Quest for a perfect power engineering program

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Abstract

Following a prolonged decline in enrollment and interest in power engineering, educators have formulated a variety of responses they believe will stem the tide of woes that seem to have besieged the profession. The range of creative solutions proposed in many programs are centered around what power engineering curriculum should contain, how course materials should be delivered, and how to market (or promote) the program. This paper takes a critical look at a number of studies on curriculum development and learning in higher education. It examines the role that should be given to students' conception about learning, instructors' experience and teaching philosophies, and the impact of curriculum organization on students' performance in the design and implementation of educational innovations. The best aspects of the new innovations in power engineering curriculum are then combined with other components that are deemed necessary to come up with what a model power engineering program should look like.

Introduction

Current Situation

The steady decline in enrollment and interests in power engineering area has been noticed for a while, and has lead to a devotion of concerted efforts to address various factors that lie within the realm of control or practical intervention. A summary of observations and recommendations by a panel of international expert educators have been reported by Karady et al. [1]. The current situation and needs in the field and in academia were clearly highlighted. There appears to be a recognized need for engineers with broader educational backgrounds in the new deregulated utility industry. In addition to general engineering knowledge, some breadth extending towards economics, management, and communication skills has become necessary. The environment imposes a need for flexibility by engineers, and preparedness for changing jobs and roles that may require learning new skills, and adapting to new environment. In academia several power engineering programs have been eliminated for lack of students' interest. Students perceive the field as old fashioned and out of touch, as faculty commitment steadily declines. Many universities are left with aging power engineering faculty, very few of who have significant industrial experience. Also, power engineering faculty had difficulties with promotion owing to perception about the area and scarcity of research funds.

The efforts to identify the root of the problem in the UK revealed that students' perceptions are strongly negatively influenced by what they know about electric power – old laboratory equipment, out-of-date courses and presentation, depressing images of power stations, lines, etc., a lack of proper counseling, and non-visible application of Information Technology.

The Innovations

The components of various creative solutions proposed in many programs [1-3] may be conveniently organized into three categories: (1) what power engineering curriculum should contain, (2) how course materials should be delivered, and (3) how to market (or promote) the program. This is summarized in Table 1. The active engagement of a few in the field and their innovations are commendable, they offer a vision and direction for other programs that are struggling to stay relevant.

From the range of solutions proposed however, it appears that an assumption is made that programs fail or under-perform because the contents are inadequate, delivery does not avail of new technologies, and publicity is lacking. Clearly there is some validity to these. But, is mere repackaging or presentation adequate to secure the future of the field, or sustain the interest of students who have difficulty identifying the relevance of the area? What information served as basis for the solutions proposed? Which of the stake-holders were involved in these determinations? Were assumptions made about the students' motivation, and interests? Are these responses a desperate attempt to keep alive power engineering as we know it? It is troubling that some proposals take the view that the students must be 'induced' into what they would otherwise stay away from. It therefore becomes necessary to use a fair amount of 'entertainment' style in the presentation of course materials to keep their interest through the first courses.

This paper takes a critical look at a number of studies on curriculum development and learning in higher education. It examines the role that should be given to students' conception about learning, the instructors' experience and teaching philosophies, and the impact of curriculum organization on students' performance in the design and implementation of educational innovations.

The best aspects of the innovative proposals are extracted and combined with other components that are deemed necessary to develop another model power engineering program.

Examination of the New Initiatives

The general pattern discernible from the succession of new ideas has been scrutinized; Phadke [4] criticized the trends in fixing the power problems and expressed concern that "*making the courses in power engineering more 'attractive' to students in order to increase enrolment is not a supportable strategy*." He argued that "*if we added 'attractive' material to the course, inevitably something would have to be left out or diluted. What do we leave out*?" He saw the new track as a response to the trend in modern university education of encouraging much greater freedom for students to take combinations of courses as they like. The outcome in his view is predictably that the student naturally seeks out the path of least resistance. He concludes that a student cannot be a competent judge of what should be in his or her course of study, and in which order.

It is obvious that fundamental or structural changes in the field will clearly put into question some long-held beliefs and practices on the part of both the student and the instructor. It may be instructive to examine various studies on curriculum development and learning in higher education, and to identify learning models that are proven effective and beneficial to a newer generation of learners, and taking into account the concerns of instructors who may have conflicts with the shifting paradigm.

Three studies are highlighted in this section of the paper; they focus on some of the critical pieces that should come under scrutiny when a curriculum is evaluated; students' conception of learning, the impact of curriculum innovation on instructors, and the effect of curriculum organization on performance and progress.

<u>Curriculum and Learning Issues in Higher Education</u>
An extensive overview of works and research findings on students' conception about learning in various disciplines and cultural contexts was presented by Marshall [5]. In a qualitative study involving a sample of traditional and non-traditional engineering students, the students were asked two questions: *"What do you mean by 'learning'?"* and *"How do you know when you have learnt something?"* The five clusters in the responses obtained are related as follows: (a) memorization of definitions, equations, etc., (b) applying equations and procedures, (c) making sense of concepts and procedures, (d) seeing phenomena in the world in a new way, and (e) experiencing a change of person. The categories show representations of a rich diversity in the study context which may not be too far from the experience in many other settings. It shows in one extreme passive learners who view successful learning as memorization of concepts to pass exams, and the other extreme consisting of fully engaged learners who see success in the learning process as a change in self-perception and possession of new ways of seeing things in the world. The transition stages in-between show a growing effort on the part of the learner to "make sense of concepts," and to find some meaningful vital connections to the real world.

The study conducted by Driel [6] focuses on a curriculum innovation project in higher engineering education. The study is carried out against the backdrop of suspicions that the "*lack of success of many innovation projects are due to the failure of teachers to implement the innovations corresponding to the intentions of the developers."* The developers have traditionally reacted to this belief by designing a 'teacher-proof' curriculum, or by having teachers exposed to some specific training in order to prepare them for the changes.

The study critiqued the pattern of assigning blame to the instructor for lack of success, and the failure to take account of the instructors, students, and the culture in which the curriculum is embedded.

In examining what should be the role of instructors with respect to curriculum change, this study focuses on teachers' practical knowledge and beliefs with respect to their teaching practice, mainly derived from teaching experience. It recognizes the fact that in "*the course of their* *teaching careers, teacher's craft knowledge appears to stabilize, leading to the formation of conceptual frameworks*," and that these beliefs are not easily altered.

The major components that presents substantial dilemma for the instructor dealing with curricular revision issues include: (a) the teacher's past experiences (education, work, rules of practice, values, etc.), (b) the current teaching situation (expectations of students, colleagues, administrators, community, curriculum, resources, etc.), and (c) how the teaching situation should ideally be.

As expected, the ideal 'teaching situation' is identified in widely varying ways by the respondents within the sample. This is revealed in the conceptions of teaching identified in the study. The conceptions range from student-focused strategy aimed at students changing their conceptions to a teacher-focused strategy with the intention of transmitting information to students. The former, in a two-way transmission leaves students in control of portions of content and learning, while the latter reflects a one-way transmission where the instructor controls content, and may not take students' conceptions into account.

The effect of curriculum organization on study progress in engineering studies was recently documented by Hulst and Jansen [7]. Curricular characteristics were shown to significantly affect the quality of performance and progress. Specifically, serial programming (one course at time) have been credited by both faculty and students as contributory to better class attendance, better prep for class, fewer late papers, better overall quality of student work. It also helped students better organize their time. It is concluded in the study that in general, study progress can be improved by measures that are aimed at reduction of competition for attention between courses, among others issues.

Constitution of the Model Power Engineering Program

The studies presented in the previous section show results that are not altogether surprising. In fact, several of the findings could have been deduced from experience or a sound logical process. The real question then is how much of that has traditionally been taken into consideration when poor-performing programs are being diagnosed or re-invented? If it is well established that how students view learning will influence the way they go about learning, then how commonly is students' conception of learning reflected in engineering curricular designs? If "*educational innovation projects, attempting to change teachers' strategies, can only be successful when teachers' intentions and conceptions are taken into account* [6]," how readily are engineering instructors' fully formed conceptual frameworks or ideals of teaching taken into account? If study progress and better performance have been clearly linked to some form of serial programming in engineering studies, how much thought has been given to that in curricular changes?

In this section some ways for incorporating these studies in power engineering curriculum design are identified and proposed for consideration in a new model program.

The Program - Student's Conception

How should the power engineering curriculum be designed to intentionally reflect students' conceptions of learning? As it was underscored in the study presented by Marshall [5], students' conceptions may spread across the spectrum from passive to fully engaged learners who view learning as a change in self-perception or a changing outlook on things. It is likely that while younger and recent high school graduates cluster around the lower level perception, a non-traditional and perhaps more mature student associates learning with real-life phenomena. After all, the latter may have had the benefit of some exposure to the professional world. Since "*fostering higher-level conception of learning is certainly consistent with the espoused aims of 'higher' education*" [5], the aim of the curriculum should be that of moving every student in a class toward the higher-level conception of learning. The dimensions of learning that are associated with transformation seen in high-level conception learners include (a) planned time for reflection on their learning, (b) nurturing of skills for transferring knowledge and analytical approaches to situations beyond the learning context and to the real world, and (c) informal peer discussions around wider issues connecting with the learning material. This leaves one to conclude that power engineering courses should intentionally build in time for reflection, exposure, and discussion. Regular and multiple minimally weighted examinations, laboratory work, and simulations may help students better organize and reflect on materials learned. Regularly planned and targeted field trips or purposeful internships would offer exposure and meaningful vital connections to the real world. Regular small group discussions and group projects will connect learners in various stages of conception, and offer opportunities for higher conception learners to influence the rest of the team. This could further help affirm more mature learners in their advanced view of what learning really is.

Use of internships and field trips are effective in helping learners see 'the big picture' as they grow towards the higher conception. A more extensive use of simulation and visualization will serve in aiding imagination as learners struggle to comprehend difficult power engineering concepts. Also, regular interaction with power engineering professionals through seminars, local professional lectures, or student-sponsored conferences, are effective in transferring textbook knowledge and analytical approaches to situations beyond the learning context.

<u>The Program – Instructors' Conception</u>

It is apparent that the success or failure of any curricular revision initiative is pinned on members of the faculty who have the custody of the program, and therefore the responsibility of carrying out the requirements of the change. It is almost unthinkable that the teaching philosophies of the instructors, their professional experience, strengths, limitations, visions, and style would not have a significant role in curricular reform issues. So, how could a revision initiative reflect such widely divergent styles ranging from student-focused to instructor-focused strategy? It is realistic to expect that any kind of reform should reflect portions of individual teaching philosophies. Therefore there needs to be a planned intervention to promote specific changes in teachers' conceptions and beliefs (philosophy or point of view) when they are undesirable or incompatible with the missions and objectives of the institution or program.

Clearly, students need to be encouraged to be more actively involved in the learning process; they should not be made to be passive recipients of information from the professor. If not in the classroom, there needs to be an alternate forum for expressing some learning goals. This could be creatively done through off-classroom, student feedback sessions on missions, goals, and objectives of the department or school. Exit interviews of graduating seniors could also offer vital feedback for fine-tuning the program for the benefit of the next class of students.

Karady et al. [1] noted some of the challenges that are tasking the power engineering profession. The list included poor record of research funding in the field, aging power engineering educators, and the lack of industrial exposure. How could they then be called upon to teach innovative, cutting-edge material that is clearly outside their realm of comfort? It becomes critical to work out a scheme for collaboration with the industry to create an avenue for the instructor to update his/her knowledge and skill. Beyond professional development expectations of the university administration, there is a definite need for the power engineering instructor to spend summers or sabbatical leaves in the industry (call it a coop for faculty). Regular and focused faculty development workshops could also offer opportunities for training in the use of new simulation tools, instruments, and advanced technology for instruction delivery. Skill in using alternative presentation media such as the web or video delivery will create opportunities for reaching out to prospects in the industry.

The Program – Study Progress

The positive impact of curriculum organization on study progress is documented in research studies. This benefit should be exploited to the fullest extent in the redesign of power engineering programs. While it is impractical to structure all courses serially in order to eliminate competition between courses, closely related course materials could be grouped and offered in modules. Students may benefit significantly from flexibility in scheduling that may result from using the web or other electronic media for delivery of some of the module materials. This also gives the students some control as they take more responsibility in expeditiously completing their program. This mode could be used for offering lower level for-credit courses to students from high schools and community colleges. It could also serve as a motivator for prospective college students to see some credit-hours generated at an early stage towards a long-term degree objective. Such courses would help young learners realize the relevance of power engineering in their current contexts. More specialized course modules will serve post graduate professionals' needs as they avail themselves of life-long learning without having to return to a college campus for advanced degrees.

Conclusions

A new and innovative power engineering program that would remedy some of the perceived weaknesses and failure must pay close attention to research studies on curriculum development and learning issues in higher education. Students' conception of learning provides the curriculum designer useful insights into how students approach their learning, and therefore implicitly the learning outcomes. The value of this insight is significant, and should be helpful for educators as they see these conceptions manifest themselves in the way students interact with their courses. Instructors have the responsibility of carrying out the requirements of the change, when their conceptions and beliefs are unknown or remain implicit, success may elude the reform effort. It is essential that efforts be devoted to determine the teaching philosophies of the instructors, their professional experience, strengths, limitations, and visions. A plan should be in place for intervention to promote specific changes in instructor's conceptions and beliefs when they are undesirable or incompatible with the missions and objectives of the institution or program.

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Biography

Peter Idowu obtained his Ph.D. degree from the University of Toledo, Ohio in 1989. He is a registered professional engineer in the state of Ohio and is currently an associate professor of electrical engineering at The Pennsylvania State University - Harrisburg, PA.

Table 1. Summary of recent curricular innovations in power engineering

Case #	
1	**Solution Proposed [2]:** Show multidisciplinary nature energy sector. Show the 'big picture.' Emphasize "high tech" (computer technology). **Proposed Course Content:** Offer a new introductory course in energy processing systems – Traditional topics in power, business, economics, regulatory & environmental aspects, and related historical issues. **Course Delivery:** CD-ROM, WWW, multimedia presentation **Promotion:** Require all EE majors to take course.
2	**Solution Proposed [3]:** Increase accessibility to courses. Adapt course materials for wide-ranging learners, (high school to practicing professionals). Modularize course materials and offer self-contained modules. **Proposed Course Content:** Same body of materials. **Course Delivery:** CD-ROM, WWW, multimedia presentation, and computer simulations. **Promotion:** Offer "mini courses" to high school students (exposure to the field), and to professionals in the industry (refreshers).
3	**Solution Proposed [3]:** Replace current inflexible and unprogressive curriculum. Offer continuous training to practicing professionals. Engage industry in determining what the needs are. **Proposed Course Content:** Development of a whole new curriculum. **Course Delivery:** Expand and refine use of simulation. **Promotion:** Attract or target students in high schools (strategy is unspecified).
4	**Solution Proposed [3]:** Gather input from industry and adapt curriculum to changing trends. Expand breath by including topics outside core area. **Proposed Course Content:** Development of a whole new curriculum. **Course Delivery:** Expand the use of simulation. Introduce computation and visualization software. Use of computer-aided lab exercises. Technology-enhanced classrooms. Fostering of active-learning environment. **Promotion:** Offer distance courses to community colleges. Offer summer programs to students in high schools.
5	**Solution Proposed [3]:** Develop new senior and graduate level courses to stress fundamentals, prepare undergraduates for industry, and continuity to advance courses. **Proposed Course Content:** Review of curriculum. **Course Delivery: -** **Promotion: -**
6	**Solution Proposed [1]:** Include some non-traditional courses from other EE specialties. Organize a larger part of courses in project oriented group work. Expand use of computer simulation. Highlight application of computer technology. Push for undergraduate as well as graduate projects to be done in cooperation with the industry. **Proposed Course Content:** Review of curriculum. **Course Delivery: -** **Promotion:** Find ways to attract 'younger' generation, and highly qualified students.
7	**Solution Proposed [1]:** Provide opportunities for post graduation continuing education. Promote the understanding of continuing education as the norm rather than the exception. Modularize courses for flexibility to attract full time and part time students. Include economics, project management, computer technology and simulations. Need to redesign courses, and make them more attractive to students and relevant to industry and professional needs. **Proposed Course Content: -** **Course Delivery: -** **Promotion: -**