CURRICULUM INTENSIFICATION THROUGH INTEGRATION OF UNITS OF STUDY IN THE CHEMICAL ENGINEERING DEGREE PROGRAMME

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Abstract: Chemical engineering education is made more relevant and up-to-date through integration of the units of study. Curriculum integration has received considerable attention in recent years and many educators promote the idea because of its many advantages. This study looks at the integration of the units of study in the chemical engineering curriculum. The concept of integration is defined and different integration models are discussed. Vertical and horizontal integration are revisited and examples of these types of integration are presented in the context of chemical engineering units of study. A framework for implementing the integration is presented. The current integration and related issues are examined through a questionnaire targeted at final year chemical engineering students. An integrated chemical engineering curriculum will give positive results including elimination of poorly coordinated units of study, promotion of deeper learning and enhancement of generic attributes.

Keywords: chemical engineering; curriculum; integration; deep learning; generic attributes.

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INTRODUCTION

Chemical engineering (CE) is associated with the design, construction, operation and management of commercial products and industrial processes. These products and processes have chemical, physical, biological or environmental attributes. The profession of CE is broad and chemical engineers may be found across a large sector of the professional community. Chemical engineers may work in a variety of industries including chemical, petroleum, minerals, paper, cement, plastics, pharmaceuticals, food, semiconductor just to name a few as well as other sectors such as research, financial and consulting. The degree program typically is focused on a number of main tracks of CE education. These include chemical, bioprocess, environmental and energy, process systems and chemical (management) engineering. Students opt to undertake their learning in one of these streams. The degree is focused on developing students who are industry oriented as well as competent in many aspects of personal development.

Like many other degree programs, the curriculum structure of the CE degree consists of fundamental and core units of study in the preliminary years followed by diverging streams of elective study and specializations in the final years. This represents a degree programme that aims at producing graduates with the right engineering know-how and who are also competent to work in a problem-based team environment. Being a broad profession, it is necessary for the CE degree to adapt to changes in the profession and thus produce graduate students who are continually in touch with the real world. Recent changes in the landscape of the CE profession have further underpinned the necessity for change in the engineering educational landscape, thus requiring radical changes in the curriculum. Advances in biotechnology, biomolecular and nanotechnology fields need to be incorporated in the CE degree syllabus since the contribution of chemical engineers to these disciplines and other advancing areas are quite evident. The curriculum must keep course material up-to-date at all times reflecting current practice. This raises the question of continuous adaptability of the curriculum. One can soundly conclude that the curriculum is a dynamic entity and change, it must, to retain its credibility in professional instruction and training. To develop CE graduates who would be ready to face real life multi- and inter-disciplinary technical as well as

professional problems, academia is pressured to address the instruction issue at a number of levels and curriculum is certainly one of them.

Once the individual units/modules of the degree programme list are identified (which is another facet of curriculum development and is not the focus of this paper) then the implementation of the curriculum becomes the key hurdle. The curriculum from the student's point of view may be described as being a programme that engages students in the productive application of knowledge and skills learned in academic subjects (De Leeuw, 1992). At the point the student enters the degree, he/she receives a programme of subjects that he/she, we may fairly say, views as individual units on a list which he/she must pass and thus tick off the entire list to achieve the short term goal of graduating. Moving the student to perceive the learning differently and to appreciate and adopt a deep learning approach is the daunting challenge for the academic. When examining the curriculum from the teacher's point of view, it is also fair to assume that he/she is, mainly because of the busy nature of his/her work, forced to compromise certain facets of the curriculum. The teacher's facilitation and teaching efforts may depart from achieving sound learning outcomes, because perhaps like the student, many an academic perceive the curriculum as a set of notes, slides and tutorials that they need to deliver in a particular course during a particular semester. This compartmental perception needs to be further scrutinized firstly for its existence and predominance amongst academics. Then if the latter case is valid, we need to carefully investigate and learn about its influence on teaching and learning outcomes.

Nevertheless, we press on, and suggest simply that the curriculum consists of the course content and the mode(s) of delivery of this content. The National Council of Teachers of Mathematics (NCTM) define curriculum as (Woodbury, 1998)

> '... an operational plan for instruction that details what students need to know, how students are to achieve the identified curricular goals, what teachers are to do to help students develop their knowledge, and the context in which learning and teaching occur.'

The curriculum content is vital to producing competent graduates who carry with them a set of skills derived from experiencing the content. The delivery of the content is also crucial, as it may impact positively or negatively on the learning experience of the student. Examining the contents part of the curriculum is a large area of research and is a curriculum design issue that is beyond the scope of this paper. On the other hand it is the delivery of the contents that is the focus of this paper (i.e., 'what teachers are to do to help students develop their knowledge') and particularly how the integration of the units of study influences the way CE students perceive their degree and consequently how their performance shapes up.

DEFINING CURRICULUM INTEGRATION

The notion of curriculum integration is not a new one and it has been a central idea in the delivery of educational instruction and has also presented itself as a hotly debated issue. This debate argues whether or not an integrated curriculum is any better than a separate-subject curriculum (Vars, 1991; Beane, 1995; Venville *et al*., 1998; Lederman and Niess, 1998; Czerniak *et al*., 1999). The idea of curriculum integration has been traced back as far as the 1800s in the writing of Herbert Spencer (Vars, 1991). There is currently increasing interest in integration in academia as evidenced by educational literature. A special issue was dedicated to curriculum integration in 1991 in the *Journal of Educational Leadership* and also a special issue on the same topic was produced in 1998 in the *Journal of School Science and Mathematics* (JSSM). Different researchers use different words to describe integration. Interdisciplinary, multidisciplinary, thematic and fused are some of these terms. Many researchers use these terms to mean integration and they use them synonymously. Beane (1995) suggests that

> 'Curriculum integration is not simply an organizational device requiring cosmetic changes or realignments in lesson plans across various subject areas. Rather, it is a way about thinking what schools are for, about the sources of curriculum, and about the uses of knowledge. Curriculum integration begins with the idea that the sources of curriculum ought to be problems, issues, and concerns posed by life itself.'

Beane is a self-proclaimed advocate of curriculum integration and in his article titled 'Curriculum integration and the disciplines of knowledge', he puts forward arguments defending curriculum integration as being the way for achieving high-status knowledge and argues that integration is important because it rearranges subject-area sequences that define the flow of knowledge and thus it is student centred. Beane does not favour separate-subject teaching and suggests that this offers little more than a disconnected and incoherent assortment of facts and skills. Beane suggests in his last statement in the above quote that real life problems should be sources for curricula. This point is echoed by another researcher (Huckaba, 1983), who stresses the need to align the engineering education with real problems. Other educational researchers have discussed the issue. In the editorial of JSSM, the editors Lederman and Niess (1998) attempt to resolve a definition to the term 'curriculum integration' by stating that

> '... future attempts to elaborate and clarify the meaning of an 'integrated' curriculum should abandon attempts to dissolve disciplines and create incongruous hybrids.'

Here the editors are explaining that it is not a requirement of integration that units of study become blended in a manner that units of study should lose identity. The integrated curriculum from this perspective is one that has discrete units of study that are linked with each other via common topics. Other workers have warned about the drawbacks of misunderstanding the meaning of integration. Pang and Good (2000) state

> '... real integration requires full understanding of integration ideals. In order to help teachers reconceptualize the vision of integration, the argument for integration should include effects of integration on students' conceptual development.'

For the purposes of this paper, integration is defined as the process that requires units of study to work together in a fashion that enables the student to see the application of the theory and/or practice in one unit of study to the theory or practice in another unit of study allowing for construction of knowledge and skills which are applicable in real life situations.