a 5-point scale with 0 being novice and 5 being expert). By comparison, these averages would suggest that if a student believes a skill is important then she will tend to express her proficiency as high. If a student believes a skill is less important, she will tend to express her proficiency as correspondingly lower.

More detailed results can be obtained by contacting the researchers.

SUMMARY

The findings support the researchers' belief that both the classroom and the cooperative education experience are essential to a comprehensive curriculum.

Next steps

From past findings the researchers have narrowed down the skill sets. They are now in the process of scheduling focus groups with faculty, employers and students in order to develop scoring rubrics that will be useful for assessing a student’s accomplishments while on these cooperative work assignments. CCIS has integrated its in-class and out of class curriculum objectives and identified levels of attainment for each learning objective.

Scheduled activities for September - October 2002.

The researchers have already received limited funding from the university and will be conducting initial focus group discussions with selected CCIS faculty, employers and students to begin developing rubrics for programming and operating skills assessment.

In CCIS a pilot set of skills areas has been selected for immediate application. The content areas to be covered are based on the following college objective skill sets: programming, operating systems, non-technical skills, communications, creative thinking, problem solving, natural world impact and ethical/professionalism. Procedures to develop and score the rubrics will be started during a series of focus group meetings scheduled for September and October of 2002. The researchers have identified through literature review various scoring methods for the selected skills. Because scoring of the rubrics will be time-intensive, only eight skill areas will be utilized for these pilot focus groups.

Special Note: An extensive number of data charts are available. If the proposal is accepted than a few charts can be made availble for the final publication. One chart in .pdf format is attached as an Appendix. Charts are available upon request on line.

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Special Appendix – Complete single chart of all data.