

# EVOLVING ASSESSMENT STRATEGIES IN ENGINEERING EDUCATION: PERCEPTIONS AND PRACTICES

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## Abstract

In the actual learning situation, students develop context specific strategies for learning in response to their own perceptions of the requirements for learning. Among all the contextual factors, assessment has been demonstrated to have a powerful effect on the learning process and is a defining feature of the students' approach to learning. However, assessment in the engineering discipline is typically orientated towards demonstrating competence in specific tasks using only traditional assessment techniques. However, the effectiveness of education programmes is dependent on how well lecturers understand the role of assessment in student learning and how well they are prepared to change their strategy in such a way that they use assessment as a tool for the improvement of student learning.

## 1. INTRODUCTION

The growing importance of knowledge, research, innovation and evolving perspectives on expertise are changing the social role of higher education institutions in the globalised world. One of the most popular concepts used to highlight these changes is the knowledge society together with a number of other conceptualisations, such as knowledge economy, information society, learning society, aiming to illuminate the nature of societal change (Valimaa & Hoffman, 2008: 265). The crucial new skill in a learning society is the ability to learn how to learn. Furthermore, learning is no longer the privilege of an elite or one age cohort, but rather covers entire communities and individual lifespan (UNESCO 2005; cited in Valima & Hoffman, 2008: 269).

Today higher education is increasingly becoming the object of research because of its importance in "knowledge economies" and its importance for social equity and mobility and for social cohesion and integration. The growth of research interest in higher education is also partly a function of higher education's enormous expansion in recent decades so that today its character and performance have large implications for all members of society, whether or not they engage directly with higher education (Brennan & Teichler, 2008:259).

According to the Australian Government Department of Employment, Education and Training (1987:1; cited in Gow & Kember, 1990: 307), the major function of higher education was to increase individuals' capacity to learn, to provide them with a framework with which to analyse problems and to increase their capacity to deal with new information.

With respect to learning, however, many higher education institutions persist with old models of support and fail to recognise that learning to learn at university requires a fundamental change in students' beliefs. This is a complex process which requires support measures that go beyond ad hoc initiatives (Wingate, 2007:392).

## 2. ENGINEERING EDUCATION

During the first half of the twentieth century, engineering education focused primarily on the application of techniques through laboratory experiments with practical problems in mind. After World War II, engineering educators realised that their students needed more than just techniques, i.e. understanding of the science underlying the techniques. This led to new curricula that included more science subjects with a greater focus on theoretical problems (Seely, 1999; cited in Fink, Ambrose & Wheeler, 2005:185). During the last decade of the last century, however, calls emerged for yet another round of major reforms and a new kind of engineering education (Fink et al., 2005:185).

Today, engineering curricula seems to have solid foundations in science and mathematics, with the expectation that students connect mathematical and scientific concepts to engineering practice of design and modelling. However, it appears that the relationships between mathematics, engineering, and science have not been clearly communicated to students through science-based engineering curricula resulting in high dropout rates and low retention of engineering students (Froyd & Ohland, 2005:147). Students' perceptions on this issue demonstrate this lack of clear communication. For instance, the following comments were made by two mechanical engineering students at the University of California, Berkeley.

*“Well, mathematics is, basically...abstract...unless you apply it to something, you don't have a physical foundation... It's more conceptual, you have to be able to manipulate symbols... You got to get over the fact that it may seem pointless, and just do it. That's probably one of the hardest things in math, that there's no reward, there's no tangible physical thing that you have. You didn't find out how far this ball is going to fly, or how long it will take for this thing to cool down. You have a number, and you can't do anything with this number.” “The problems in math have absolutely no significance at all. It's purely an exercise.” (McKenna, McMartin, Terada, Sirivedhin & Agogino, 2001: online, 11 of 14).*

These reasons suggest that students need to make better connections between mathematics, science, and engineering to perceive mutual relevance and apply concepts and ideas from one subject area to tasks in another subject.

Recognising the problem, several institutions initiated programs to help students make stronger connections among mathematics, science, and engineering subject areas. These initiatives are frequently described as integrated curricula (Froyd & Ohland, 2005:147).

On the other hand, the advancement of engineering education was also reported to be dependent on assessment. Since approximately the mid-1980s, there has been increasing pressure on institutions of higher education to be accountable to the government, accreditation agencies, the public as well as students and their parents, by taking responsibility for and demonstrating the effectiveness of their educational programme (Olds, Moskar & Miller, 2005:13-14). However, the effectiveness of education programmes is dependent on how well lecturers understand the role of assessment in student learning and how well they are prepared to change their strategy in such a way that they use assessment as a tool for the improvement of student learning.

### **3. IMPACT OF ASSESSMENT ON STUDENT LEARNING**

Assessment is probably one of the most important tasks that teachers can perform to facilitate meaningful student learning. Brown (2004:81) reports that while students can ignore our teaching; they cannot afford to do away with assessment. This is because if they want to get a qualification, they have to participate in the assessment processes that we design and implement. For this reason it is worthwhile to think critically and explore how best one can ensure that the assessment practices facilitate the learning process rather than hindering it. Clark and Rust (2006:74) propose that every assessment event should be analysed for its potential as a learning opportunity.

However, current assessment practices tend to focus only on the assessment of learning. These assessments largely fail to consider assessment as a way of improving learning, i.e. assessment for learning: assessment as a means to measure learner progression and to inform the learners about their progression. In other words, a paradigm shift is required to move from the notion of assessment of learning towards a strategy of assessment for learning (Birenbaum, Breuer, Cascallar, Dochy, Dori, Ridgway, Wiesemes & Nickmans, 2006:63; Segers & Dochy, 2006:172). This implies that assessment should be considered as part of the curriculum and integrated into the learning process.

To ensure that assessment is part of the learning process, assessment methods and approaches should focus on evidence of achievement. Assessment methods that measures students' ability to regurgitate the information (Brown, 2004:82) obtained through rote learning may lead to students learning superficially just for assessment, also known as a surface learning approach.

## **4. INTEGRATION OF LEARNING AND ASSESSMENT**

Many education researchers believe that the integration of learning and assessment can increase efficiency. They are convinced that assessment procedures are potential educational tools that enhance learning (Dochy, Moerekerke & Martens, 1996:309; Birenbaum et al., 2006:64) when it is presented as an integrated learning and assessment system.

When assessment is considered as an integral part of learning, students tend to adopt a deep learning approach which is characterised by making connections and actively searching for a meaning and understanding of a given task (Geysers, 2004: 92). This is a prerequisite for the realisation of significant learning and the development of critical thinking. The key to developing such an integrated learning and assessment approach for the creation of a knowledge base is to build upon the learners' prior knowledge.

### **4.1 The Contribution of Prior Knowledge**

Investigations into human cognition showed that prior knowledge is an important variable in student learning (Vosniadou, 1996:99). A well-organized and coherent prior knowledge base initiates a deep learning approach, such as conceptualization and the acquisition of principled understanding. Acquisition of new knowledge becomes exceedingly difficult when prior knowledge, both informal and formal, is not used as springboard for future learning. It is assumed that the information coming out of knowledge profiles will reveal the students' strengths and weaknesses which will then provide a more objective basis for making diagnosis and giving guidance during the learning process (Dochy et al., 1996: 319).

### **4.2 Integration of Informal and Formal Assessment**

In response to problems observed in higher distance education, Dochy (1992; cited in Dochy et al., 1996: 316) developed a model for flexible learning in which informal assessment, formal assessment and learning are integrated. In this model students are given the responsibility of formative assessment, such as for prior knowledge state tests and progress tests, which help them to get started in their study and give them the opportunity to monitor their progress. On the other hand, lecturers are responsible for formal final testing, which certifies students.

Formal and informal assessments can be used as part of an assessment process in order to judge the learner's competence against the assessment criteria and to improve the learning progress (Geysers, 2004:100). Informal assessment is done during interaction with the learners, as part of learning. This will help the lecturer to make learning and instructional decisions based on the learners' progress and to enable learners to improve on their previous performance.

Formal assessment, on the other hand, is used for summative purpose and is planned carefully in terms of methods and time of assessment (Geysler, 2004:101). In order to be an effective tool for improvement of learning, both formal and informal assessments must be carefully planned and integrated with the teaching and learning process.

## **5. FUNCTIONS AND FORMS OF ASSESSMENT**

Assessment as part of classroom activities is a fundamental process required to promote learning and ultimately students' achievement (Jones, 2005:4). According to Brown (2001:6) there are three main purposes of assessment: (1) to give license to proceed to the next stage or graduation; (2) to classify the performance of students in rank order; and (3) to improve their learning. The South African Qualification Authority (SAQA, 2001:15) defines assessment in education and training as being the collection of evidence of learners' work so that judgments about the learners' achievements or non-achievements can be made and decisions arrived at. In the SAQA policy document (SAQA, 2001:16) it has been pointed out that the most important use of assessment is to judge the performance of learners so that qualifications may be awarded. This suggests that the quality of assessment is important to provide credible information. In order to assure its credibility, assessment practices and procedures are governed by certain principles, namely fairness, validity, reliability and practicability (SAQA, 2001:16).

Quality assurance of assessment practices is fundamental for delivery of quality programmes. Assessment has a major influence on what learners learn, how effectively they learn and consequently on the quality of their learning. In order to achieve this, appropriate and diversified approaches or forms of assessment practices must be applied.

### **5.1 Formative Assessments**

Formative assessment refers to assessment that takes place during the process of learning and teaching (Biggs, 2003:142). According to SAQA (SAQA, 2001:26), the main purposes of formative assessments are:

- to support the teaching and learning process,
- to assist in the planning of future learning,
- to diagnose the learner's strength and weakness,
- to provide feedback to the learner on his/her progress,
- to make decisions on the readiness of learners to do a summative assessment,
- and it is developmental in nature.

However, this form of assessment cannot be used to award credit or certificates. Furthermore, Biggs (2003:142) points out that the students need to learn to take over the role of formative assessment by monitoring themselves as they learn.

Similarly, Nicol and Macfarlane-Dick (2006:199) argue that, in higher education, formative assessment and feedback should be used to empower students as self-regulated learners. Self-regulation refers to the degree to which students can regulate aspects of their thinking, motivation and behaviour during learning (Pintrich & Zusho, 2002; cited in Nicol & Macfarlane-Dick, 2006:199). The requirement for self-regulation is that the students must have some goals to be achieved against which performance can be compared and assessed. In order to support student learning, Nicol and Macfarlane-Dick (2006:201) propose a conceptual model of formative assessment and feedback that is centred on the processes inherent in learner self-regulation. A key feature of this model that differentiates it from everyday understandings of feedback is that students are assumed to occupy a central and active role in all feedback processes.

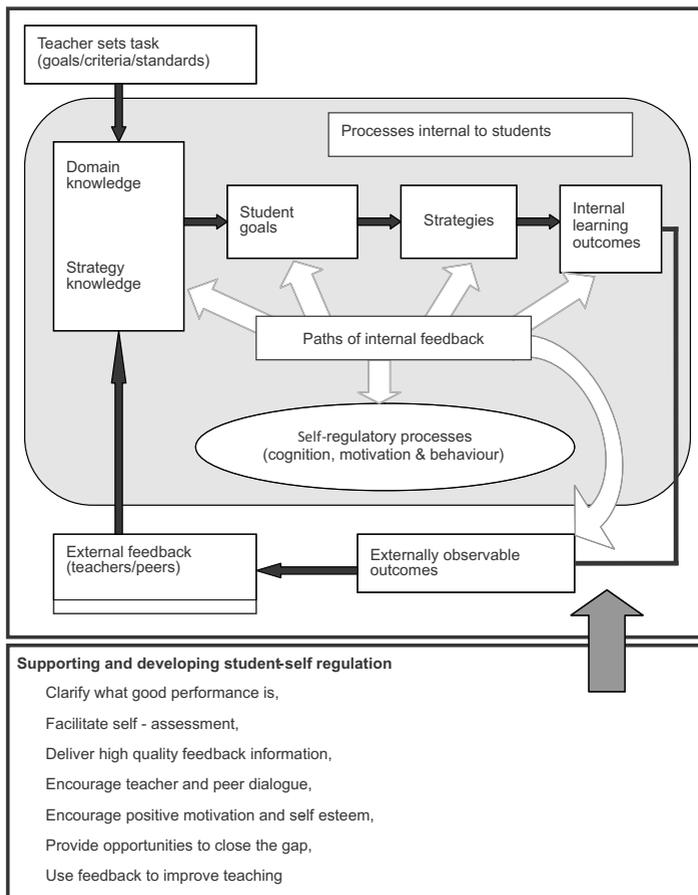


Figure 1: A model of self-regulated learning and the feedback principles that support and develop self-regulation in students (Source: Nicol & Macfarlane-Dick, 2006).

From the self-regulation model and other research information on formative assessment, Nicol and Macfarlane-Dick (2006) identify some principles of good feedback practice, which they define as anything that might strengthen the students' capacity to self-regulate their own performance.

Good feedback practice:

- *helps clarify what good performance is (goals, criteria, expected standards);*
- *facilitates the development of self-assessment (reflection) in learning;*
- *delivers high quality information to students about their learning;*
- *encourages teacher and peer dialogue around learning;*
- *encourages positive motivational beliefs and self-esteem;*
- *provides opportunities to close the gap between current and desired performance; and*
- *provides information to teachers that can be used to help shape teaching.*

(Nicol & Macfarlane-Dick, 2006:205)

Similarly, other researchers (Brown, 2001: 17) also concur with the above statements by highlighting the importance of formative assessment for the purpose of feedback in order to motivate students and to inform them how to improve their knowledge base, understanding, and problem solving skills.

## **5.2 Summative Assessments**

Summative assessment is a type of assessment that takes place at the end of the time allocated for the programme, course or qualification. It is still part of the learning process, but differs from formative assessment regarding the time it occurs within the learning process (Le Roux, 2004:57). Similarly, the South African Qualification Authority (SAQA, 2001:26) indicates that the purpose of summative assessment is to make a judgment about achievement of a learner at the end of a programme of learning. The results of summative assessment can be expressed in two ways (Biggs, 2003:143): norm-referenced assessment (NRA) in which students are ranked according to their performance; and criterion-referenced assessment (CRA) that tells us what a student has learned and how well they have learned.

Some researchers (Knight, 2002:282; Sternberg, 1997; cited in Knight 2002:282) are, however, very critical of summative assessment in terms of its reliability about some achievements. For instance, they point out that, at a given point in the undergraduate years, the reliability of summative assessment can be moderate or poor predictor of career achievement.

In order to address the above concern, it would probably be wise to implement continuous assessment which involves assessing learners regularly in a manner that integrates teaching and assessment. In this regard, it is suggested that the use of the above two different assessment forms are not mutually exclusive and therefore should be applied in an integrated manner (UFS, 2006:3; Geysler, 2004:101-102).

### **5.3 Traditional Assessments**

Traditional assessment refers to assessment practices that have been used by assessors in the teaching of a particular discipline over many decades (Van Tonder, 2007: 29). Traditional assessment has been almost entirely summative in nature with the educator as a sole and unconditional judge. It is basically targeted at the learner's ability to demonstrate the acquisition of knowledge, i.e. achievement. This form of assessment is reported to reward reproduction of knowledge and rely heavily on an examination system only, which then encourages surface learning (Geysler, 2004:90). However, it is important that we become aware of the new perspectives on assessment with new sets of principles, known as alternative assessment. This type of assessment represents a paradigm shift in assessment theory and practice (Le Roux, 2004:59).

### **5.4 Alternative Assessments**

Alternative assessment is a non-traditional assessment practice that has not been used in particular discipline in the preceding decades (Van Tonder, 2007: 29). Some of the positive attributes of alternative assessment as compared to traditional assessment are that: it is constructive, formative, encourages deep learning, and is integrated, learner centred and a tool for learning (Le Roux 2004:59). The key features of alternative assessment are active participation of learners in evaluation of their own performance and the development of reflective thinking. Several forms, methods and instruments are available to achieve this, namely, among others, portfolio, project based assessment, self and peer assessments, and oral and poster presentations.

#### **5.4.1 Portfolio assessments**

Portfolio is an instrument of collecting and evaluating student work over time. Typically a portfolio is the compilation of evidence of students' achievements, including major pieces of work that incorporate feedback comments from lecturers and reflective analyses by the students themselves (Van Tonder, Wilkinson & Van Schoor, 2005:1291). It is becoming a prominent type of alternative assessment with significant advantages over conventional instruments to assessment (McMillan, 2004:234). Portfolio assessments are also used for promoting student self-regulation and motivation (Lumina, 2005:78).

Portfolio assessment tells much more about students, because it can contain evidence reflecting a wide range of skills and attributes. However, Tisani (2006:183) warns that the excitement about portfolios as an alternative assessment technique should not preclude an awareness of weaknesses and pitfalls related to this approach. The author points out a general concern about portfolios that they can be devoid of substance. Moreover, it also takes long time to assess and much harder to mark (Race, 1995:10 of 13).

#### 5.4.2 Project based assessment

A project-based alternative assessment system refers to assessing student activities and learning outcomes that integrates various assessment forms, methods and instruments (case studies, product development, project portfolio, self-assessment, etc.) used in different cultural and intellectual settings (Tal, Dorf & Lazarowitz, 2000:173; Van den Bergh, Mortelmans, Spooren, Petegem, Gijbels & Vanthournout, 2006:347). This type of assessment system is especially suited to assessment of interdisciplinary studies where assessment is done to measure the extent to which the projects contributed to the development of students' higher order cognitive and social skills (Tal et al., 2000:173).

#### 5.4.3 Self and peer assessment

In problem based learning lecturers often develop assessments that measure content knowledge rather than areas such as self-directed learning and problem solving skills (Sluijsmans, Moerkerke, van MerrKnboer, & Filip, Dochy, 2001:153). The authors point out that it is important to identify an assessment system that requires students to use higher-order thinking skills to solve and analyse problems. Two of these higher-order skills, which are important in professional organisations, are that students be able to reflect on their own behaviour (self-assessment) and that of their peers (peer assessment).

In many instances, student assessment of other students' work (peer assessment), both formative and summative, has many potential benefits to learning for the students. It encourages student autonomy and higher order thinking skills. By judging the work of others, students gain insight into their own performance (self-assessment). Black and William (1998, cited in HEA, 2004:1 of 4) point out that students should be trained in self assessment so that they can understand the purpose of their learning and thereby grasp what they need to do to achieve. Once students can assess their own work and their current knowledge base, they will be able to identify the gap in their own learning, which will then promote progress and self-regulated learning.

#### 5.4.4 Oral and poster presentations

Posters are self-contained visual displays of information created either by groups of students or individual students.

Posters can represent an alternative assessable product in projects that typically lead to traditional outcomes such as essays. They can combine varying amounts of text and images. Submission of posters can be combined with oral presentations or other relevant assessment instruments. Presentations also can be organised into public displays, with wider audiences invited to view the results and discuss the underlying projects with the students. Posters can be assessed as the finished product of a course project. They can also be used in formative assessment, either presenting an on-going research in a finished poster or a partially complete work using a display. Different stages of a poster project can support peer and self-assessment (Jarvis & Cain, 2003:50).

## **5.5 Authentic Assessments**

Authentic assessment is an assessment process of performing real life tasks in real life contexts with the application of complex and higher order thinking skills (Baron & Boschee, 1995, cited in Geysler, 2004:102). This type of assessment is used for assessing practical competence and functional knowledge such as problem solving, and diagnosis of a case study.

## **6. CONCLUSION**

An important goal of education is to prepare students for a professional life through the integration of assessment, teaching and learning. Assessment is probably one of the most important tasks that teachers can do to facilitate meaningful student learning. However, current assessment practices tend to focus only on the assessment of learning. These assessments largely fail to consider assessment as a way of improving learning, i.e. assessment for learning: assessment as a means to measure learner progression and to inform the learners about their progression.

Many education researchers believe that assessment is a potential tool to enhance learning (Dochy et al., 1996:309) when it is presented as an integrated learning and assessment system. This system will encourage students to adopt a deep learning approach which is characterised by making connections and active search for a meaning and understanding of a given task (Geysler, 2004: 92). The key to developing such an integrated learning and assessment system is to build upon the learners' prior knowledge and integration of formal and informal assessments. Formal and informal assessments can be used as part of assessment process in order to judge the learner's competence against the assessment criteria and to improve the learning progress (Geysler, 2004:100).

Quality assurance of assessment practices is fundamental for delivery of quality programmes. Assessment has a major influence on what learners learn, how effectively they learn and consequently on the quality of their learning. In order to achieve this, appropriate and diversified approaches of assessment practices must be applied, such as formative and summative assessments.

However, traditional assessment has been almost entirely summative in nature with the educator as a sole and unconditional judge. It is basically targeted at the learner's ability to demonstrate the acquisition of knowledge, i.e. achievement. This form of assessment is reported to reward reproduction of knowledge and rely heavily on an examination system only, which then encourages surface learning (Geyser, 2004:90). Thus, it is important that we become aware of the new perspectives on assessment with new sets of principles, known as alternative assessment. This type of assessment represents a paradigm shift in assessment theory and practice (Le Roux, 2004:59). The key features of alternative assessment are active participation of learners in evaluation of their own performance and the development of reflective thinking. Several instruments are available to achieve this, namely portfolio, project based assessment, self and peer assessments, and oral and poster presentations.

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