Developing a Computer Science-specific Learning Taxonomy

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ABSTRACT
We propose a working group to look at the successes and failures of learning taxonomies as applied to computer science, and to develop a new taxonomy that takes into account discipline-specific issues. This will be built on set of experiments which have been piloted by the group leaders, and which will be carried out by members of the group at their own universities before the group meets.

Keywords
Computer science education, taxonomies of learning, curricula, assessment, credit transfer, benchmarking

1. THE ROLE OF LEARNING TAXONOMIES
In many countries, it is usual practice to describe courses of study by listing the learning objectives that successful students will achieve upon completion of the programme [1,2]. It follows that assessments should be able to determine which of these learning outcomes have been satisfied. These objectives need to be expressed in an unambiguous language that can be understood not only by those teaching the course, but also by learners, employers and other educational institutions that students may move on to.

One tool that is used in the expression of learning outcomes is learning taxonomies such as that of Bloom et al. [5] and the SOLO taxonomy [4]. Bloom, in particular, is commonly used in curriculum and assessment design in schools and universities. These endeavour to categorise the ways in which students engage with the material being learned, focusing on generic aspects of learning. Frequently, these taxonomies are seen as forming a hierarchy or continuum [3].

For example, the taxonomy of Bloom et al. consists of the following levels:

- Knowledge
- Comprehension
- Application
- Analysis
- Synthesis
- Evaluation

These levels are used as guidelines to encourage students to adopt deep rather than superficial learning of the subject. In some cases institutions go further and require that assessments can measure performance at each level in the taxonomy.

2. PROBLEMS WITH EXISTING TAXONOMIES
A number of problems have been noted with such taxonomies. For example, is learning single-dimensional or multi-dimensional? Does achievement at one level in a hierarchical taxonomy imply achievement at all lower levels?

One difficulty (first pointed out by Bloom et al. themselves [5]) is that it is not easy to put particular assessment tasks into specific taxonomy levels. In particular, a given assessment may sit at a number of different levels in a hierarchy depending on how the students have studied prior to carrying out the assessment. For example, a complex design task might be placed at a high level in the hierarchy if it requires the student to bring together a number of pieces of knowledge that they have studied in different parts of their course; on the other hand if that particular task had been studied in detail on the course, the same assessment would be a recall task and be placed at a lower level in the hierarchy.

The learning taxonomies discussed above are generic, implying that the types of learning and the ordering of the hierarchy is constant across subjects. For example, in applied subjects such as computing, a principal learning objective is the ability to develop artifacts (in computing, pieces of software) [6]; by contrast, other subjects (such as English Literature) are focused on skills of critique rather than producing artifacts (such as novels). It could therefore be argued that in applied subjects, application encompasses synthesis and evaluation, rather than being a lower level skill. It is notable that the recent ACM overview of computing curricula [2] refers to *performance competencies* rather than *learning outcomes*, which reinforces the perceived importance of application.

3. METHODS FOR STUDYING TAXONOMIES

In a recent paper [6], we described two approaches used to study whether Bloom's taxonomy is appropriate for computer science. The first of these consisted of an analysis of the assessments that were given to students during their first year of university study. These assessment instruments were read by a panel of academics, and each part of each one was placed into the Bloom taxonomy. The second approach consisted of semi-structured interviews with the lecturers on those same courses, which explored where in the Bloom taxonomy they believed their teaching on that course was focused, and at which levels on the taxonomy they believed that their assessments were targeted.

This study generated more challenges and questions than it produced answers:

- Why couldn't a panel of experienced computer science lecturers agree on the taxonomic level to assign to each assessment instrument?
- Why was there an inconsistency between the taxonomic level assigned to the assessment instruments by the panel and by the lecturers responsible for setting the tasks?
- The lecturers were consistent in seeing application as the most important taxonomic level; where they felt that they were encouraging students to use skills of synthesis and evaluation, this was to improve the quality of the application.

These issues call into question the uncritical application of Bloom's taxonomy in computer science. The aim of this working group is to adopt a critical approach to the use of existing taxonomies within CS, and to propose an alternative taxonomy that will address these problems.

4. WHAT THE WORKING GROUP WILL DO

In the period before the conference, the members of the working group will review existing taxonomies, and replicate the studies described above at their own institutions. This will provide the background for the work of the group during the conference.

At the conference the working group will carry out four tasks:

- Critically review existing taxonomies from a CS perspective.
- Analyse the results of the studies carried out before the conference.
- Propose a new taxonomy that takes into account the discipline-specific issues identified by the previous two tasks.
- Suggest how this taxonomy could be evaluated.

5. WHAT THE WORKING GROUP WILL DELIVER

The final report will start by detailing the history of learning taxonomies. It will provide an overview of their use in CS curriculum design and assessment in a number of countries. It will discuss the effects on Computer Science programmes of the uncritical application of Bloom's taxonomy and evaluate the extent to which it has any sensible effect. We will describe the result of our experiments. Finally, the report will make proposals for a CS-specific taxonomy and ways in which its utility could be investigated. We will also discuss the implications for CS curricula and make recommendations aimed at CS educators.

6. POTENTIAL MEMBERSHIP

This working group proposal is motivated by the response to the proposers' discussion session [6] at the 6th Baltic Sea Conference on Computing Education Research November 2006. A number of participants at that conference expressed an interest in carrying this forward through a working group, and we have received subsequent expressions of interest from members in Australia and Finland. We are actively approaching other potential candidates.

7. LEADERS CREDENTIALS

Ursula Fuller is a lecturer in Computer Science at the University of Kent and was previously Dean of the Faculty of Science, Technology and Medical Studies. Ursula has been involved in four previous ITiCSE working groups, including two as group leader. Colin Johnson is also a lecturer in the same department, he is actively involved in research into computing education as well as teaching at the university and leading a number of research projects in the area of bioinformatics.

8. REFERENCES

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