
Dr. Salahuddin Qazi, State University of New York, Institute of Tech.

Salahuddin (Sala) Qazi holds a Ph.D., degree in electrical engineering from the University of Technology, Loughborough, U.K. He is a full Professor (Emeritus) and past chair in the School of Information Systems and Engineering Technology at the State University of New York Institute of Technology, Utica. Dr. Qazi has published several articles, book chapters in the area of fiber doped amplifiers, wireless security, MEMS based wireless communications and Nanotechnology for photovoltaic energy. He is a member of ASEE and a senior life member of IEEE.

Dr. Adeel Khalid, Southern Polytechnic State University (ENG)

Dr. Adeel Khalid is an Assistant Professor of Systems Engineering at Southern Polytechnic State University (SPSU) in Marietta, Georgia USA. His expertise includes Multidisciplinary design and optimization of Aerospace systems. Dr. Khalid received his Ph.D. in Aerospace Engineering from Georgia Institute of Technology. He holds Master of Science degrees in the discipline of Mechanical Engineering from Michigan State University, and Industrial, and Aerospace Engineering from Georgia Institute of Technology. He obtained Bachelors of Science degree in Mechanical Engineering from Ghulam Ishaq Khan Institute. His academic background is notable for a strong emphasis on research and teaching.

Dr. Qaiser H Malik, National University of Sciences and Technology (NUST) Pakistan University

Qaiser H. Malik is Principal NUST Institute of Leadership in Education (NILE) and founding Head of Dept. of Engineering Education Research (DEER) at National University of Sciences and Technology (NUST), Pakistan. He has a Ph.D. in Electrical Engineering from Michigan State University. His research interests include assessment, evaluation, and cyberinfrastructure technologies in Engineering Education.
Incorporating New Trends and Teaching Methodologies: Improving State of Engineering Education in Pakistan

Abstract

There has been an exponential rise in both the government and private universities in Pakistan since the creation of the Higher Education Commission (HEC) in 2002. There are over 69 universities and colleges which are providing education in Engineering and Technology in the country of approximately 180 million people. At the time of independence in 1947 from United Kingdom there was no engineering university and barely a few engineering colleges. According to one estimate, Pakistan produces about 445,000 university graduates and 10,000 computer science graduates per year.

The paper reviews the state of engineering education in Pakistan. It also presents a set of pedagogical techniques, tools and methodologies to foster the growth of the scholarship of teaching and learning in engineering education. Engineering and technology plays an important role in the development of a country by creating jobs and helping to improve the standard of living. The job of educating engineers however has become more challenging on the face of addressing issues such as poverty reduction, sustainable development, disaster response, climate change, reconstruction and risk reduction. These challenges are further compounded with new trends of learning and teaching in engineering education. The learning is not only knowledge acquisition or participation in a social community but also about knowledge creation as in the case of project based learning. Similarly the new developments in electronic media are leading to enormous challenges for teachers in regards to the role digital devices can and should play in the learning process. For some educators, the view is that technology should only be utilized as a tool to help facilitate student understanding and mastery of the current curriculum. Whereas for other educators, technology is as fundamental to learning as reading and writing and therefore must become an integral segment of the school curriculum. The paper also discusses new trends and teaching methodologies to help improve the state of engineering education in Pakistan.

Introduction

Pakistan was created in August 1947 by the partition of British India, and had a population of around 30 million. The British rule in regions that became Pakistan was considered the periphery of the British Raj in India. The overall literacy rate at the time of independence was under 10% with more than 85% population living in the villages. There was only one university, a few colleges and no engineering university. The only university, the University of the Punjab existed as a state institution established in 1882 at Lahore. There were two engineering colleges namely the “Mughalpura Technical College” started in 1921 and later became the Maclagan Engineering College in 1923. The second engineering college is the oldest privately funded institution established in 1922 at Karachi. It was named NED College after its principal donor Nadirshaw Edulji Dinshaw (NED). The NED College later became NED University. The urgency of scientific and technical education was explicitly emphasized by the founder of the nation, Quaid-e-Azam Muhammad Ali Jinnah to the participants of First National Education Conference on November 1947 in the following words.
“Education does not merely mean academic education, there is an immediate and urgent need for giving scientific and technical education to our people in order to build up our future economic life and to see that our people takes to science, commerce, trade and particularly to well-planned industries. We should not forget that we have to compete with the world which is moving very fast on this direction.”

On the recommendation of the conference, a council was formed in June 1948 to look into the affairs of technical education and establishment of Polytechnics throughout the country. The Government of Pakistan placed high priority in setting up these technical institutions with the objectives of increasing access of rural youth to technical and vocational education to cater the contemporary and future needs of the country and improve the job skills and means of livelihood. A three years program leading to Diploma of Associate Engineer (DAE) was introduced with the core objective of making technicians to perform broad range of functions at middle supervisory level to bridge the gap between semi-skilled workers and the Engineers. In the late seventies a number of polytechnics were upgraded to Colleges of Technology for offering Bachelor of Technology (B.Tech) program through affiliation with recognized universities in the province. Since then many private and Government institutions of higher education have been established in the country. In the early 1970s all educational institutions were nationalized until the beginning of 1980s. The number of private institutions exploded at the end of 1990s as a result of higher demand of higher education. The country went through several education policies and reforms in which several polytechnics were upgraded to college of technology and engineering colleges into university of engineering & technology (UETs). Currently there are over 55 private degree-awarding institutions and around hundred government degree awarding institutions. The universities of engineering and technology offer engineering programs at the undergraduate and graduate levels unlike the college of technology and polytechnics which offer degree or diplomas in technology. The UETs offer programs at several locations throughout a particular province.

State of Engineering Education in Pakistan

The Pakistan Engineering Council (PEC) lists accredited 59 engineering colleges and universities in Pakistan. PEC, established in 1976, is a statutory body which has successfully accredited and evolved an effective system for assessing quality of engineering programs. There is currently one or more university of engineering and technology in all the four provinces of Pakistan and Azad Jamu Kashmir. These universities were upgraded from engineering colleges and offer undergraduate and graduate courses at several locations as listed below:

- University of Engineering & Technology at Lahore was established in 1921 and is the oldest engineering educational institution of Pakistan, which was affiliated in 1932 with the University of the Punjab for award of a Bachelor's Degree in Engineering. UET Lahore has campuses in other cities of Panjab such as Kala Shah Kaku, Faisalabad, and Gujranwala. It offers 29 undergraduate and 55 graduate programs including PhDs in a number of disciplines. UET Lahore established an engineering college at Taxila, in 1975, which later became an independent university in 1998 by the name of University of Engineering and Technology, Taxila.
- NED University of Engineering and Technology is a state owned school that started with privately-donated funds in 1922 and still carries the initials of principal donor of Nadirshaw Edulji Dinshwa. NED University of engineering and technology presently offers undergraduate programs in twenty five engineering disciplines and thirty four Master’s level graduate programs.\(^\text{3}\)

- University of engineering and technology at Peshawar started as an engineering college in 1952 as a constituent college of the university of Peshawar. The college was granted a charter to operate as an independent engineering university in 1980 under the name NWFP University of Engineering and currently has three satellite campuses in Abbottabad, Bannu and Mardan. The university UET Peshawar has joint research, faculty and student training and exchange programs with several North American, European and Asian universities.\(^\text{6}\)

- Quaid-e-Awam University of Engineering & Technology (QUEST) was established at Jamshoro in 1963 as Engineering College of Sind University. It was upgraded to Quaid-e-Awam University of Engineering & Technology in 1996 and was moved to Nawanshah. The university has undergraduate and post-graduate programs in various engineering disciplines as well as basic sciences, mathematics and statistics.\(^\text{7}\)

- Balochistan University of Engineering and Technology, at Khuzdar was founded in 1987-88 as a constituent engineering college of Balochistan university. The college was upgraded in 1994 to become Balochistan University of engineering and technology (BUET). The university offers Bachelor degrees under these four departments, Electrical Engineering, Mechanical Engineering, Civil Engineering and Computer Systems Engineering.\(^\text{8}\)

- The Ghulam Ishaq Khan Institute of Engineering Sciences and Technology (GIKI) was founded in December 1985 by the donations from the Benevolent Community Care and Infaq Foundation for setting up an institute in the Khyber Pakhtunkhwa for promotion of science and technology. It is named after the president of the country who was also elected the president for the Society for the Promotion of Engineering Sciences and Technology in Pakistan (SOPREST) in 1988. There are five programs in the area of computer science and engineering, electronic engineering, mechanical engineering, material science engineering and engineering sciences at the undergraduate level.\(^\text{9}\)

- National University of Sciences and Technology (NUST) is a state owned university that was founded in 1981 to train members of the Pakistani armed forces by combing other institutes and colleges. It was chartered in 1993 and moved its headquarters from Rawalpindi to Islamabad in 2008. NUST is a multi-school university with campuses in Karachi, Rawalpindi and Risalpur. It offers undergraduate and postgraduate degrees leading to PhD in the fields of engineering, information technology, management and medical sciences.\(^\text{10}\)

Engineering education leading to advanced degrees in Pakistan was largely neglected in favor of producing engineers at the Bachelor level. Until 2000, only about 10 PhDs were produced from engineering institutions. In 2001 under the instruction of newly appointed Federal minister, the ministry of science and technology (MOST) decided to create major endowments for each of the government engineering universities in order to promote research. In 2002 the Government of Pakistan established Higher Education Commission (HEC). It gave the highest priority to engineering sciences by adopting new measures and allocating funds to strengthen the engineering institutions, updating libraries, laboratories and computing facilities. Thousands of students were sent abroad for PhDs. In the subsequent 9-year period, from 2002 to 2011, four
thousand PhDs were produced and the number of engineering institutions increased to sixty nine. These efforts also resulted in bringing the ranking of the Pakistani engineering universities NUST and UET Lahore at 274 and 281 respectively in engineering sciences in the world.\textsuperscript{11, 12} According to current chairman of HEC the number of faculty with Ph.D., degrees has doubled in the last five years, but even then, hardly 20\% of the faculty has Ph.D., degrees in the higher education institutions. Pakistan needs to triple this number by 2015. This will increase the number of Ph.D. faculty to at least 40\% by 2015.\textsuperscript{13}

In 2003 MOST and the US Department of State signed a comprehensive Science and Technology Cooperation Agreement that established a framework to increase cooperation in science, technology, engineering and education for mutual benefit and peaceful purposes between the science and education communities in both countries. This was followed by the US Agency for International Development (USAID) joining in 2005 with MOST and HEC of Pakistan to support the joint Pakistan-U.S. Science and Technology Cooperation Program. The program objectives include improving the quality, relevance, or capacity of education and research at Pakistani institutions of higher education in science and technical fields and increasing the capacity of science and technology to improve the well-being of ordinary Pakistani people. Over 70 projects have started between 2005 to 2009 in 4 phases in different field of science and engineering. In 2012 Pakistan and the United States have renewed science collaboration for phase 5 in a range of sectors like agriculture, university education, water and renewable energy by pledging additional funds by each partner.\textsuperscript{14, 15}

To further the cause of engineering education in Pakistan, NUST (National University of Science and Technology) has introduced a new discipline of engineering education research (EER) in August 2011 which will be followed by the establishment of a full department in 2014 within the NUST Institute of leadership in Education. The purpose of such a department will be first to use it as a catalyst in transforming engineering students into active learners with the aim to produces world class engineers and second to offer graduate programs for engineers to become professional engineering educators. These objectives are planned to be accomplished as part of their respective engineering programs offered at NUST. Short undergraduate courses in engineering education research are already being offered and graduate programs are planned for subsequent semesters. Contacts are made to collaborate with the renowned US universities having programs in engineering education research.\textsuperscript{16}

**Challenges and Trends of Engineering Education**

Despite efforts of the Pakistani Government and private sectors the numbers of engineering institutions are limited in a country of over 180 million where more than 63\% of the population is under the age of 25 years.\textsuperscript{17} The country spends around 2\% of GNP on education. Due to the shortage of seats in the engineering institutions only a select number of candidates are enrolled. Many of the trained engineers immigrate to other countries in pursuit of better opportunities causing shortage of young engineers. The ones that stay in the country are often attracted to lucrative multinational corporations and high level government jobs and not inclined to academia. This coupled with lack of opportunity for advanced research creates shortage of faculty especially in the new areas of engineering and technology. A study was recently conducted to investigate the quality of Pakistani university graduates in terms of professional, intellectual,
personal, social and organizational skills. The result of study found that employers from industries ranging from IT, oil & gas, glass & ceramics, banking, food, cement and automobile were unanimously dissatisfied with the graduates possessing these skills. This result is attributed to the state of teaching and learning in Pakistani universities where students learn by rote memory and lack problem solving skills that could lead to creativity and innovation. It also attributes to inadequate curriculum and deficiencies of teaching ability of faculty in instructional, professional and organizational skills. The capable faculty leaves the country due to lack of facilities for quality research. These deficiencies combined with new challenges of engineering education are making the state of engineering education in Pakistan more complex and demanding. These challenges include among others the broadening of engineering education in order to address global problems such as energy, health care, environment, populations, food, poverty alleviation, security, disaster recovery, and conflicts etc. Most of these challenges are met or will be met by finding engineering solutions. According to Waitz of MIT, this breath is apparent across many time zones, cultures, dimensions, length-scales, and disciplines within engineering not traditionally considered being part of engineering. This means that the future engineers have to work collaboratively to solve these challenges. The US national academy of engineering (NAE) has listed the following fourteen challenges which are related to engineering, technology and science.

1. Make solar energy economical
2. Provide energy from fusion
3. Develop carbon sequestration methods
4. Manage the nitrogen cycle
5. Provide access to clean water
6. Restore and improve urban infrastructure
7. Advance health informatics
8. Engineer better medicines
9. Reverse-engineer the brain
10. Prevent nuclear terror
11. Secure cyberspace
12. Enhance virtual reality
13. Advance personalized learning
14. Engineer the tools of scientific discovery

Additional challenges are emerging from new modes of communications and interconnectedness, knowledge production and ever changing technology landscape and information. Engineering students in Pakistan could be introduced to these challenges so they understand the broader picture and could use their potential to help solve the real world problems. It is also important to understand how the information technology can be used to improve and enhance learning and teaching to educate engineers by departing from the traditional ways. The engineers of the future not only need to be knowledgeable in their own disciplines, but also need a new set of skills to thrive in a world of complexity, volatility, uncertainty and ambiguity where there will be risks as well as opportunities.

The Committee on Engineering Education of the National Academy of Engineering completed a two-phase vision-casting initiative on engineering in the future and educating engineers to meet the needs of the new era Engineer of 2020. The report on “The Engineer of 2020: Vision of
“Engineering in the New Century” completed in 2004, and “Educating the Engineer of 2020: Adapting Engineering Education to the New Century” completed in 2005 discusses various future scenarios based on scientific and technological trends for United States to maintain its economic competitiveness and improve the quality of life for people around the world. It also identifies ideal attributes of the engineer of 2020, and recommends ways to improve training to prepare engineers for addressing the complex technical, social, and ethical questions raised by emerging technologies.\textsuperscript{22,23} Many engineering institutions in the US are trying to update their curriculums and practices to meet the recommendations set by the report. Agogino\textsuperscript{http}\textsuperscript{24} from University of California, Berkley, summarized the changing role of engineers as a result of globalization of industry and engineering practice; shift of engineering employment from large companies to small and medium-sized companies, and the growing emphasis on entrepreneurialism; growing share of engineering employment in nontraditional, less-technical engineering work (e.g., management, finance, marketing, policy); shift to a knowledge-based “services” economy and increasing opportunity for using technology in the education and work of the engineer. The author further lists the following successful attributes for the Engineer of 2020.

- Possess strong analytical skills
- Exhibit practical ingenuity; posses’ creativity
- Good communication skills with multiple stakeholders
- Business and management skills; Leadership abilities
- High ethical standards and a strong sense of professionalism
- Dynamic/agile/resilient/flexible
- Lifelong learners
- Ability to frame problems, putting them in a socio-technical and operational context

For engineering educators in Pakistan, it is important to recognize these attributes so they can inculcate them in the emerging workforce of global engineers.

Improving the Quality of Engineering Education

To overcome the above mentioned challenges in engineering education in Pakistan and to achieve the successful attributes of the engineer of 2020, it is important for affiliated faculty members and academics in general to device methods to improve the current quality of engineering education. The quality of education can be improved by the use of digital media and other high tech instruments but on the fundamental level, educating the engineering educators is of paramount value. The standard of education in engineering institutions can be significantly enhanced by the introduction of basic and advanced pedagogical techniques, tools and methodologies in the classroom. This will foster the growth of scholarship of teaching and learning. A number of effective teaching techniques are discussed in this section. Some of these techniques have been studied in detail and are being used in US institutions while others are at the exploration stage.

The Scholarship of Teaching and Learning (SoTL) is a growing movement in higher education.\textsuperscript{25} SoTL is scholarly inquiry into student learning which advances the practice of teaching by sharing this research publicly.\textsuperscript{26} Sharing the teaching style that an instructor finds useful in a
classroom is what makes it scholarship. SoTL builds on many past practices in higher education, including classroom and program assessment, the reflective practice movement, peer review of teaching, traditional educational research, and faculty development efforts to enhance teaching and learning.

In this section various methods, techniques, tools and methodologies are explored that engineering faculty members in different disciplines can use to enhance their teaching and student learning.\textsuperscript{27} It is our desire to continue to grow the list and include all possible methods to help improve student learning. Detailed description of some of these techniques is given in the following sections. These techniques are applicable in Pakistani institutions without significant infrastructure changes or financial investment.

\textbf{Teaching Methodologies and Learning Tools}

Interactive techniques, as the name implies, are intended to get the students involved in the learning experience. Active learning refers to techniques in which students do more than simply listening to a lecture. Students are “doing” something, including discovering, processing, and applying information. It is important to remember, however, that lecture does have its place and that an instructor should not do active learning without content or objectives. The elements of active learning are talking and listening, writing, reading, and reflecting.\textsuperscript{28} There may be some resistance to active learning by students who are accustomed to lectures, students who prefer passive learning, or students in large classes (who don't expect it). Bonwell assert that instructors need to prepare students. He suggests “Explain your objectives and the benefits of the active learning techniques explicitly to students. Expect both successes and failures as you try active learning techniques. Solicit feedback on the activity afterwards from the students to improve it in the future.”\textsuperscript{29} Some active learning techniques take little faculty preparation and may be done spontaneously; others require much more preparation. Active learning techniques can occur in class or outside of class (e.g., computer simulations, internships, internet based assignments, class discussion lists, and independent study research). Active learning can be used with all levels of students from first year through graduate students. Teaching a large class does not prohibit the use of active learning techniques; in fact, active learning may be especially useful in promoting interest and learning in such classes. Drueke listed nine strategies to allow for active learning.\textsuperscript{30}

1. Talking informally with students as they arrived for class.
2. Expecting that students would participate and acting accordingly.
3. Arranging the classroom to encourage participation including putting chairs in a cluster or circle.
4. Using small group discussion, questioning, and writing to allow for non-threatening methods of student participation.
5. Giving students time to give responses, not rushing them.
6. Rewarding students for participating by praising them or paraphrasing what they say.
7. Reducing anonymity by introducing yourself and asking the students for their names, and by asking the class to relate previous library experiences as you do this.
8. Drawing the students into discussions by showing the relevance of the library to their studies.
9. Allowing students time to ask questions at the end of class.

Most of these approaches are identical with minor modifications to points made by proponents of active learning. This shows that with a little effort any lecture can be turned into an active learning experience. Few examples of in-class active learning techniques used in small and large classes and with all levels of students are listed below:

- **Jigsaw**
  An innovative active learning teaching technique is called a jigsaw.\(^{31}\) Using the jigsaw, students work in groups studying an issue. Each of these groups works on a small portion of the overall issue. The jigsaw is put together when different groups report their findings to each other. This allows the entire issue to be covered in a single class but also allows for each student to be involved in learning the material.

- **Most Important / Muddiest Point**
  The Muddiest Point is not only one of the simplest classroom assessment techniques; it is also remarkably efficient, since it provides a high information return for a very low investment of time and energy.\(^{32}\) The technique consists of asking students to jot down a quick response to one question: “What was the muddiest point in________?” The focus of the Muddiest Point assessment might be a lecture, a discussion, or an assignment. The Muddiest Point technique provides information on what students find least clear or most confusing about a particular lesson or topic, which can tell faculty which points are most difficult for students to learn and to guide teaching decisions about which topics to emphasize. This technique underscores the instructor’s effort to help students master the course content and usually produces a powerful positive effect on their attendance and learning.

- **Think-Pair-Share**
  Think-pair-share is a cooperative discussion strategy that provides structure in the classroom while allowing students "think time" to internalize content. Students follow a prescribed process that keeps them on task and holds them accountable for their results. The instructor gives students a task such as a question or problem to solve, an original example to develop, etc. Students work on this 2-5 minutes alone (think). Then they discuss their ideas for 3-5 minutes with the student sitting next to them (pair). Finally, the instructor asks or chooses student pairs to share their ideas with the whole class (share). This technique has been used in classes ranging from 12 to 340 students.\(^{33}\) The immediate reinforcement this process provides allows students to move from one positive learning experience to another with little time for wandering from the task.

- **Quiz Bowl for Studying**
  Quiz bowl is an enjoyable, educational technique that uses a game format derived from the TV show *College Bowl*. In most cases, the quiz-bowl questions are based entirely on one subject, typically the subject covered in the previous lecture. But the instructor can make it interesting by including non-curricula questions. It keeps the students engaged and encourages them to actively participate in class. The amount of knowledge that students can absorb can be significant. Students learn from each other; the role of the instructor becomes that of a facilitator. Most of the participants in quiz bowl contests enjoy the experience, especially when the instructor helps them relax, laugh at their own mistakes, and get caught up in the contagious spirit of the game. Using
this technique, the individual and team efforts are recognized, providing an opportunity for students and groups to demonstrate their knowledge. While strong leadership and coaching contribute to individual or team success, individuals involved inevitably pursue their own independent learning through research for answers. Members can also learn by helping to develop questions for the quiz bowl.$^{34}$

- **Use of Multi-Media**
Multimedia has the potential to extend the amount and type of information available to learners. Multimedia can offer positives and negatives, from layers of beneficial resources to gratuitous information leading to frustration and overload—or anything in between [9]. For example, online encyclopedias can provide links to videos and additional articles on specific topics of interest. News stories can reference links to audio commentaries, replays of video footage, and links to websites with additional resources. Online instruction can include explanations, links to resources, simulations, illustrations and photographs, and myriad types of activities that can also include multiple media.$^{35}$

- **Use of Props**
Props are mental or physical images used in the classroom. When used properly, props can help students better understand the course material. They can also be used to anchor the message, to get a laugh, and to wake up the group. They reinforce the point, support humorous interaction, and introduce variety. Props can also prevent the instructor from becoming a “talking head.” The information that the instructor wants to impart can best be understood, related to and used when real examples are shown or used.

- **Candy Questions**
One of the greatest motivators to improve student behavior could be to provide an incentive or reward for active participation in class. One of the authors has used this technique in several classes over the years and has experienced that students are generally more motivated and interested in actively participating in class when they know that there is a possible reward. The instructor can ask oral questions from the material that was recently covered in class, and the student who gets the right answer gets an immediate reward. The reward not only acknowledges the active participation from students, but students also get a sense of accomplishment when they receive the reward in front of their peers. This also motivates others to actively participate. The phrase “candy question” is used here symbolically. Careful consideration should be given to messages that rewards and incentives send to the students receiving them. There are many effective ways to motivate students other than food. These include, but are not limited to, partial quiz grades, praise, extra credit, etc.

- **Mind Breaks**
Mind breaks are used to refresh the listener’s attention span during more demanding presentation components, for example, “take a 2-minute break to chat with your neighbor before we move on . . .”$^{36}$ The authors often use questions that are completely unrelated to the class; e.g., in an engineering class, an instructor might ask, “What is the capital of Canada?” This helps students who have otherwise zoned out bring their attention back to class. The exercise typically takes less than a minute, but it prepares students to listen and pay attention for the next several minutes. The authors also use “asides” during a lecture. These include items of interest that may or may not be related to the course material. Students often enjoy the asides. The author has observed that oftentimes, asides are the most important items students remember from a class. A couple of other different types of possible mind breaks include sharing the related news of the day, having students stand up or raise hands etc.
Engaged Tests

The educational literature indicates that student engagement is generally recognized as one of the better predictors of learning.\textsuperscript{37,38,39} Thus, creating classroom conditions that enhance student engagement will lead to increased student learning, which is a primary goal for both students and teachers.\textsuperscript{40} There are many ways to engage students during evaluation. Instead of traditional tests, students can be asked to record the material and present a video of their material in class. The grades can be based on their performance in the video and on peer evaluations. The videos can be uploaded to social media sites (e.g. YouTube), and students can be asked to review all the class videos outside of class. Students can also be asked to present their material in an online environment. Several institutions offer online classes that use online portals accessible to all students. These engaged tests get students motivated, oftentimes resulting in them putting in more time and effort, and therefore ending up learning and retaining the material for a longer time.

Overview, Prime, Drill, Check

Constance Knop (1982) developed a model called Overview, Prime, Drill, Check for setting up and carrying out classroom activities.\textsuperscript{41} This model applies to exercises as basic as mechanical grammar drills and as complex as small-group role-plays or listening and reading activities using authentic texts. This paradigm is useful for setting up activities, giving clear instructions, getting students "on task" right away, following through without wasting time, and checking to see that students actually understood and learned.

Overview-prime-drill-check is a strategy for helping instructors systematically and consciously plan their lessons. By using this sequence, instructors can be certain that they have included an introduction and motivation to an activity, examples and review of material necessary for conducting the activity, varied and appropriate drilling techniques, and evaluation of students' progress. This sequence gives instructors a secure base for lesson planning, and attempts in this way to reduce the insecurities and anxieties felt by many novices at the start of their teaching careers. In addition, this approach can be used as a means of analyzing the teaching and learning actually accomplished in a class. Thus, it could become an instrument for developing skill in self-critique, which may well be the most valuable and long-lasting skill that instructors can develop.

Fostering Engineering Education in Pakistan

It is a well-known fact that the economic and social growth of a country depends on the pool of engineers and scientists. Engineers are not only important for solving local problems but also in knowledge creation and knowledge transfer. The basic problems in developing countries are the weak educational and scientific infrastructure, and a lack of appreciation of the importance of science as an essential ingredient of economic and social growth. Salam\textsuperscript{42} in 1987 addressed the issue of science in developing countries by stating that it has been treated as a "marginal activity" and perceived even as an "ornament." Indeed, most of the developing countries do not realize that their situation can only be rectified with the infusion of modern science and technology into their societies. Morell et al\textsuperscript{43} of Hewlett Packard emphasizes a global approach in a flat world that is needed to innovate engineering education and establish effective process of high quality engineering education to assure a global supply of well-prepared engineering graduates who can act locally but think globally. According to a Pakistan Education Census\textsuperscript{44}
the country graduated over 10,000 engineers in 2005 with 4-year degrees and about 25,000 polytechnic graduates with three year diplomas. The number of PhDs awarded by Pakistani institutions is currently 700 per year which needs to be increased to at least 1000 by 2015 with a significant increase in science and technology disciplines\textsuperscript{13}. These number of engineering graduates fall short of the number needed for sustaining economic development and global workforce demand considering the size of the country and the number of young people seeking to enroll in engineering institutions. All this stems from a limited number of seats in majority of state engineering institutions, shortage of qualified engineering faculty and lack of Government commitment to promote engineering education. The authors feel that the following measures should be adopted to promote engineering education and increase the number of engineers and engineering institutions in Pakistan\textsuperscript{45,46,47}

1. \textit{Increase the enrollment in the existing engineering institutions}
   The majority of the engineering institutions in Pakistan are state owned with a set number of students to be enrolled. The numbers of students can be increased by offering classes in the evening and more sessions throughout the day.

2. \textit{Partnership and joint programs}
   The faculty and labs can be shared by different engineering institution and colleges. This will help to maximize the capability of the resources.

3. \textit{Use of web based and online programs}
   The shortage of faculty can be addressed by sharing the local faculty via web based instruction. This instruction can also be supplemented by the use of free on-line courses developed by Stanford, MIT and others. The use of simulation and virtual labs for different engineering disciplines can also be employed to substitute for expensive equipment. Some equipment can be shared by using remote access available locally and overseas.

4. \textit{Make use of foreign faculty}
   The foreign faculty can give short and condensed courses in the summer and winter breaks. This will help students to get exposed to the engineering institutions and method of instruction used in the developed world. It may also help the overseas universities to recruit students for advanced degrees. Many universities from the developed world use private consultants or admission administrators to recruit students from China, India and other countries.

5. \textit{Initiate engineering program in science and Information Technology (IT) colleges.}
   The number of science and IT colleges is greater than the engineering institutions in Pakistan. These colleges equipped with basic science and computing labs can add engineering programs by adding a few more labs and engineering faculty at much less cost than starting a new dedicated engineering institution.

6. \textit{Develop and offer a parallel less intense curriculum.}
   This would obviously not match the training the engineers who complete the standard curriculum would get, but it may allow for those who could not complete the regular curriculum to enter the engineering field. This may be done by developing a path between four-year engineering schools and polytechnics or college of technology already present in Pakistan.

7. \textit{Involve private sector}
   Most of the engineering institutions are state funded and are suffering with fiscal problems, which affects the enrollment of students and quality of education. A few
universities like GIKI, LUMS (Lahore University of Management Science), Islamabad University of Science and Technology and others from private sectors have started engineering programs.

8. **Make use of affordable outreach programs from the foreign countries.**

There is an increase in outreach and on-line education which can be utilized for some students who can afford it.

9. **Collaboration with industry**

Universities and industry have worked together to develop innovations that are commercially viable. It can be helpful in training the students on their equipment and employing their personnel for adjunct faculty.

10. **Create an engineering education society**

It is important to have a society of engineering education educators where people can meet, discuss and share the issues facing engineering education. This can be modeled after the American Society of Engineering Education with its annual conference, a publication and several activities throughout the year. Various engineering universities and colleges can start a chapter of ASEE in Pakistan or IEEE, ASME and others.

**Conclusions**

The paper reviews the state of engineering education in Pakistan which has established more than 69 Engineering institutions in 65 years of its creation. Pakistan, being the sixth most populated country of the world need more engineering institutions to sustain economic development and address problem of poverty, food, environment, disasters and create jobs for younger generation. The paper suggests new teaching methodologies and learning techniques on the face of new challenges sweeping the developed and developing countries. Some of these methodologies are already used in USA and can easily be applied to Pakistan without much cost to the engineering institutions. To increase the growth of engineering education in Pakistan, it is vitally important to incorporate industry, academia, government and private sector in addition to the use of on-line education as well as by sharing resources among various engineering institutions. More work is needed to undertake the case study of various efforts used to foster collaborations between Pakistani and US universities and embark in the field of engineering education research which has already started at the National University of Science and Technology in Pakistan.

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