Chapter 5
Curriculum Initiatives to Help Engineering Students Learn and Develop

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ABSTRACT

This chapter discusses two sets of initiatives: the first set aims to improve student learning in engineering through the use of computer simulations and Problem-Based Learning, and the second set aims to help students grow through building community and developing their sense of identity as engineers. The chapter shows how these initiatives have been underpinned by viewing learning as participation and not simply acquisition of knowledge, by embracing knowing, acting, and being as three pillars of curriculum design, and by recognising the important role that variation plays in learning. It also discusses other frameworks that have been drawn on, namely pedagogies of engagement, Problem-Based Learning, learning through computer simulations, and learning outside the classroom. The chapter concludes after describing each of these sets of initiatives in some detail.

INTRODUCTION

In this chapter we will deal with two sets of initiatives aimed at improving students' experience of learning and their development as engineers. Both these have emerged from the research into student learning conducted by others as well as ourselves, and are underpinned to a large extent by a common conceptual framework.

The first set of initiatives is aimed at improving students learning through the use of computer simulations, first on their own, and later combined with Problem-Based Learning. The second set of initiatives is built around the need to build community and to develop students' sense of identity as engineers, through particular interventions first in our second year programme and later in our first year programme.

The South African education system was for many years segregated by racial categories, under the previous apartheid dispensation. Even though this changed even before the first democratic elec-

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tions in 1994, and to a much greater extent since then, the legacy of apartheid continues to impact many aspects of our society today, not least our education system.

Black African students were only allowed to enter the universities which offer engineering programmes in the early 1980s. Given the extremely poor DET schooling system from which they came, especially with respect to Mathematics and Physical Science, these students struggled particularly with the demands of engineering studies. The intake of black African students to our programme grew rapidly in the 1990s, leading to a concomitant increase in the total intake. The proportion of black African students in the programme has been around 60% for the last twenty years.

The poor success of black African and other previously disadvantaged groups of students in our programme has led to a range of curriculum development initiatives to address it (Fraser, 2012). We started with improving the teaching and learning process in individual courses (Fraser, 1993), then dealt with the wider curriculum structure (Fraser, 1999), and later tackled particular conceptual blocks to understanding that many students struggled with (Fraser and Case, 1999; Case and Fraser, 1999 and 2002). Each of these initiatives had been beneficial to our students, but had reached a threshold of improvement.

We began to realise that we had largely been dealing with the cognitive domain, and had neglected the affective domain. Our further engagement with education theory led us to the understanding that we had not really dealt with student motivation, particularly as far as it affected how they saw themselves as engineers in the future. This led us to develop a position paper, which has subsequently been published in a reduced form (Allie, et al., 2009; see the next section for further details on this).

While we have been practising more active learning in our classrooms, we were challenged to find ways to help students form a more inclusive learning community (we have a wide diversity of student backgrounds in our programme, and students generally tend to stick to a group of friends who come from the same background), as well as to assist students in forming their identities as future engineers.

This chapter will first set out the conceptual frameworks for these initiatives, starting with what is common, and continuing with other frame works that informed each of the particular sets of initiatives. It will then deal with each of the initiatives in turn, describing the particular implementation and how it developed, as well as the impact it has had. Finally we will draw conclusions about the effectiveness of these initiatives, and the role that conceptual understanding of the education process has played in them.

CONCEPTUAL FRAMEWORKS

There are a number of conceptual frameworks for learning that have strongly influenced the approaches we have taken to teaching and learning in our programme, as well as curriculum development in the programme.

The first conceptual framework is the set of perspectives on learning identified by Sfard (1998) and which we developed into a position paper in the Centre for Research in Engineering Education (CREE) at UCT (Allie,*et al*. 2007 and 2009). In this we argued that learning should be seen as taking on a discursive identity through participation in a community of practice, and not simply as knowledge acquisition.

The second conceptual framework is the notion that curriculum should be built on the three pillars of *knowing, acting* and *being* (Barnett and Coate (2005). This again goes beyond information, and understanding that information, to being able to use it effectively, and further to your sense of who you are. This framework is complementary to the first one, reinforcing many of the ideas from a different point of view.