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ALIGNING INFORMATION TECHNOLOGY EDUCATION & EMPLOYMENT IN DEVELOPING COUNTRIES: A CASE STUDY OF PAKISTAN

Ashraf Shirani, San Jose State University, ashraf.shirani@sjsu.edu
Malu Roldan, San Jose State University, malu.roldan@sjsu.edu

ABSTRACT

Rapidly accelerating advances in information and communication technologies have profound social, economic, and geo-political impacts worldwide. This study, which is part of an ongoing global collaboration, examines the state of information technology (IT) education and employment in Pakistan. Analysis of the data collected through a survey of IT graduates in Pakistan and other sources indicate possible gender and geographic imbalances in the supply and demand for IT skills in the country. An information technology education maturity model is used to objectively assess the adequacy of computing education in the country with a view to prepare graduates for jobs within the country and worldwide. It is hoped that the findings and recommendations of this study would be of use in other developing countries, especially those that are at similar stages of development.

Keywords: Information Technology Education, IT Workforce, IT Curriculum, Global IT Employment

INTRODUCTION

According to the International Monetary Fund [11], Pakistan is one of the emerging economies of the world, and based on the country's national income and infrastructure, the country is considered a secondary emerging market by the FTSE Group of the London Stock Exchange [7]. With an estimated current population of 196 million, Pakistan is the 6th largest country in the world [21]. This paper presents a review of the state of IT education and employment in Pakistan.

Information, computing, and communication technologies have been evolving rapidly for quite some time, though the pace of change has accelerated in recent years and is expected to increase at an increasing rate. Commensurate with as well as independent of these changes, organizational processes and new business models are employing information technology more intensively and often in unprecedented ways. At the same time, higher education in IT as well as most other disciplines is undergoing a sea-change. New approaches to creating and delivering content are exciting and also challenging traditional institutions of higher education worldwide to adapt quickly or risk losing relevance and appeal for new generations of learners. The cumulative effect of these developments, in turn, is likely to have profound impact on education and employment of IT graduates – today and for the foreseeable future. For the purpose of this study, information technology is defined as "degree programs that prepare students to meet the computer technology needs of business, government, healthcare, schools, and other kinds of organizations" [1]. Also, the terms *computing*, *IT,* and *technology* are used interchangeably and as umbrella terms for a number of constituting disciplines including computer science, software engineering, and information systems.

From the global perspective, however, the aforementioned developments are asymmetric. Almost by their very definition, less developed countries are generally behind their developed counterparts in incorporating technology into their business processes and preparing IT graduates to participate competently in the global workplace. Developing countries are likely to continue to recede further unless they address these new realities and do so soon. The growing disparity between developed and developing countries in their capacity to utilize IT and capability to adequately train IT workforce is likely to have profound economic, social, and geo-political consequences.

This study is part of a global initiative to develop capability and infrastructure to enhance distance education in Pakistan. It is hoped that lessons learned in implementing the project, known as Pakistan Distance Education Enhancement Program (PDEEP), would be adapted for use by other countries that are at the stage of development similar to that of Pakistan. Sponsored by the US Department of State, the PDEEP project aims "to enable San Jose State University in California to partner with Allama Iqbal Open University (AIOU) in Pakistan with the goal of increasing the efficiency and effectiveness of globally networked distance education in both countries" [15].

Through a number of interrelated initiatives, the PDEEP project is engaged in supporting the AIOU's mission as an open university to deliver higher education throughout the country. Enhancing the delivery of world-class online *computing* education is one such initiative. To facilitate work on this objective, it is essential to examine and understand the current state of computing education and employment in the country. The aim of this research is to help provide such an understanding. Specifically, it views computing education and employment as two sides of the same coin and attempts to present a recent, unified view of both. The findings of this study should be of use to policy and decision makers in the fields of workforce development and computing education and curriculum design in formulating strategic and short-term plans and timelines to narrow the gap between Pakistan and more advanced economies in computing capability and utilization.

Data for this study were collected through an online anonymous survey of IT graduates in Pakistan and publicly available sources such as international organizations and employment websites. The authors use an IT education maturity model for examining the current state of IT education in Pakistan in terms of its preparedness to respond to the IT workforce demand and make recommendations for preparing IT graduates to meet domestic and global IT workforce expectations.

Survey Methodology and Profile of Respondents

An IT education and employment survey was prepared by the authors. The first version of the survey instrument was reviewed and pre-tested by PDEEP members, IT educators, and IT graduates in Pakistan. Using the feedback from pre-testing, the survey instrument was subsequently revised. Major modifications included reformatting the survey, excluding or consolidating questions, using academic and employment related terminology consistent with the country's education system and work environment, and re-wording questions to make them culturally appropriate. The final version of the survey instrument was then reviewed and approved by the San Jose State University's Human Subjects Institutional Review Board.

The project manager of the PDEEP project and faculty at Pakistan's Allama Iqbal Open University (AIOU) distributed a link to the survey to a large number of IT graduates in the country requesting their participation. After about one month of initial request, a reminder was sent to all individuals on the mailing list. From August through December 2013, a total of 51 graduates filled out the online survey. Two respondents opted out after answering a few initial questions and thus only the remaining 49 responses were used for data analysis. The response rate was moderately low and hence the survey results, though they render a good high level view of the overall IT education and employment landscape in the country, be interpreted accordingly. Table 1 shows demographics of the respondents.

Table1. Demographics of Survey Respondents

Attribute	Count	%
Gender		
Male	48	98%
Female	1	2%
Age Group		
Less than 25 years old	4	8%
25-34 years	29	59%
35-54 years	15	31%
55 years and older	1	2%
Residence by Province		
Islamabad Capital Territory	21	49%
Punjab	15	35%
Khyber Pakhunkhwa	3	7%
Sindh	2	5%
Federally Administered Tribal Areas	1	2%
Azad Kashmir	1	2%
Balochiatan	0	0%
Gilgit-Baltistan	0	0%
Total		**100%**

Source: Survey conducted by the authors

A quick look at the demographics reveals significant differences among the survey respondents, especially in terms of gender and residence. Not discounting any possible sample selection bias, females are disproportionately under-represented perhaps due to cultural norms, the nature of technical education and employment conditions, or simply hesitance in responding to the survey. Future research would attempt to investigate possible reasons. Also, most IT graduates tend to reside in large urban centers (the Islamabad capital territory) and more populous provinces (e.g., Punjab) possibly because most IT employment opportunities are concentrated in those areas. Both of these findings have important policy implications for delivering education and employment opportunities.

The following section of the paper focuses on IT education. It includes a review of current IT education in Pakistan and examines various technology disciplines in terms of an information technology maturity framework. The third section discusses IT employment and demand for the leading technology skills in the country and compares sample jobs data with that from a developed country, the US, to gain a better perspective on the adequacy of job openings. Challenges, opportunities, and recommendations are presented in the concluding section of the paper.

INFORMATION TECHNOLOGY EDUCATION

Under the broad umbrella of *computing*, a number of academic disciplines have emerged over the years including computer engineering, computer science, information systems, software engineering, and information technology [20]. Along with unique and defining characteristics of each of these disciplines, there is inevitable overlap among knowledge areas within these programs. In a recent study, the Association for Computing Machinery [1] has attempted to delineate various computing disciplines in terms of two dimensions: a continuum of theoretical vs. applied knowledge; and focus on computer hardware and architecture to organizational and people issues. In this characterization, computer engineering and computer science focus more on theory, principles, and innovation, whereas the other three disciplines primarily address user and organizational issues associated with design, development, and application of technology.

In order to address the specific objectives of the PDEEP project, which include enhancing content and delivery of computing education in Pakistan, we use an information technology education maturity model (ITEMM) to examine the current state of IT education in Pakistan [19].

The ITEMM Framework

Various maturity models have been used by researchers, policy makers, and managers to assess a technology, business process, organization, or system for its "maturity" or level with respect to some benchmark and to help in quality improvement [14]. Originally developed by the US Department of Defense to evaluate vendors, such models have been developed for and used in a number of different domains. For maturity models in information systems, for example, Becker et al. [3] provide a classification based on their review of 117 such models. Maturity models and frameworks typically embody a set of predefined, *progressively advancing* stages in achieving the desired or mature stage or a state of excellence (e.g., [13]). However, not all researchers agree on the feasibility of evolutionistic approaches or stage models [12]. Besides, excellence and maturity are relative terms whose metrics and targets continue to evolve over time. This is especially the case in business processes and systems in today's rapidly changing technology and business environments.

The ITEMM framework is thus used as a point of departure from the stage-based notion of maturity. The IT education landscape is continuously morphing and evolving and is not expected to reach an optimum end stage any time soon. This model, instead, helps provide a reference in time and geography to gauge progress of an IT education system over time and compare it with other such systems.

This framework is partly based on the ACM articulation [2, 6] of categories of computing education along with placement of each category in a two dimensional space comprising of the following dimensions: one of the dimensions places computing knowledge areas on a continuum that ranges from theory and principles at one end to application deployment and configuration at the other. The second dimension represents the level of granularity of the knowledge areas, ranging from computer hardware and architecture to focus on organizational issues. The

ITEMM framework collapses these two dimensions into one: the extent to which the focus of a computing discipline or knowledge area is on its application in organizational and societal settings, versus theory and principles. It also adds a new dimension representing the level of specialization and/or advancement of knowledge in the discipline. Doing so helps in identifying education and training needs more readily. As one moves higher on the vertical axis (Figure 2), it indicates availability of advanced degree programs such as master's and doctoral degrees. The same axis also helps in evaluating availability or the need for providing more specialized education in the underlying applied domains such as bio-informatics, genetics, neuroscience, pharmacology, cryptography, business analytics, and so on. This second dimension is particularly useful given the overall objectives of the ITEEM framework, listed below:

- Provide guidance and direction for IT education policy makers, curriculum designers, and workforce development managers by comparing supply and demand of IT graduates in specific disciplines and specialties in the two-dimensional space of the framework.
- Facilitate benchmarking an IT education system against a more advanced system to help guide policy and programs for curriculum enhancement.
- Help gauge progress, over time, of an IT education system.

The five categories of the computing disciplines specified by the ACM include *computer science*, *computer engineering*, *software engineering*, *information technology*, and *information systems*. *Computer science* "largely focuses on the theory, design, and implementation of algorithms for manipulating data and information" [2, p. 71]. *Computer engineering* is a discipline with focus on computer hardware and related software; *software engineering* is primarily concerned with building reliable and affordable software systems; and *information technology* programs "prepare students to meet the computer technology needs of business, government, healthcare, schools, and other kinds of organizations" [6, p.2]. *Information systems* is described in IS 2010 curriculum as a discipline that shares a common core with information technology but is differentiated by its emphasis on business systems analysis and design, business process management, IT strategy and acquisition, and enterprise architecture [20]. Based on the scope of the PDEEP project, the present study examines only the four systems and software related disciplines, excluding the computer engineering category.

Computer science as a discipline "was born in the early 1940s with the confluence of algorithm theory, mathematical logic, and the invention of the stored-program electronic computer." [5]. It formally became an academic discipline in the US in 1962 when Purdue University established the first computer science department. Perhaps because of its origins in mathematics and later the use of electronic and digital technologies, its focus continues to be on teaching and advancing theory, concepts, and practice of the profession. Over the years, the computing discipline has contributed greatly and continues to do so in most other fields in the service of individuals, organizations, and society. Recognizing the need for workers who understand the technology and are also knowledgeable in the functional area of the organization, various applied and specialized computing sub-fields and academic disciplines have emerged in recent years - prominent among these are *software engineering* and *information systems*. Though the names, teaching, and practice of these fields vary slightly worldwide, it is generally recognized that software engineering is nearer the computer science end of the continuum while information systems lies towards the applied end of it (Figure 2). The relatively new discipline of *information technology*, due to its focus on end-user computing and support, is placed towards the applied end of the horizontal dimension.

IT Education in Pakistan

The survey data pertaining to self-reported IT education by discipline and level of the degree program is depicted in Figure 1. Since the data in this figure (and reported elsewhere in the paper) is based on sample data of 49 respondents, it should be interpreted accordingly. Figure 1 more accurately shows *relative* combination of degrees by discipline rather than absolute figures.

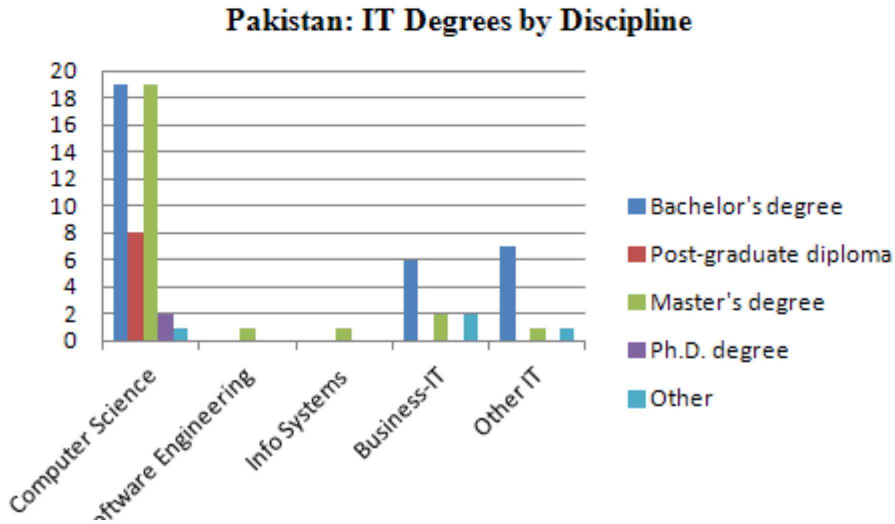

Figure 1. IT Education Survey: Degrees by Discipline

In order to examine the relative mix of IT graduates in Pakistan in terms of the two dimensions in the ITEMM framework, we overlaid the survey data onto the framework as shown in Figure 2. The shaded areas within the diagram represent *relative* prevalence of IT degrees and their levels of specialization and/or advancement along with the extent to which they are foundational or applied.

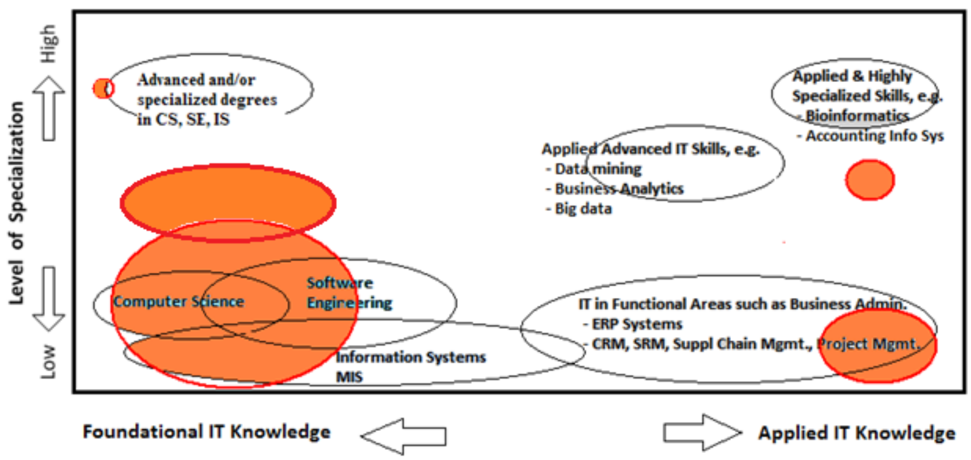

Figure 2. IT Education in Pakistan Depicted in the IT Education Maturity Model Framework
Sources: Model adapted from [19]; relative size of the disciplines based on survey data

As shown in Figure 2, the most IT graduates (65% of the total) hold bachelor's degrees (lowest levels on the vertical axis) in computer science (lower left corner) and information systems or information technology (lower right corner). Also, a relatively large proportion of the respondents (38.8%) have master's degrees in computer science. There are fewer (6.1%) graduates with an MBA or another master's degree with specialization in IT as depicted in the shaded area in the middle-right side of the diagram. There are still fewer (4.1%) graduates that hold any advanced degrees such as a Ph.D. in computer science or information systems.

Overall, the survey results, viewed in terms of the ITEMM framework indicate great potential for expanding meaningful IT education in more specialized and advanced areas of information technology – in both the computer science and applied categories.

INFORMATION TECHNOLOGY EMPLOYMENT

An important objective of the PDEEP project is to prepare IT graduates for meaningful work. This requires parallel and coordinated efforts on both the education and employment fronts.

Among the survey respondents, 67.85% agree or strongly agree that they themselves chose to study information technology or it was recommended to them by counselors and friends for favorable employment related attributes of the field. Eighty-four percent reported having a full-time job, 8% part-time job, and another 8% were jobless. About 58% of the respondents reported having secured a job within 6 months of their graduation. As to whether their college or university education prepared them well for their IT jobs, 49% reported that their education was effective while 25% said it was ineffective.

To gain an independent perspective on the demand for IT jobs, we compared the number of ads for the same job tiles in Pakistan with those in a developed country - the US in this case. Among the two leading job websites for IT jobs in Pakistan and the US are www.Rozee.pk and www.dice.com, respectively [18]. A list of 23 leading IT job titles in eight categories was selected from a recent study of technology jobs by Robert Half Technology [16], a leading provider of skilled technology professionals in the US.

Figure 3 and Table 2 display job ads per 100 million of population in each country using population data from the US Census Bureau [21] with current US population as 319 million and Pakistan population as 196 million.
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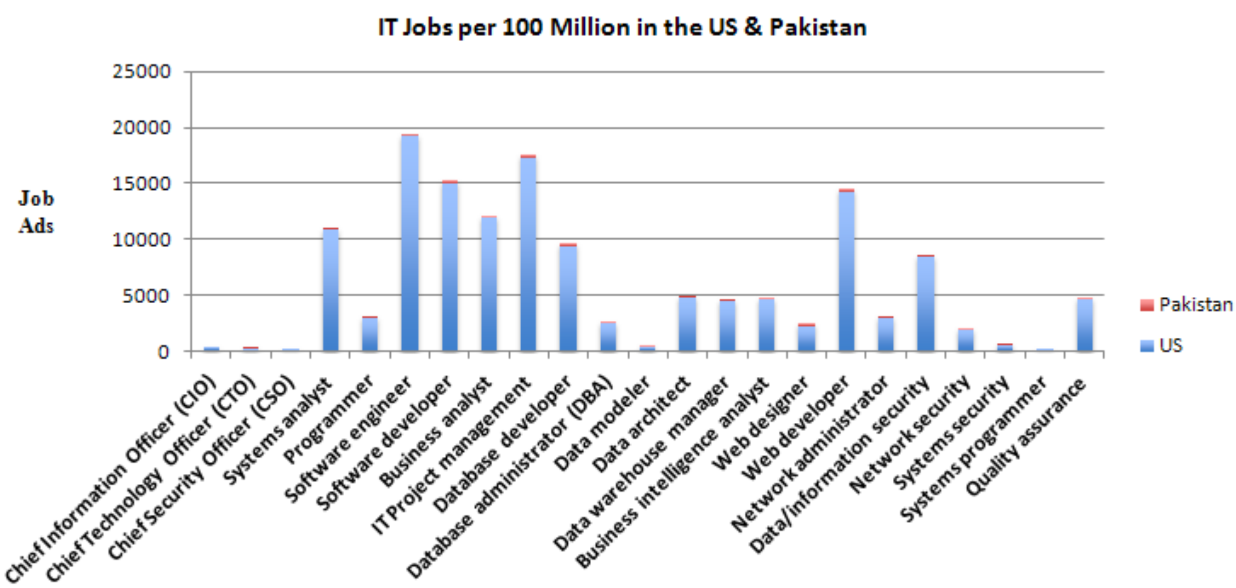

Figure 3. A Comparison of Demand for the IT skills in Pakistan and the US

Sources: US Job ads data are from www.dice.com. Pakistan job ads data are from www.Rozee.pk
Note: The data were obtained from the respective websites at the same time on May 9, 2014 in the US; the date at that time in Pakistan was May 10, 2014.

Table 2. A Comparison of Demand for the IT skills in Pakistan and the US

CATEGORY	Titles and terms used for job ads search	US (Ads per 100 million of population) Source: http://www.dice.com	Pakistan (Ads per 100 million of population) Source: www.Rozee.pk
IT Administration	Chief Information Officer (CIO)	105.02	0.00
	Chief Technology Officer (CTO)	89.34	1.53
	Chief Security Officer (CSO)	27.59	0.00
Application and Software Development	Systems analyst	3,413.17	10.20
	Programmer	936.68	31.63
	Software engineer	6,038.87	97.45
	Software developer	4,711.60	171.43
	Business analyst	3,766.46	69.90
	IT Project management	5,420.38	147.96
Data/Database Administration	Database developer	2,940.44	108.67
	Database administrator (DBA)	795.92	14.80
	Data modeler	115.67	13.78
	Data architect	1,481.82	3.06
	Data warehouse manager	1,399.06	5.10
	Business intelligence analyst	1,463.32	3.57
Internet and E-Commerce	Web designer	684.33	146.94
	Web developer	4,448.28	187.24
Networking & Telecommunications	Network administrator	949.53	19.39
Security	Data/information security	2,636.36	4.08
	Network security	605.96	3.06
	Systems security	141.38	1.53
Operations	Systems programmer	29.15	0.00
Quality Assurance	Quality assurance	1,436.68	18.88
Total:		43,636.99	1,060.20

Sources: US Job ads data are from www.dice.com. Pakistan job ads data are from www.Rozee.pk
Note: The data were obtained from the respective websites at the same time on May 9, 2014 in the US; the date at that time in Pakistan was May 10, 2014.

A look at the data in the table and the graphics above reveals a glaring difference in relative demand for all of the IT skills between the two countries. The data should, however, be interpreted cautiously since not all jobs are advertised on the selected two websites and some jobs are not advertised at all, especially in Pakistan and other developing countries. However, these data are a reasonably good indicator of *relative* mismatch in the magnitude of the demand between the two economies. At the same time, this mismatch represents a great potential for developing these skills for jobs within the country and possibly abroad. Since demand for IT skills is largely a reflection of the absorptive capacity and stage of development of the economy, policies and programs in various sectors of the economy would need to be coordinated to work towards enhancing the demand by integrating IT in more business processes and training adequate IT graduates to meet the resulting demand.

DISCUSSION: CHALLENGES AND OPPORTUNITIES

Data and analyses in the foregoing sections indicate both challenges and opportunities. One recurring theme in this and a number of other studies often is that some developing countries tend to exhibit gender and geographic disparities in education and employment. Although the focus of this study is on information technology, the Government of Pakistan and other developing countries would need to initiate broader structural changes to help transform their economies from primarily agrarian to more service and knowledge based economies. As the data in Table 3 shows, Pakistan as well as a number of other developing countries, large proportions of total workforce are employed in the agriculture sector, which often tends to be subsistence agriculture providing meagre incomes.

Table 3. Employment By sector in Selected Countries

	Agriculture			**Industry**			**Services**		
	% of Total	**Male**	**Female**	**% of Total**	**Male**	**Female**	**% of Total**	**Male**	**Female**
Pakistan	48.1%	65.0%	35.0%	16.0%	86.3%	13.7%	35.9%	94.0%	6.0%
Afghanistan	54.7%	79.5%	20.5%	13.1%	86.9%	13.1%	32.3%	91.8%	8.2%
Bangladesh	54.6%	37.2%	62.8%	13.7%	83.9%	16.1%	31.7%	88.9%	11.1%
India	45.1%	69.4%	30.6%	25.8%	79.4%	20.6%	29.1%	82.7%	17.3%
China	32.9%	53.4%	46.6%	29.6%	59.4%	40.6%	37.5%	55.6%	44.4%
Philippines	32.1%	75.6%	24.4%	15.2%	69.1%	30.9%	52.7%	48.6%	51.4%
Malaysia	13.8%	71.5%	28.5%	27.6%	73.6%	26.4%	58.7%	53.4%	46.6%
Indonesia	36.5%	66.0%	34.0%	20.3%	64.8%	35.2%	43.2%	58.2%	41.8%
Japan	3.8%	65.1%	34.9%	27.6%	76.7%	23.3%	68.5%	49.4%	50.6%
USA	1.6%	76.2%	23.8%	18.4%	77.9%	22.1%	80.0%	47.6%	52.4%
Developed economies	3.6%	66.2%	33.8%	22.5%	77.4%	22.6%	73.9%	47.0%	53.0%

Source: ILO [9]

Data also indicate large gender gaps in labor force participation rates (Figures 3a and 3b). Information and communication technologies offer one viable path to such transformation by enabling "virtual" mobility of the workforce within the country as well as globally. Online education can further help overcome gender and geographic inequities in providing education.

Figure 3a. Overall Labor Force Participation Rates by Gender
Source: ILO [10]

Figure 3b. Youth Labor Force Participation Rates by Gender
Source: ILO [10]

More than half of Pakistan's population is 15 to 29 years old [9]. The significantly large youth population presents a unique opportunity for the country if it is adequately trained and provided the opportunity to participate in the country's economy as active workforce. Under- and un-employment as well as high gender inequity (as shown in Figure 3b above) can, however, pose major challenges now and in the future. Prior work in the areas of workplace deviance and exclusion can help inform future research in understanding and working towards alleviating gender and regional imbalances (e.g., [17]).

The global demographic trends indicate an over-supply of labor force in developing countries and an oncoming shortage of skilled labor in more developed economies – in some because of their shrinking populations and others due to expanding knowledge based economies. Quality assurance is one major hurdle that developing countries face today in placing their graduates worldwide or participating in globally outsourced IT projects. Most of their academic programs are not accredited by globally trusted accrediting organizations. Until selective IT programs are accredited by globally recognized accreditation agencies, one common currency that lends credibility to the skills of IT graduates is certifications by the industry or leading IT companies. Among the survey respondents, for example, four reported Microsoft and CISCO certification credentials including MCSE, MCDBA, and CCNA.

In the current phase of the project, PDEEP is collaborating with Allama Iqbal Open University (AIOU) in Pakistan to build necessary infrastructure for delivering IT education online. As an "open" university, AIOU has traditionally delivered academic materials to its learners located all over the country through postal service, first in print format and later on CDs and DVDs. Online education would bring IT education in the country one step closer to the current world-class content.

Pakistan and other countries could potentially be beneficiaries of one of the leading "disruptive" technologies of the day – the new academic business model — massive open online courses or MOOCs. With minimal or no cost to learners and low marginal costs to content providers, MOOCs promise to deliver highly rated online education worldwide. One major obstacle that MOOCs face today and that they are working to overcome is the accreditation of their courses [4]. The American Council on Education has recommended for accreditation five courses offered by *Coursera*, the largest of the three major MOOC competitors. AIOU and other academic institutions throughout the world need to prepare to weave high-quality MOOC offerings into their curricula.

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