Provision of Computing Education in Pakistan: An Experience Report

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***Abstract*—**Computing is a favorite subject to study at universities in Pakistan as computing professionals are in huge demand in the software industry. The educational institutions are providing programmes of study in Computing at all levels and the Higher Education Council of Pakistan have agreed a framework and syllabus for such programmes. The Ministry of Science and Technology have also played their part by helping to recruit experienced faculty form abroad through their *faculty hiring programs*. Thus, the will is there and signs are good, however, there are a number of issues at ground level, especially with respect to design, delivery and assessment of modules. This paper presents an experience report of the author, who was a visiting professor for six months at a university in Pakistan. The issues are highlighted and solutions are suggested. The aim is to provide some relevant information for colleagues in academia so that the teaching of computing is improved and students' learning experience is further enhanced.

***Keywords*—**Teaching, Computing, Software Engineering, University Education, Pakistan.

I. Introduction

Computing is one of the favorite subjects to study at institutions of higher education in Pakistan. The universities have developed programmes of study in Computing at all levels. The programme structures have also changed to align them with similar programmes in the UK, the USA and Western Europe. Numerous Diploma programmes also exist, a majority of them offering professional qualifications.

The Higher Education Council (HEC), within the Ministry of Education and Science (MES) of Pakistan, has also been highly instrumental in providing the necessary guidance and assistance. The HEC [1] regard Computing as consisting of a family of disciplines, most notably the areas of Computer Science (CS), Software Engineering (SE) and Information Technology (IT). They have also published programme structures and brief indicative content for modules on these programmes.

HEC have also a number of schemes, within its 'Faculty Hiring Programs' [2, 3] to attract experienced Pakistani professionals, living abroad, to come to Pakistan for a period of 3 months up to a year, and help to develop and deliver courses, as well as set up research in related disciplines. The author was also invited as part of this program, who worked for six months as a Visiting Professor at a university in Islamabad, while on sabbatical from the University of Derby, UK. The author's brief was to provide consultancy, including development and delivery of modules and organizing research.

In Pakistan, the software industry is also moving forward at a healthy pace and there is a growing demand for skilled software engineers, project managers and quality auditors [4]. Although, the HEC and the institutions of higher education are making huge efforts to produce graduates with the required knowledge and skill, there is a noticeable lacking in the required skills, especially in the computing and software industry.

This paper presents the experience of the author and highlights the issues observed during the author's visit. The paper also presents suggestions and the actions taken, towards the improvement for a better teaching and learning experience.

II. Background

The author was invited by the MES to visit and work at an institution of higher education in Pakistan from January to July in 2005. A university in Islamabad was selected, which was structured to have a number of faculties, where each faculty was divided into a number of schools. The authors worked within the School of Computing. The School had a healthy portfolio of programmes at under-graduate and post-graduate levels. A few of its staff were active in research or scholarly activity. The atmosphere was healthy and the teaching environment was good.

The author's brief included the following:

- Development of detailed syllabi for the *Software Engineering 2* (SE2) and *Advanced Software Engineering* (ASE) modules.
- Delivery of the SE2 and ASE modules.
- Setting up strategies for teaching and learning so that teaching became more effective and students' learning experience improved.
- Setting up research in the School.
- Any other activities that the author could be involved in.

The above was delivered in time and reported in the author's final report to the School. The following sections provide details of the issues observed and the actions taken or

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recommended.

III. Development And Delivery Of Modules

The structure for the programmes of study at the under-graduate and Master's levels and the brief module outlines were already defined by the HEC [1]. In the case of the SE2 module, the indicative content suggested the teaching of the following topics:

- Software development paradigms.
- Software testing, verification and validation.
- Quality assessment and control.
- Software correctness.
- Risk assessment and monitoring.
- Technical reviews and inspections.
- Reliability and performance.

For the ASE module, the indicative content was as follows:

- System development using formal techniques.
- Algebraic and abstract model specifications.
- Verification techniques.
- Proof techniques, systems and obligations.
- Design: data and operation refinement, design decomposition.
- Software reliability and metrics.
- Defect models: failures faults and measurements.
- Software reliability: simple models, Markov modeling.

The brief for the author included teaching of these modules. Thus, the first task required the development of detailed specifications and assessment strategies for these modules. This served as a template for colleagues to develop specifications for other modules. The modules were delivered using lectures, tutorials and guest lectures and the assessment included essays, reports, examinations and student presentations.

IV. Issues Relating To Modules' Delivery And Research

The academic semester at the university is 16 weeks long and there is a 3-hour traditional face-to-face teaching per week per module. While, the author delivered the SE2 and ASE modules, he also observed the way the teaching was carried out by other colleagues. Many concerns were noted. The main issues are discussed below.

A. Module design and content

Although, the indicative content was well defined by the HEC [1], the assessment strategy was missing and detailed module specifications did not exist. Thus, module lecturers were at liberty to teach and assess in their own way. Obviously, the experienced faculty performed better and produced better results than new lecturers, however, there was no mechanism for mentoring the new colleagues. Thus, different cohorts of students were getting dissimilar experience.

B. Inexperience of teaching staff

Lecturers were mostly fresh graduates without, or with minimal, industrial experience. They knew the theory well but lacked the understanding of the inherent issues, especially if the modules required a high practical content e.g. modules on Programming, Group Project and Project Management. Delivery was often traditional one-way communication so the students also lacked the practical understanding of the subjects involved. Sometimes, modules were taught by visiting faculty or part-time lecturers, who often delivered them in their own way, not fully concerned with the completion of the syllabus. There was no internal or external moderation of the process so the teaching and assessment strategy was left entirely to the module lecturers. Since the industry pays more handsomely, experienced computing personnel are less likely to join or move over to academia [4].

C. Overlap of teaching material with other modules

A considerable overlap was noted between related modules e.g. the overlap between *Software Engineering-1* and *Software Engineering-2* or between *Programming-1* and *Programming-2* or the overlap between *Project Management* and *Quality Management*. A certain amount of overlapping content is to be expected and a session or two to revise the content covered in the pre-requisite module is useful, however, when the same member of staff teaches similar modules, overlap can become unacceptably high. No control existed because of the absence of a moderation process.

D. Lack of library resources

This is a generic problem in nearly all fields of study, in most institutions. Libraries exist but book and journal stock is often inadequate. It was noticed that while some subject areas (e.g. *software engineering*) were well stocked, the library resource was noticeably lacking in other subject areas e.g. *Algorithms and Data Structures* and *Formal Methods*. Although, books are available in open market and they are relatively inexpensive, students cannot afford to purchase too many books. This lack of learning resources resulted in a lack of research and wider reading, especially for post-graduate students. Students' knowledge was therefore restricted to what was imparted by the lecturers.

E. Incomplete coverage of module content

This is another generic problem, not restricted to just Computing. Delivery of modules is the responsibility of module lecturers and there were no checks to ensure that the required content was fully delivered. As already mentioned in a previous section, this was partly due to the inexperience of the teaching staff and partly due to the duplication of coverage

(from other related modules), which resulted in a lack of time available to cover all the required topics.

F. Lack of appropriate practical content

Software Engineering is a practical subject. It requires practice in designing, writing and testing software: a skill that cannot be gained by just reading the books on programming. Such modules should include a high practical content [5]. Although, the first year modules contained the required amount of practical content and second year modules also had some practical element, its coverage in the final years was noticeably lacking. The *Group Project* module, where students worked in teams, required design and development of programs. Here, the projects were too small for students to appreciate the issues related to programming-in-the-large. There were no project management or software testing tools used in project management and software development modules.

G. Lack of software and hardware equipment

Computer laboratories were available with software and Internet facilities; however, the provision was less than robust. If a piece of hardware failed, it took several days to get it fixed. Repair service was provided by external contractors who repaired machinery on a collect-back-to-firm-to-fix basis. Software was often older versions and the licenses purchased were not enough. Internet facility was too slow and available only during the mornings and afternoons on weekdays.

H. Absence of research strategy

There was no research policy, although a number of staff was engaged in research and scholarly activity. Research was rather fragmented but the potential was there. It was pleasing to note that there was enough appropriate research material that could be converted into publishable papers and presentations.

V. Actions And Recommendations For Improvements

The process of the delivery of modules, assessment strategies, learning objectives and students' experience was observed for roughly half the semester. At the end of this period, recommendations were made and certain plans of actions were put in place. Since the author's time was limited, there was some urgency to get the procedures and systems right. The following paragraphs detail the recommendations made and the actions taken.

A. Special interest groups

The first major step, taken, was to set up three special interest groups (SIGs), with a designated SIG leader in each case, with the brief that they ensure the academic health of their subject areas, in particular ensuring that:

- Detailed module specifications existed for each module and their assessment strategies were fully defined.
- Assessments (including examination papers) were internally moderated for appropriateness.
- Enough library sources were obtained, or at least the expenditure plan on books stock submitted to the management for possible action.
- Other improvement plans developed and updated, as required, to improve the situation.

B. Module specifications

Steps were taken to produce detailed module specifications for some final year modules to ensure that the prescribed content was fully described. For each of these modules, the assessment strategies were also fully defined. It was suggested that the process should continue to develop specifications for other modules in future semesters.

C. Delivery of modules

The SIGs were tasked to look into the methods of delivery of modules. For the SE2 and ASE modules, a more practical approach was considered, placing a much higher emphasis on tutorials (for discussions), presentations (by students), guest lectures (for currency of information) and use of case studies (to better understand the difference between theory and practice). It was clearly evident that this approach enhanced the students' learning experience. A moderation process was also established. Using this, the examination papers and assignments were internally moderated to ensure that they were set at the correct level.

D. Staff training

The general concern, regarding the inexperience of teaching staff, was raised with the management. However, for the reasons mentioned above, it is not easy to attract experienced teaching staff. Staff training and short internal courses was suggested as a way forward. A number of half-day training sessions were held to set the process in motion. It was suggested that this process should continue in future.

E. Tutorial exercises and case studies

The SIGs examined the modules at the final year level and provided guidelines for developing tutorial exercises and using case studies. Individual module lecturers were required to produce the relevant teaching materials. The work was started, initially, in the case of just a few modules. It was suggested that this should continue for other modules in the following semesters.

F. Student presentations

Majority of final year lectures were turned into interactive discussions. Teaching was delivered through a combination of

lecture slides, class discussions and student presentations. Students were asked to work in groups to give presentations on advanced topics of their choice on a related subject matter. This also helped with their communication skills and provided students a feeling of research being carried out in the subject matter, which they highly appreciated.

G. Library resources

It is the responsibility of the educational institutions to ensure adequate supply of book and journal stock in their libraries. Recommendations were made and a list of essential reading was suggested to the School. Hopefully, the situation has improved for the next cohort of students.

H. Laboratories for practical content

It is important that the software engineering related modules have a substantial practical content. Recommendations were made to purchase the required software for use in later semesters. A list of freely available software was also compiled; some of this was downloaded and made available to students. It was suggested that this process should continue in future.

I. Research

As mentioned previously, research existed in the School but it was rather fragmented. A research group was formed and a research bulletin organized. The research-interested staffs were encouraged to produce first drafts of their ideas, which the author helped to further improve. As a result, three papers were published in the following year. Research was a difficult area to organize, however, the interest and keenness was noticeable. The most the author could do in the limited time was to set up a strategy and leave it to the research-interested staff to pursue it further.

J. School newsletter

About a month before the end of author's contract, first issue of a newsletter was published. It was only a single sheet i.e. two pages in length but the style and logo were established and an editor was also appointed. It was suggested that this should also continue in future years.

VI. Conclusion

Computing is one of the fast growing areas in Pakistan. Students are keen to study this to fulfill the skills gap in the computing industry in Pakistan. Although, the educational establishments are providing programmes of study and there is enough appropriate backing from the government, there are a number of issues that need to be addressed, especially in the areas of module design, module delivery, module assessment, research and scholarly activity. The author was invited to visit and provide consultancy to one of the universities in Islamabad, Pakistan, for a period of six months. During this time, two modules were designed and delivered by the author. The author also managed to set up Special Interest Groups tasked with the responsibility of looking after the academic health of the computing subjects including detailed specifications of modules, agreeing on assessment strategies as well as ensuring that modules delivery is, at least, satisfactory and the students' learning experience is improved. The author is happy to acknowledge that most of the tasks agreed were carried out and the results were encouraging. It is hoped that the process in continuing.

The primary aim of this paper is to present the issues noticed during the visit of the author and present actions taken and the recommendations made for future implementation. A secondary aim is to disseminate the ideas, explored and implemented, so that a wider academic community my also benefit.

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