Directions and Challenges in Informatics Education

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Abstract: The role of this working group is to focus on examples of recent efforts to address current challenges in teaching informatics, and also to identify future challenges in informatics education. (The term 'informatics' is seen here to be broad and inclusive.

1. DISCUSSION SUMMARY

1.1 The Current State of Informatics Education

1.1.1 Curricular Developments

There have been a number of recent notable curricular developments in informatics. These include

- Curriculum 2001 and in particular the Computer Science volume; there is a related volume for two-year colleges in the US but also the promise of complementary volumes on Software Engineering, Computer Engineering, and Information Systems.

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- The IFIP / UNESCO curriculum ICF-2000; This is not a model curriculum, but a curriculum framework that contains links to other prominent and current informatics curricula

An important facet of these initiatives is that they have sought (with varying degrees of success) to be international in nature; this is to be interpreted to mean that they offer curricular advice of relevance to many countries.

Other developments of a national nature are also occurring. In Brazil, for example, the Ministry of Education has provided a framework in the form of curricular directives – essentially guidelines – for certain kinds of programs. These include computer science, computer engineering, information systems and a further pedagogical strand. Within these strands, there are certain required topics but there is scope for local variation and specialisation. Further input to curricular details is provided from the Brazilian Computer Society. As in Australia, the advice here takes the form of accreditation guidance, which mandates a clear set of objectives, a certain breadth as well as a portion (e.g. one third) of the material at an advanced level and all this within a properly resourced environment. There is a body of knowledge and certain basic requirements of all programs: transferable skills, professional issues, societal impact, quality concerns, and project management.

1.1.2 Quality Issues

These curricular developments can be seen as one approach, a constructive approach, to quality. By defining advice and guidance on curricular matters, appropriate support is provided for curricular developers; this has the effect of setting expectations and providing points of reference.

Related to, but distinct from the above, are developments related to the quality of programs. These include benchmarking standards for Computing in the UK. Certain countries (for example, Australia and the UK) have the concept of a qualifications framework which captures a range of qualifications and, in support of life long learning, this provides encouragement for individuals to acquire ever higher qualifications.

A third approach to quality is about to be used in informatics in Brazil. A national examination for graduates of informatics programs is to be implemented. This already exists in the more popular disciplines, e.g. engineering, administration, the law. The examination is mandatory for all students and there is pressure from institutions for students to perform well since success is seen as a hallmark of the best institutions. Indeed the results of such examinations are used to rank institutions. In the Brazilian context it is currently unclear whether there will one examination for the whole field of informatics or one examination per strand; in either case there are concerns

in Brazil about the possibility of stifling diversity. However, at higher levels, this entire process is seen as encouraging quality.

Additional approaches to quality include accreditation activities by professional bodies and government boards, and customs such as the external examiner system in the UK and Norway; recently there have been signs of this role being further enhanced in the UK. In some parts of the world, licensing and certification are also important quality indicators.

1.1.3 Use of Curricular Developments

The manner in which published curricula such as CC2001 are used outside of the United States varies. Many institutions tend to see such documents as points of reference. Thus, they tend to adopt good features but do not accept the recommendations blindly. An important aspect here is the recognition that, for instance, the needs of the United States and the needs of countries such as Brazil are different; accordingly, the university curricula ought to reflect this.

2. TRENDS IN INFORMATICS EDUCATION

2.1 Growth Issues

The number of programs has increased in all countries. In some countries the number of degree titles is controlled by government edict, but in others – such as the UK and Australia where market forces operate – the diversity of course provision has also increased dramatically.

There has been an expansion in the number of institutions and organisations offering courses and qualifications. In part, this has been a response to the need for certain skills to be acquired in a short time. Traditional universities have had to address foundational issues and this has frequently prevented rapid response to market demands. Organisations, including major hardware and software providers, have therefore moved to fill the gaps (niche markets). These organisations are, by their very nature, transnational and provide qualifications that are a form of international currency. In other places existing organisations have introduced new ‘fast track’ programs often with support from government. In Brazil, for instance, the concept of the ‘sequential program’ (sequential) is one such development in universities that already offer full degree programs.

3. CHANGES OF EMPHASIS TOWARDS LEARNING

There has been a shift in emphasis towards learning and away from teaching. Thus the role of the teacher changes to “the guide on the side” and no longer “the sage on the stage”. This is manifest in an emphasis on learning outcomes and competency. Students are now more aware of these issues and, ideally of what is expected of them. Activities such as problem solving foster a focus on active learning. The teacher needs to pay greater attention to setting goals to extend the horizons of students and to set expectations. The concept of such induction is of growing importance. Educational techniques such as peer review might be used to stimulate students to assume responsibility for their learning.

These developments can be seen as important support for life long learning. They are not the only pre-requisites since fundamentally life long learning can be interpreted as stemming from an attitude of mind. This needs to be fostered by approaches to learning and teaching that continually challenge the student around the forefronts of knowledge and development.

The rate of change in the discipline is such that, for the foreseeable future, there will be need for professionals to continuously keep up-to-date. Once in employment, learning often needs to occur over a short time frame. There are apparent contradictions here – life long learning, short term needs and requirements.

4. CHANGES IN THE DISCIPLINE

There has been no decrease in the rate of change within the discipline. However, with the many new developments it is important to identify changes that appear to be occurring within the discipline of informatics. In some courses, there does appear to be a de-emphasis in the importance of programming; in such courses there tends to be an emphasis on the use of packages and of tools.

Although change continues to take place, there is an increasing consensus on the nature of the core of certain parts of the curriculum, e.g. computer science.

Another important trend is towards greater emphasis on curricula that integrate informatics with other disciplines (interdisciplinarity or multidisciplinary).

5. TRANSFERABLE SKILLS

Basically, the era of the asocial programmer has come to an end. Thus there is greater need in all programs for interpersonal skills. In the context of informatics these are particularly important to extract requirements, to learn from others, to teach and explain to others, to form part of a group or a team, and so on. The development of additional skills including critiquing and negotiation needs to be addressed.

It is no longer adequate for graduates in informatics to possess only technical skills. They also need to possess skills that recognise the social, legal, ethical and professional context in which they work, and they need to be aware of their responsibilities.

6. FACULTY PERSPECTIVES

The increased attention on quality concerns and the changing emphasis on learning has created faculty who are now more concerned with learning and teaching. Thus, awards and rewards for quality have had a beneficial effect.

There remain considerable problems in attracting well qualified staff into informatics, and in particular into such areas as information systems and communications.

7. STUDENT INTEREST

Retention rates within informatics seem to be a problem in all countries, with some situations being more acute than others.

8. CHALLENGES IN INFORMATICS EDUCATION

8.1 Internationalisation

The discussion on internationalisation of curricula is important. However, this needs to address directly the following question: from a curricular perspective, a key aim for many countries is to produce graduates who are internationally competitive. The reasons for this relate to the global economy, to open markets, to multinational companies, to trends such as the outsourcing of software, to the nature of the software and computing

industries, to employment, and fundamentally to the confidence of new graduates. Without this, any country runs the risk of jobs being taken up by graduates from abroad, of losing industry to other countries and so on.

What does internationalisation mean in practice? Clearly, advances such as CC2001 and the ICF 2000 curriculum are crucial in this regard but some additional insights are needed. To reiterate, the blind adoption of these published curricula is often not an entirely sensible approach. These have been successful to a large degree in their attempts to eliminate cultural bias but this is only one step on the pathway to the internationalisation of the curriculum.

An aspect of internationalisation relates to the use of the English language, the lingua franca of the informatics field. Textbooks and other important materials are commonly in English. It is important to recognise that, for difficult topics, the use of English presents an additional hurdle to learning at all levels. Currently in many countries, postgraduate courses are often delivered in English.

A modest but important contribution would be a standardisation of terms such as 'course', 'class', 'program', 'credit systems', etc.

This internationalisation matter merits considerable further thought and attention.

9. CURRICULAR DEVELOPMENTS

The nature of the CC2001 effort is such that, wisely, the CC2001 steering committee did not unduly constrain the teams involved in developing software engineering, computer engineering, etc. With the publication of the final volumes there will be a challenge to evaluate the resulting documents with a view to determining best practice in terms of curricular design. From this there should emerge guidance on matters such as how best to provide a body of knowledge. Part of the considerations here will include the logistics associated with the difficult task of keeping published curricula up-to-date. Of course, there is a related issue of approaches to curricular design that facilitate keeping an individual institution's offerings up-to-date.

It would be a mistake to assume that the curricula emerging here will meet all of the community's needs. Undoubtedly further developments will be required; for instance in Australia there are courses on multimedia and e-commerce that do not sit well with these developments. However, there just has to be some economy of effort. It must be possible to build on these foundational efforts without the investment of many person-years of effort.

Therein lies another challenge.

10. INDUSTRIAL CONCERNS

With recent changes in the computing and informatics industries, one of the challenges now facing educators is having to produce graduates for a dynamic, volatile and uncertain industry sector.

11. DELIVERY OF THE CURRICULUM

In terms of the delivery of the curriculum, (and perhaps even access to it) those involved in informatics teaching often do not use technology itself to increase the efficiency and effectiveness of their efforts. In this regard, developments in e-learning are relevant.

In this context Seymour Papert's comment that 'any teacher who can be replaced by a computer should be' is highly relevant. Greater attention to learning strategies must be beneficial.

Success in the development of teaching materials is most common when an individual uses material for their own class; when material is used by another the success rate tends to fall off dramatically; a further stage is reached with publication and then the success rate is even smaller. Part of the problem here is the effort and commitment (time, effort and resources) needed to produce material that is sufficiently flexible yet useful and reliable.

In 1997, at the IFIP WG3.2 Working Conference held at the University of Twenty, the key issues around the (then) current state of informatics education were identified as:-

- an ongoing identity crisis for informatics
- a danger of isolation, with informatics being internally focused, to the exclusion of the needs of its domains of application
- changing roles for informatics graduates as software technologies develop
- changing learning environments (to more flexible student-centred approaches)
- an increasingly global information infrastructure.

Recent curriculum initiatives have gone a long way towards resolving the identity crisis. The demand to avoid isolation has grown, with increasing trends towards interdisciplinary curricula in areas such as bioinformatics and enviro(nmental infor)matics. The other issues are as relevant today (and possibly no closer to resolution) as they were in 1997.

12. FUTURE DIRECTIONS

It has to be important to encourage experimentation with new approaches to curricular design and to new ways of teaching informatics. The current problems of retention are testimony to the fact that many people wish to become skilled in informatics, but are being turned off. Generally, the economies of many countries require people with these important skills. Developments such as

- experimenting with the use of games for learning and teaching
- the development of interpersonal skills early in the curriculum

are to be encouraged but it is important that, for example, negative gender issues do not appear. Basically new and more effective approaches to learning are needed.

In this context, one future direction may be to teach informatics to students who do not possess the normally expected mathematical skills. Some would argue that mathematical requirements are often grossly overstated, and a more limited mathematical agenda can be taught in the context of informatics. Is it the mathematics that is needed, or is it the formal and logical reasoning that underpins both informatics and mathematics that is important? There is also merit in seeing a distinction between mathematics and logical reasoning; many aspects of the latter can be conveniently - and more meaningfully, from an informatics perspective - taught in the context of programming. There is a challenge in devising curricula that reflect the abilities of students rather than impose impediments to study.

Although many would claim a decrease in mathematical ability of students, this is often accompanied by an increase in language ability; this appears to be the case in Norway.

To support many of these challenges and initiatives it will be important to have appropriate quality measures in the background to guard against ill-conceived developments. A judgement has to be made here as to whether the current and evolving quality standards are indeed appropriate; they must not be excessively bureaucratic and they must not stifle development.

At the end of the day, those involved with these matters must think deeply and sympathetically about future generations of young aspiring informatics students.

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