PREPARING PROFESSIONALS FOR THE DEMANDS OF INTELLECTUAL QUALITY AND CONNECTEDNESS IN ENGINEERING EDUCATION

Ahmed Elgezawy & Patrick Keleher
Central Queensland University

ABSTRACT

"In future, professionals may lack the option to choose not to engage in learning activities over the lifespan" (Gooler, 1990). The implications are that one's professional occupational preparation can become obsolete in a matter of years. Professionals' capabilities require meeting emerging demands of productive pedagogies in intellectual quality and connectedness.

KEYWORDS

Professionals – Intellectual Quality – Connectedness - Policies

INTRODUCTION

The world of education is facing rapid changes today and will undoubtedly face even greater changes in the future. The shift away from the perception of formal institutions as the sole providers of education and the increasing recognition of the learning opportunities which exist outside the walls of institutions have put an immense pressure on the institutions to prepare their professionals for such challenges. Adding to that, the decreasing interest of potential learners in engineering studies has meant that the providers of engineering education are facing even greater challenges.

Higher education today is facing an increasing demand for new knowledge and skills. In the meantime, the body of information that needs to be learned is growing rapidly and often becomes obsolete just as quickly.

The famous mathematician and scientist Rene Descartes (Moncur, 2007) observed:
"Each problem that I solved became a rule which served afterwards to solve other problems." He further stated: "Except our own thoughts, there is nothing absolutely in our power."

The authors concur with the words of Descartes. It is vital to solve the problems of the new era and train professionals through lifelong learning strategies. The methods developed as a consequence of such training could be used as rules to solve future problems. Preparing the professional for the new era of improved intellectual quality and connectedness in learning will be the only means to overcome existing and future problems.

Problems facing the professionals in academia

Under-preparedness in professionals

The nature of under-preparedness is usually where the knowledge and competencies of the learner entering an educational program compare negatively with the assumed knowledge and competencies on which that program is based (Braun, 2003b). Under-preparedness carries with it the implication of lack of sophistication by the educational professionals in delivering course outcomes. The professionals have to be prepared to devote efforts to improve students' intellectual quality and connectedness in the delivered courses – for example, by introducing in courses the requirement that students solve problems which are complex or open-ended.

Taylor (1995) reinforces the importance of the education of professionals and stresses that "What really matters is the quality of the instructional message, rather than any inherent characteristics of the instructional medium used." He cites instructional design as "the key process for improving the quality of teaching and learning". This consists of the use of cognitive task analysis (Ryder & Redding, 1993), novex analysis (Taylor, 1994), concept mapping (Novak, 1990) and knowledge engineering (Taylor & Thomas, 1994) with a view to designing a sequence of well-structured learning experiences.

The quality of the learning experience provided by academic professionals will be determined by the training in educational methodologies they receive as well as by their willingness to work as members of multi-disciplinary teams, rather than perpetuating the 'silo' mentality which currently exists in many tertiary institutions. In short, academic professionals need formal educational training if they are to inspire students to reach their full potential and to embrace the thirst for knowledge which leads to lifelong learning.

Issues related to cognitive functioning

Three levels of cognitive functioning are recognized (Strohm, 1983). The first includes general thinking and reasoning abilities such as perceiving, calculating, problem solving and the ability to conceptualise and function at an abstract level. The second is meta-cognitive functioning, which has to do with thinking about one's thinking, knowledge about cognitive strategies and tasks, knowledge about when and how to apply them and the ability to recognise the "success or failure of any of these processes" (Strohm, 1983; see also Amos & Fisher, 1998). The third level of cognitive functioning – epistemic cognition – has to do with understanding how to approach problems and how to monitor the epistemic nature of a problem and the truth value of alternative solutions (Strohm, 1983).

All programs dealing with preparing professionals for lifelong learning pay attention to what is called "academic proficiency" (Alfred, Dison & Hagemeiar, 1999). This emphasises the role of the academic professionals who must be able to function effectively in a tertiary learning and higher education environment. Such professionals require the means to improve their learning and study skills, their instructional skills and their questioning skills as well as appropriate motivation and approaches to lifelong learning. Life skills such as time management, basic financial and social skills and the ability to adapt to an unfamiliar social environment should also be encompassed.

Learning and teaching environment

Increasingly it is being recognised that the most effective way to teach professionals skills is to integrate the teaching in the context of a relevant discipline nationally and internationally (Alfred, Dison & Hagemeiar, 1999; Strohm, 1983). There is little doubt about this. It is now common at Central Queensland University (CQU) to use strategies implementing project-based learning when the course allows or problem-based learning when the course is context-based. Such strategies enhance the intellectual quality and connectedness among the learners and prepare them for lifelong learning when they work with real life problems.

Teaching styles

The educational approach is 'learner centred' as opposed to 'teacher centred', as in traditional formats, or 'student centred', as in more modern activity-based formats (Ramsden, 1992). This requires the professional to have improved intellectual quality and connectedness capabilities for an effective engagement of the students in the learning activities that are set. An example of the emphasis on lifelong learning is the CQU engineering degree, where teaching practice in the past consisted of lectures and reference to textbooks and has now moved to preparation for problem solving in the complex world in which we live. Academic professionals should therefore be trained to undertake action research to ensure that courses are increasingly more sound both theoretically and practically.

Higher education policies

Higher education worldwide, especially engineering, has changed to outcomes-based education while embracing new technology. It is imperative that we, as academics, keep up with these changes and understand and relate to the experiences and backgrounds of new undergraduates.

Shortage of academic staff

One major problem presently affecting the quality of engineering education, for example in Queensland, is the shortage of senior lecturers with PhD qualifications. This has the snowballing effect of overloading the existing staff and making it difficult for them to attend professional development courses which would enhance their knowledge of new technologies in their relevant fields.

Extensive research (Peel & Quayle, 2001) has shown that the professionals, in some circumstances, are not able to cope with the application of continuously improving software in their fields. The shortage of academic staff, and the consequent lack of time for maintaining currency of skills, have a negative effect on their ability to improve the quality of education of their students. Even if the academics are able to cope, there are not enough funds or grants to support such technology upgrading in the infrastructure of the existing systems.

Lack of university/industry partnership polices

Owing to the rapidly changing requirements of employers, and especially industry, regarding the necessary qualifications of graduates, academic professionals are not prepared for proper practical industrial exposure. This is because there are no polices to oblige industry to have partnerships with universities. In Germany, the successful collaboration of industry with universities and research institutions has made the engineering industry the highest exporter of machines and systems designed and manufactured in Germany (Zahedi, 1995).

Lack of interdisciplinary training for academic professionals

Providing more interdisciplinary training, especially for academic professionals, would have the flow-on effect of enabling them to prepare their students for a more complicated and demanding work environment. The implementation of such training necessitates increased cooperation from various departments within universities and from industry.

The present ills of research education

Research candidates must broaden their views to other areas and be educated professionally to be innovative (Braun, 2003a). It is suggested that research programs be enriched through employing a set of 'core' and 'elective' attributes. It is further suggested that the research program be an 'outcomes-driven', managed learning environment, designed to train the highest level of researchers through the progressive attainment of core and domain abilities.

It is believed that the research will:
- Improve completion rates;
- Improve the quality of research;
- Support experienced supervisors;
- Develop inexperienced supervisors;
- Build cohorts of students;
- Help to recruit good international students; and
- Support the engineering faculty goals in the research area.

Researchers need to develop lifelong learning policies and practices to improve the intellectual quality and connectedness of lecturers and academic professional in engineering education.

It is the intellectual demands embedded in classroom tasks, not the mere occurrence of a particular teaching strategy or technique, that influence the degree of student engagement. The intellectual quality and connectedness of the teaching and learning of academic professionals should be standardised and supported by policies and practices. This will facilitate the development of lifelong learning policies and practices. The relationship between what is recognised and what is rewarded has to be fairly clear. Examining and revising the relevant policies and practices of the developed strategies are necessary to improve the quality of teaching and learning of professionals from the intellectual quality and connectedness point of view.

Following wider adoption and implementation of intellectual quality and connectedness standards by universities, agreed benchmarking data would be available for sharing across the sector. Preparing academic professionals and training them for new highly demanding programs implementing intellectual quality and connectedness have been tried in many institutions. A new wave of engineering programs using project-based learning and/or problem-based learning has been emerging around the globe.

In recent years, the engineering profession and the bodies responsible for accrediting engineering programs have called for a change from 'chalk and talk' strategies in learning (Mills & Treagust, 2003). CQU introduced a project-based engineering degree in 1998. As reported by Wolfs, Howard, Vann and Edwards (1997), CQU offers engineering degrees in the specialisation areas of civil, electrical, mechanical and computer systems engineering. All of these programs have adopted a project-based model, with 50% of the students' workload in each semester allocated to a project-based unit. Each semester consists of two six-unit courses, used to develop the theoretical knowledge bases, and a 12-unit project-based course. The projects gradually increase in length and difficulty throughout the program. An added difference in the CQU program is that it is a cooperative format, where students undertake two semesters of a total of nine semesters in a full-time industrial work placement. In contrast (Mills & Treagust, 2003) to Aalborg and Monash Universities, CQU has introduced project-based courses as 50% of first year as well. These first year courses focus on developing skills in teamwork, communication, computing, problem solving and others, as well as introducing students to engineering issues such as ethics and environmental and social factors. Initial indications are that retention rates have improved along with student grades. Program assessments have again been focused on student evaluations.

The aspects that students have perceived to be negative about the project-based learning curriculum are the high time demands of projects and problems with members of groups who do not pull their weight. The recommendations for continuing progress towards the intended project-based curriculum primarily revolve around continued training for both students and staff in the skills needed to make project-based or problem-based learning effective, such as teamwork and problem solving. Another recommendation is for continuing education for staff in implementation and assessment

methodologies that are more attuned to problem- and project-based learning philosophies.

Initiatives for preparing professionals for enhancing intellectual quality and connectedness of the learning society

In 2007, the Faculty of Science, Engineering and Health at CQU established, within the School of Engineering, a group of educators who are interested in taking engineering education further for lifelong learning (the FEED Group). It is aimed to have group meeting discussions to swap knowledge of developments in engineering education fields such as enhancing student-centred learning through project-based learning, curriculum-implemented technology and problem-based learning as well as exploring new strategies for assessments. It is considered to be one of many ways to prepare professionals for improved intellectual quality and connectedness with the new sophisticated world. This could be achieved when group discussion is encouraged and collaborative learning and group work of various kinds are used extensively. The regular use of qualitative and reflective questions will also promote the development of meta-cognitive skills and deeper understanding.

In the past, international exchange programs have been organised primarily for undergraduate students. Now the time has come to facilitate similar exchanges for the professionals, especially the academic staff. This would improve intellectual quality and connectedness in the new programs by ensuring that academics gain an understanding of new technologies from around the world. Initiatives that will attract international academic staff through exchange programs will contribute to the overall effort of addressing the preparedness of professionals. Education is the foundation on which technology is borne. Funding of education must be a priority, not just for government alone but also for industries and wealthy individuals!

The project of finding and collecting data about the best strategies used for preparing the professional for the demands of improved intellectual quality and connectedness will be collaborative among the higher education institutes around the globe.
Now that CQU is taking up the challenge of research into engineering education, it would be good to hear news from others who are doing the same. It is the authors' belief that maintaining and improving the quality of engineering education could make a positive contribution nonetheless (Heitmann, 1996).

CONCLUSION

To facilitate lifelong learning, educators have to be prepared to be part of the learning process with their students. Taylor (1995) recommends that "to effect qualitative change in the teaching–learning process, it is necessary to generate qualitatively different teaching–learning environments, pedagogical practices and organisational infrastructures" and advances in instructional science need to be shared. Professionals must be trained how to teach students in environments which know no boundaries. The problems facing academic professionals are enormous and this paper highlights only a relative few. Preparing professionals for lifelong learning and the demands of intellectual quality and connectedness needs more researching and the data gathered around the globe require organising and to be centralised for easy access by those professionals. The arguments advanced here should act as a wake-up call not only to professionals but also to the policy makers in higher education. This paper now opens the door to others to share their ideas and contribute to a lively discussion.

REFERENCES

Alfred, L., Dison, L., & Hagemeiar, L. (1999). Developing a sociology foundation course: An analysis of principles, methods and materials. *SAJHE/SATHO, 14*(3), 112-118.

Amos, T. L., & Fisher, S. (1998). Understanding and responding to student learning difficulties within the higher education context: A theoretical foundation for developing academic literacy. *SAJHE/SATHO, 12*(2), 17-22.

Braun, R. M. (2003a). Enriching the research training experience at University of Technology, Sydney. *Engineering Educators, 8*(1), 27-30.

Braun, R. M. (2003b). *Dealing with under-preparedness in engineering entrants.* Paper presented at the Engineering Educators' Conference (PEEC), Potchefstroom, South Africa.

Gooler, D. D. (1990). Changing the way we live and work in an information age. In R. M. Smith (Ed.), *Learning to learn across the life span*. San Francisco: Jossey-Bass.

Heitmann, G. (1996). Project-oriented study and project-organized curricula: A brief review of intentions and solutions. *European Journal of Engineering Education, 21*(2), 121-131.

Mills, J. E., & Treagust, D. F. (2003). Engineering education – is problem–based or project-based learning the answer? [Electronic Version]. *Australasian Journal of Engineering*

Education. Retrieved from
http://www.aaee.com.au/journal/2003/mills_trea
gust03.pdf

Moncur, M. (2007). The quotations page:
Quotation #26952 from Michael Moncur's
(cynical) quotations. Retrieved from
http://www.quotationspage.com/quote/26952.ht
ml

Novak, J. D. (1990). Concept maps and vee
diagrams: Two metacognitive tools to facilitate
meaningful learning. *Instructional Science,* 19,
29-52.

Peel, H. R., & Quayle, M. (2001). University for
industry: Widening participation. *International
Journal of Continuing Engineering Education
and Life-Long Learning, 11*(3), 273-296.

Ramsden, P. (1992). *Learning to teach in higher
education*. London: Routledge.

Ryder, J. M., & Redding, R. E. (1993).
Integrating cognitive task analysis into
instructional systems development. *Educational
Technology Research and Development,* 41, 2,
74-96.

Strohm, K. S. (1983). Cognition, meta-cognition
and epistemic cognition: A three-level model of
cognitive processing. *Human Development, 26*,
222-232.

Taylor, J. C. (1994). Novex analysis: A cognitive
science approach to instructional design.
Educational Technology, 34, 5, 5-13.

Taylor, J. C. (1995). Distance education
technologies: The fourth generation. *Australian
Journal of Educational Technology, 11*(2), 1-7.

Taylor, J. C., & Thomas, N. R. (1994). A
knowledge engineering approach to accounting
education. *Accounting Education, 3*(3), 237-248.

Wolfs, P. J., Howard, P., Vann, A., & Edwards,
R. (1997). A response to the national engineering
education review, BE2001 - A project based
engineering degree. In J. Conway, R. Fisher, L.
Sheridan-Burns & G. Ryan (Eds.), *Research and
development in problem based learning* (vol. 4)
(pp. 674-681). Newcastle, NSW: University of
Newcastle.

Zahedi, A. (1995). *Experiences in the integration
of research projects into electrical engineering
education in Germany.* Paper presented at the
Australasian universities power engineering
conference, Perth, WA.