The future of human resources qualifications in Software Engineering –

meeting demands from industry and benefiting from educational and technological advances

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***Abstract*— The recent economic growth in Brazil has resulted in a strong demand for human resources qualification. Software Engineering education, in Brazil, offers qualifications at all levels: undergraduate, further education and postgraduate. However, current market demand indicates a mismatch between the academic provision and the industrial demand. To address this mismatch, it is important to take into account the large geographic distribution of Brazil and its regional inequalities. We suggest that innovative strategies in education including Distance Education, Open Education and Open Educational Resources will need to play an important role in the future of professional qualifications in Brazil. This raises opportunities and challenges that can only be addressed by a strong interdisciplinary research and political agenda. This paper discusses the scenario of the Software Engineering education in Brazil and presents research questions and political issues associated with the future of human resource qualification in this area.**

Keywords: Software engineering; human resource qualification; distance education; open educational resources; professional education.

I. INTRODUCTION

Brazil is a country in rapid development but with strong regional inequalities.

The recent economic growth in Brazil has resulted in a strong demand for human resources qualification. A recent study carried out by Brasscom[i] (2011), pointed out a need of 78,000 professionals whereas the education sector will only provide half of this demand. In Software Engineering, this is reflected in demands from industry that are currently far from being met by current offerings from academic institutions. This mismatch between academia and industry is not only in the number of professional qualifications but also in the skills required, and in the opportunities of research collaboration.

The Brazilian plan for postgraduate education 2011-2020 (MEC, 2010, Miolo p.260) recognizes professional education as a "State Policy" and a key issue for development in Brazil. It considers human resource qualification and the establishment of a research agenda for the economical development needs of the country as one of the main factors to promote innovation in organizations and in the society.

The current situation, added to the large geographic distribution of the population, and new technological opportunities in education, ask for innovative strategies in education, where Distance Education (DE), Open Education (OE) and Open Educational Resources (OER) will have a prominent role.

This paper discusses the scenario of the Software Engineering education in Brazil and presents research questions and political issues associated with the future of human resource qualification in this area.

II. BACKGROUND

Software Engineering education in Brazil[ii] is provided at all levels: undergraduate, further education and postgraduate. The regulations for the undergraduate level have been through a recent review which indicates that a Software Engineering award is going to be created along with the Computer Science, Computing Engineering and Information Systems awards. There are already five institutions providing Software Engineering undergraduate awards. This new regulation will certainly contribute to increase and adapt existing courses to provide the skills required by industry.

For historical reasons, postgraduate programmes have been developed geared to the achievement of high academic standards establishing a well-defined research path towards a doctorate. Thus, they have become rather inflexible (Porto & Berge, 2008) (Romizowski, 2005) in regard to the demands of

professional sectors. Recognition of this inflexibility has led to an increased interest in professional masters (Ribeiro, 2010). Currently, postgraduate degrees are offered as *lato sensu*, *stricto sensu,* and professional master programmes. However, professional masters have not yet been widely implemented. There are professional masters in Computing in only six state institutions in Brazil, only one in Software Engineering. In contrast, there are 59 master (non-professional) and 25 doctorate programmes. Professional masters are fee-paying, and have a different type of final dissertation.

Despite the availability of provision described above, both undergraduate and postgraduate education in Software Engineering is facing problems. A recent study[iii] carried out by Brasscom reveals that the average dropout rate in information technology undergraduate awards to be around 87%. The postgraduate sector is also suffering from a drop in the number of students. A comprehensive study is required within the education sector to determine the reasons of the current situation and point at future directions. Informal observations from day to day contact with students indicate that one of the main reasons for such poor retention has been the premature insertion of students in the market place, which leads to the lack of time to study. For postgraduate programs the focus has been on research qualifications, as shown above with the numbers for *stricto sensu* versus professional masters. This situation is influenced by the assessment rules imposed by CAPES which emphasise the production of research papers.

A recent assessment of postgraduate education in Brazil (Almeida, 2010) criticises the lack of diversity and flexibility of postgraduate courses. It proposes that *stricto sensu* master degrees as they exist (strongly research oriented) should disappear in favour of shorter, specialised professional masters that are not directly tied up with a doctorate, and are more widely available.

There is evidence that the government is willing to change this scenario. The Brazilian plan for postgraduate education 2011-2020 (MEC, 2010) puts a strong emphasis on the need to develop professional education and mentions specifically "critical spirit and reflection" as skills that should come out of that education. Amongst the main challenges for the next decade, the new plan identifies the expansion of professional education to take into account local, regional and national needs and to promote sustainable development and social inclusion. The plan, however, does not make recommendations in relation to the mode of delivery.

The debate has therefore been launched on how to address the demands for human resource qualification in Software Engineering. The situation above, added to the large geographic distribution of the population, asks for rethinking the future of higher education in Brazil.

DE has the potential to address the geographic challenges and contribute to provide human resource qualification. In Brazil, its adoption has followed a slower path than in other developing countries (Romizowski, 2005), however, since the creation of UAB in 2005, a range of different DE experiences started being reported (Litto & Marthos, 2006). DE is also evolving rapidly, with the availability of new technologies and in parallel with the changes in education in general.

DE awards start to appear in the Computing area, within the UAB, like the information systems award given by UFSCAR at a distance[iv].

III. DISCUSSIONS AND CHALLENGES

The importance of pedagogical approaches is now well accepted in higher education, in delivering a better educational experience and establishing a well-articulated relation between learning outcomes, skills development and quality assurance. Recent technological advances contribute to supporting delivery at a distance that fulfils a good quality educational experience and skills development (Beetham & Sharpe, 2007). The educational scenario has been changing as face-to-face education is also adopting DE resources delivering hybrid education (Garrison & Vaughan, 2011).

As part of the DE scenario, OE (Wiley, 2010) and OER (UNESCO, 2011) have also come into play creating new opportunities but also new challenges. OE has been enhanced with Web 2.0 resources acting as a means to complement traditional education (Meiszner, 2011) thus increasing the opportunities for free learning. Widely available resources make it possible for the students to have a social learning experience where they not only consume materials but also produce, reuse, remix and collaborate with partners in a virtual community of practice (Brown & Adler, 2008). In this context, the role of the educator, for example, will need to change and adapt to new models for education that promote reflective practice and "learning to learn" (Sommer, 2010).

An example of OE in Software Engineering is the OpenSE[v] project which brings into context previous experiences with open source projects. Collaboration with industry in the development of these resources may be a contributor to narrowing the gap between academia and the professional world.

New opportunities and new models are opening for education with several initiatives recently been launched to make available free online courses from prestigious institutions; MIT has launched MITx, Harvard and MIT have launched EdX[vi], Sebastian Thrun and David Evans from Stanford University have launched Udacity[vii], Coursera[viii] offers courses from North America universities, Khanacademy[ix] is another free online course provider. These courses reach thousands of students, they mostly give no credit but in some cases (MITx, Pearson/Udacity) under a small payment a course credential is given. These initiatives are known as Massive Open Online Courses (MOOCs). A MOOC is a course that, typically, reaches a very large distributed audience, with materials also distributed as web resources, and that is participatory[x]. It congregates people with a similar interest to participate, and to engage with each other and share work produced. It is still not clear how these initiatives will affect traditional higher education institutions but they cannot stand still.

In this context of opportunities and challenges, a strong interdisciplinary research and political agenda is needed to address the future of human resources qualification in Software Engineering. This agenda requires the cooperation of many areas: educationalists, national and governmental planning and

accreditation bodies, open source developers, open materials producers, industry and academia. In the next sections we present research questions and political issues that need to be taken into account to address the challenge of human resources qualification in Software Engineering.

A. Research Questions

- How does pedagogy support the development at a distance of the skills required by industry for the qualification of Software Engineering professionals? Software Engineering education has been changing with the development of new learning pedagogies (Seffah & Grogono, 2002). Denning (1992) did recognise already in 1992 the need to transform engineering education in universities from a broadcast mode where only good engineering concepts are taught, to one where students also acquire the skills to listen, reflect and become self-learners. Key non-technical skills for Software Engineering are cooperation and effective communication, leadership, negotiation, feasibility analysis, and, adaptation to new models and technologies (Pyster, 2009).

- What are the models for Learning Design of Software Engineering courses? A process needs to be in place for the design of courses and modules; this process defines the workflow of activities to be undertaken, associated roles, tools and support material. The learning experience needs to be thought in terms of the learning outcomes (knowledge and skills) to be achieved from that experience and these should determine the assessment of learning. Reflection and collaboration are important skills that can be developed at a distance as long as this is planned and integrated in the learning experience. For a wide success these initiatives need to be supported at different levels: institutional, professional, and governmental. Learning design of Software Engineering courses should benefit from collaboration between institutions.

- How can Software Engineering education benefit from tool support? There is now a wide body of research on Web 2.0 technologies support for skills development. This literature should be taken into account when deciding which technologies better support skills development, in particular, when considering distance education. There is, however, a need for more domain-specific evidence for the aspects of Software Engineering that can be better supported through these technologies. Course designers need to take reasoned decisions on what tools should be formally incorporated in a course and what tools students should be encouraged to try informally.

- How can Software Engineering benefit from, and contribute to, OERs? Support materials need to be planned by defining textbooks, study guides or purpose written material. A great amount of OERs (Conole, McAndrew, & Shum, 2010) is now available from many different sources such as MIT OpenCourseWare[xi], OpenLearn[xii] and iTunesU[xiii]. This can significantly improve dissemination of knowledge in emerging countries as well as reducing the cost of courses. UNESCO has a programme to disseminate OERs (UNESCO, 2011), and one of its recent forums, which took place in Brazil, focused on Latin America[xiv]. However, there are still few OERs in Software Engineering produced in Brazil (Santos, 2011).

- What are the models to maintain sustainability and quality in the provision of open education, open source tools and open didactic materials? Sustainability covers issues of quality, production costs, scale and naturally, from the producers point of view, any profits generated. But it includes also the maintenance of the life of the resources, the infrastructure required to make the resources available, and the training of staff; these are the issues that can make or break the reuse of OERs.

- How can the promotion of professional qualifications improve the relationship between industry and academy? Industry needs professional qualification and academy is specialized in its provision. Research in Software Engineering relies on the availability of practical examples and empirical data. Industry in Brazil needs a push for innovation and researchers can play an important role to stimulate this. The provision of higher education it is being liberalised to become available also outside traditional institutions. This new scenario points at a rethinking of the academy, and a need to move towards a more market competitive position.

B. Political Issues

- Changes of regulations are required to support a greater flexibility in the creation and assessment of postgraduate degrees that are educationally innovative and fulfil professional needs. There is a need to rethink the link between these professional qualifications and research-based ones and provide appropriate rules that allow their harmonious development and support from academics and institutions.

- How to scale up educational opportunities and assure their quality? DE can scale up, but this requires investment in infrastructures to support students, tutors and assessment. DE has to demonstrate that it can deliver high quality that competes in equal terms with face-to-face education.

- Social dimension – DE programmes can be an important step for democratisation of education, and a means to achieve social and economical benefits for the nation. In the context of professional postgraduate in Software Engineering this requires recognition of the context of the profession and an understanding that professional masters will develop different skills to those leading to a research career.

- The future role of academic educators: The role of the educators in the new educational contexts – digital educators – should be well supported and be seen as highly qualified. The professional development of this staff should be a concern for their institution. Their activities will cover a wide range: from the production of digital content, to maintaining well-informed blogs and articulating professional and academic networks. This new type of intellectual production in the academic scenario needs to be recognized within institutions and nationally (Weller, 2011). Web 2.0 tools are available but educators need motivation and recognition for their good use.

- Institutions need also to define strategies and the right balance between maintaining control over data and tools vs. open source adoption. Many higher education institutions have now adopted Virtual Learning Environment (VLE) as support infrastructures for learning, making resources available to students, giving students a common experience and controlling what is accessible only to registered students. The adoption of VLEs by universities has been overwhelming, reaching in the UK around 95% of higher education (Brown, 2010) However, VLEs are institutionally controlled tools giving no control to students, and matching poorly the diversity and choice of technologies introduced with the Web 2.0. That is why the idea of personalization and, in particular, of Personal Learning Environments (PLEs) that value individuals rather than institutions has been gaining interest since 2001 (Severance, Hardin, & Whyte, 2008). Many VLEs have made extensions to provide collaborative tools and support extra functionality; however, these added features tend to be proprietary and their installation restricted to the institution itself.

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ii http://fees.inf.puc-rio.br/

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