Trends in teaching informatics

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Abstract

Most of the development of informatics curricula has focused almost exclusively on the technical content of the courses in a curriculum. More recently there has been increasing attention paid to pedagogical and nontechnical subject course material. This paper surveys some of the trends in informatics education relative to pedagogical and nontechnical aspects. Some observations are made on current trends and the importance of these aspects relative to more traditional curricular concerns.

Keywords

Informatics, university education, informatics majors, curriculum (general), academic requirements, business and industry requirements

1 INTRODUCTION

Until relatively recently informatics curriculum recommendations and most work in informatics curriculum development have focused almost exclusively on the technical content of the courses and the sequence in which topics should be taught. The 1991 report of the joint ACM/IEEE-CS Curriculum Task Force (Tucker *et al.*, 1991) is the first major informatics curriculum report known to the author which in a significant way addresses important nontechnical content, as well as experiences and capabilities beyond learning of technical content which are important in the education of a student majoring in informatics. More recently there has been an increasing emphasis on pedagogy, nontechnical course content and the development of professional skills in undergraduate informatics programs, as can easily be seen by looking at the proceedings of conferences in computing education during the past five years or so.

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It is not surprising that little attention was paid to the nontechnical aspects of informatics programs. Most informatics faculty members have received intensive education in technical subjects, and many, if not most, are active researchers in technical subareas of informatics. Many faculty members feel that they have inadequate preparation to teach social, ethical andprofessional topics. During most of the time that informatics programs have been in existence there has been a strong demand from industry for graduates of the programs and enrolments have been high, so there has been little incentive to put a lot of effort into the development of effective teaching and learning techniques. The prevalent faculty reward system, which only pays lip service to education and not only rewards research productivity, but often uses it as the sole criterion for tenure and promotion, is also a contributing factor.

The past ten years have seen a significant increase in the emphasis which is placed on nontechnical course content, supporting educational experiences and effective paradigms for teaching and learning in informatics curricula. Some of this increased emphasis has been due to complaints from industry that informatics graduates were too self-centred, lacked communication skills and the ability to work effectively in teams, and were unable to work effectively in problem domains outside core informatics areas. But the changes also reflect a maturing of the discipline and growth in the number of informatics faculty members who have a strong interest in effective teaching and learning.

In the remainder of this paper some of the pedagogical and nontechnical aspects which have been used or proposed for computing programs are surveyed. Some observations about trends in informatics education and the importance of the pedagogical and nontechnical aspects conclude the paper. It is not the intention to assess the effectiveness of the proposed or implemented curricular or pedagogical changes, but only to survey them as examples of the kind of activities which are occurring. Many of the references include assessment information. It should also be noted that the cited references are not necessarily the first or most descriptive for each topic, but mostly they are chosen for their discussion of recent experiences.

The observations and opinions expressed here are mostly based on activities in the USA. These do not necessarily apply to other countries as well, but many similar activities are occurring outside the USA. The terms 'informatics' and 'computing' are generally interchangeable as used in the paper.

2 SOME TRENDS IN INFORMATICS EDUCATION

We begin by looking at some recent experiences in teaching informatics which do not focus on what informatics topics should be taught. These are partitioned into three groups: teaching and learning paradigms, the professional context and sequencing of the informatics subject material. The last group is included even though attention has been given to topic sequencing issues almost since the beginning of informatics education, because the particular issues which are addressed here, are mostly different from the traditional considerations.

2.1 Teaching and learning paradigms

Four approaches to getting students more involved in their education are:

- discovery learning;
- active learning;
- collaborative learning;
- peer learning.

There is some overlap in these approaches and the general objectives and motivation are similar: Students learn more effectively by doing, rather than by listening.

Discovery learning
Discovery learning (Baldwin, 1996) refers to a process in which students are lead to discover 'knowledge' by working through a series of exercises and problems. Students can work on their own or in groups. The teacher provides guidance when students have questions or difficulties. The objective is to prepare the students to learn on their own, thus making them better prepared for the continuous learning which is required in order to maintain currency in informatics.

Active learning
Active learning (McConnell, 1996) turns class periods away from lecture mode and more toward a laboratory mode in which students work together to solve problems. A class normally begins with a short lecture-discussion giving an overview of a topic. During the middle part of the class students work in teams on problems or questions posed by the teacher. At the end of the class the results from the teams are summarized and discussed, and there can be a general question-answer session on the topics of the day. The motivation for this approach is the belief that understanding and knowledge retention are improved if students learn by doing rather than by listening and passive studying.

Collaborative learning
In collaborative learning (Daigle *et al.*, 1996; Walker, 1997; Williams, 1997) the emphasis is on students working in teams to solve problems, including not only implementation projects, such as software development, but also general problems which illustrate concepts and develop analytical skills The collaboration can be an integral part of the educational process, woven throughout the curriculum. One motivation for collaborative learning is the belief that students often learn better from each other than from a teacher and that students also learn by explaining concepts to each other.

Peer learning

Peer learning (Wills and Finkel, 1994) is a variation on collaborative learning in which students who have completed a course, and perhaps additional courses as well, serve as mentors for students who are currently taking the course. A variation uses, as lab assistants, peers who are a bit further along in the program than the current students, and it has also had good results (Prey, 1996).

2.2 The professional context of informatics

This grouping involves nontechnical knowledge and skills which are needed by informatics graduates in order to function as informatics practitioners in a professional environment. The need for good communication skills has been discussed for some time and much attention has also been given to the need for an understanding of basic social and ethical issues of computing and information technology. Two more recent activities are discussed further here: Some new perspectives on developing team skills and the use of Total Quality Management (TQM) techniques in courses.

Developing team skills

Recent activities in the development of team skills have focused on integrating teamwork throughout the curriculum (Daigle *et al.*, 1996; Prey, 1996). One of the problems in using teams for projects in different classes is that it is easy for some students to 'hide' in positions such as librarian or documenter and therefore experience neither leadership positions nor adequate technical experience. Several recent efforts have attempted to provide coordination among different courses to ensure that students obtain a variety of experiences in team positions during the course of their education. There have also been efforts to demonstrate that the effectiveness of a team project is improved by working with industry practitioners on an actual project (Williams, 1997).

Total Quality Management in courses

Another recent aspect of professional and industrial practice which has been used in classes, is TQM (Null, 1996). At the beginning of a course a student TQM team is formed to coordinate the TQM process. Students formulate, with guidance by the teacher, the goals and objectives for the course. The TQM team then collects feedback from the students throughout the course and the team works with the teacher to evaluate the progress and to effect appropriate changes as needed in the course plan and the objectives. This activity involves students directly in the educational process while introducing them to some techniques which are widely used in industry.

2.3 Sequence of informatics topics

The final grouping includes some recent experiences and proposals regarding the sequence in which topics are covered in an informatics program. Unlike the first two groupings this one is directly involved with the informatics subject content of the courses. But the issues here are not what subject material should be taught, but rather the sequence of the material from a fairly global perspective.

First course with fundamental concepts

Some informatics faculty members have concluded that informatics students often get the wrong impression of the discipline and professional practice from introductory courses which emphasize basic programming and software development. As a result several programs have a first course for informatics majors which has little or no programming, but is designed to introduce students to important fundamental concepts of the discipline without programming (Cook, 1997; Shackelford and LeBlanc, 1998). These are not survey courses, but rather substantive courses which provide motivation for the more specialized courses in programming and other areas which follow.

Inverted curriculum model

Another proposal is to use an inverted curriculum model (Lidtke and Mulder, 1998). The motivation is similar: to provide students with an overview of professional practice in the introductory courses. This is done by having student teams work on 'industrial strength' problems, using available packages, class libraries and other previously-implemented software to develop solutions without first having to spend a substantial amount of time developing the students' software development capabilities. A key part of this approach is just-in-time learning in which new knowledge and concepts needed to solve a problem are not learned until they are needed for solving the problem.

3 OBSERVATIONS ON TRENDS IN INFORMATICS EDUCATION

It is interesting to note that all four of the listings in the teaching and learning paradigms category contain the word 'learning', but none contains the word 'teaching'. This perhaps reflects the trend toward viewing the success of education in terms of outcomes (learning) instead of process (teaching). Of course the learning which takes place in each of these four paradigms is guided and directed by teachers, so teaching is very much a part of the process. A further trend today is away from teacher-centred education, in which the teacher (lecturer) is the purveyor of knowledge and the duty of the students is to learn what is dispensed by the teacher. Instead, the student should be an active participant, with the teacher serving roles as coach and mentor, as well as that of teacher. There are similarities and overlap among the four teaching and learning paradigms, and none is intended to be used exclusively.

The increased emphasis on professional skills is mostly in response to feedback from industry that new hires are seriously lacking in these skills and sometimes even lacking any knowledge of their existence. The increasing public concerns about the societal implications of computing and concerns about safety-critical applications of computing also provide impetus for increased attention to these areas.

The efforts to provide a first course which introduces foundations of the discipline with little or no programming, reflect increasing concerns about the effectiveness of informatics education. The curriculum inversion model also reflects this to some extent, but it is primarily motivated by a desire to do a better job in preparing graduates to become highly productive practitioners in a professional commercial environment quickly after graduation.

Given that there is increasing interest in aspects of informatics curricula other than the technical subject content, it is interesting to speculate on the importance of the pedagogical and nontechnical components relative to the informatics subject content. Given that the objectives of the pedagogical and nontechnical components of a curriculum are to improve the effectiveness of the students' learning and to prepare them more effectively for productive professional practice, it could be argued that these components are at least as important as the specific informatics subject material which is taught.

It has long been the author's opinion that much of the material in most any specific course, could be eliminated from the curriculum without any detrimental effect on the graduates, and that the number of required informatics courses could also be reduced without a detrimental effect. But it is less clear that a similar statement applies to effective pedagogy and to activities which develop professional capabilities. So it might even be argued that the pedagogical and nontechnical components are the most important parts of an informatics program. However care must be taken that we do not fall into the trap of 'form over substance'. Pedagogical and professional skills components of an informatics program are definitely enhancements to the technical informatics subject material, rather than a replacement for a significant portion of this material.

Finally it should be noted that many of the changes which are taking place in the teaching of informatics are also taking place in other disciplines. Thus another factor which stimulates the efforts to improve the pedagogy and relevance for informatics curricula is the general pressure to improve the overall effectiveness of education in general.

4 CONCLUSION

The substantial increase in efforts to develop effective methods to improve student learning and to better prepare students for professional practice are probably due to three factors:

- pressure from industry to prepare graduates to be effective practitioners;
- an increased emphasis on the importance of high-quality education at the university level;

- an increase in the number of informatics faculty members who are interested in effective education.

These factors have stimulated the development of many approaches to improving informatics education which are not directly related to informatics subject material. Effective pedagogical improvements and the development of effective professional skills could well be as important to the success of informatics graduates as the specifics of the informatics subjects which are covered in a curriculum. It will be interesting to see whether this trend leads to informatics programs whose graduates are improved in the eyes of their industrial employers.

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6 BIOGRAPHY

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