[P2] How do chemical process engineering students perceive their role in assessment?

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Keywords: Assessment, Perry Scheme, Intellectual Development, Chemical Engineering

Abstract
Chemical process engineers are involved in the design, development and management of industrial processes that turn raw materials into valuable products. Graduates in this area should have the inherent aptitude for numeracy, problem solving and analysis, as well as being able to appreciate the applications of science to everyday life.

It is known that the way students approach assessment can influence their approach to learning, thus potentially affecting the level of engagement and useful outcomes of their study years. In this article, an overview of the role of assessment for chemical process engineering students is discussed alongside the preliminary results of a short study in this area.

Introduction
Assessment is an integral part of learning and teaching throughout most stages of formal education. By enhancing learning through assessment, the focus is placed upon identifying the learner's progression, diagnosing any difficulties he/she may be experiencing and providing the skills required for the student's onward career.

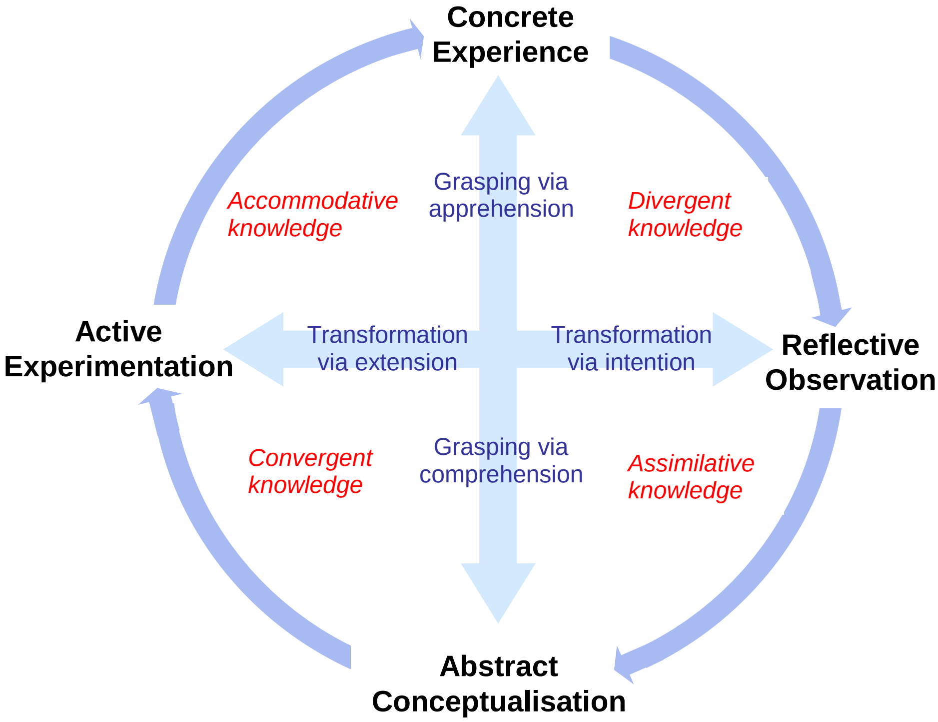
In recent years, cognitive neuroscience has gained more attention within education (e.g. Christoff, 2008, Geake, 2009) and its place may, perhaps, be due to the increasing awareness that meaningful learning is what matters to most graduates and employers. Research has shown that students who adopt a deep approach to learning gain an understanding of the whole picture and is a knowledge transforming experience. On the other hand, a surface approach to learning is limited to regurgitating facts with a focus on what might be asked in an assessment (Marton and Säljö, 1997).

Whilst skills such as analysing, interpreting and evaluating information are often key in many professions, it is paramount in the chemical process industries. Chemical process engineers are involved in the design, development and management of industrial processes that turn raw materials into valuable products. Graduates in this area should have the inherent aptitude for numeracy, problem solving and analysis, as well as being able to appreciate the applications of science to everyday life.

Most students entering Higher National courses in Chemical Process Engineering will have taken chemistry courses before and many will have made an active decision to further their studies in this domain. In addition, adult returners to education may have had experience of working in the chemical industry and perhaps from prior experience of learning chemistry, might know how they like to study chemistry best.

Experiential learning has its advantages in that adults tend to have a wider experience base and, when applied to learning, this leads to the consolidation of ideas and skills through feedback, reflection and the application of ideas and skills to new situations. Kolb (1984) proposed a four stage experiential learning model that embedded four types of learning styles.

Figure 1: Kolb's Experiential Learning Theory.



Firstly, one way of learning is to let experiences come to you (reactive) and the other is to deliberately seek out new experiences (proactive). These concrete (immediate) experiences provide a basis for reflective observation, which are in turn assimilated and distilled into abstract concepts. Thus, some sort of scanning of the learning experience is carried out for lessons to be learned and for reaching some conclusions. Finally, from the conclusions reached, this is translated into a basis for appropriate action to be actively experimented into new experiences. Building on this theoretical base, Kolb deduced two ways of knowing: by direct practical experience (Kolb calls this 'Apprehension') and the theoretical knowledge about it ('Comprehension'). Kolb also illustrates two ways of understanding knowledge whereby the experience is transformed by thinking ('intention') and by testing it out in practice ('extension').

Thus divergent learners lay emphases upon concrete experiences, observation and reflection. Divergers have passionate imaginative abilities, are interested in people and are capable of appreciating different perspectives. Assimilators base their learning preferences upon reflective observation and abstract conceptualisation. They have the ability to create theoretical models and are more concerned with abstract concepts than with people. Convergent learners are strong in the practical application of ideas and are relatively unemotional. Finally, accommodators are action orientated risk takers and enjoys solving problems intuitively. These learners work best in situations requiring immediate action.

In applying Kolb's model in the chemistry classroom, Towns (2001) proposes that a diverger would ask 'why is this important?' Some knowledge of chemistry may be required and it has to be related to their experiences, interests and future careers. Towns suggest that lecturers should act in a motivating manner for these students. An assimilator would want to know 'What is the concept?' This type of learner likes formal chemistry lectures and views the lecturer as being the expert. Convergers, on the other hand, like problem solving and practical lab work and ask questions like 'How is the concept applied?' Guided labs are welcome and the lecturer is viewed as a coach. Finally, the accommodator asks, 'What are the possibilities?' and is related to any real open ended problem.

However, Kolb's ideas are not without its criticisms. Rogers (1996) challenges Kolb's model with the notion that 'learning includes goals, purposes, intentions, choice and decision-making, and all is not clear where these elements fit into the learning cycle.' Moreover, Miettinen (2000) suggested that Kolb's experience and reflection take place in isolation and there may be a need to interact with other people to 'enhance reasoning and conclusions'. In addition, the model takes little account of the differences of cultural experiences and empirical support for the model is weak (Smith, 2001). Nevertheless, despite these criticisms, the model is widely used in further and adult education as a base for planning learning and teaching activities.

Intellectual beliefs and assessment

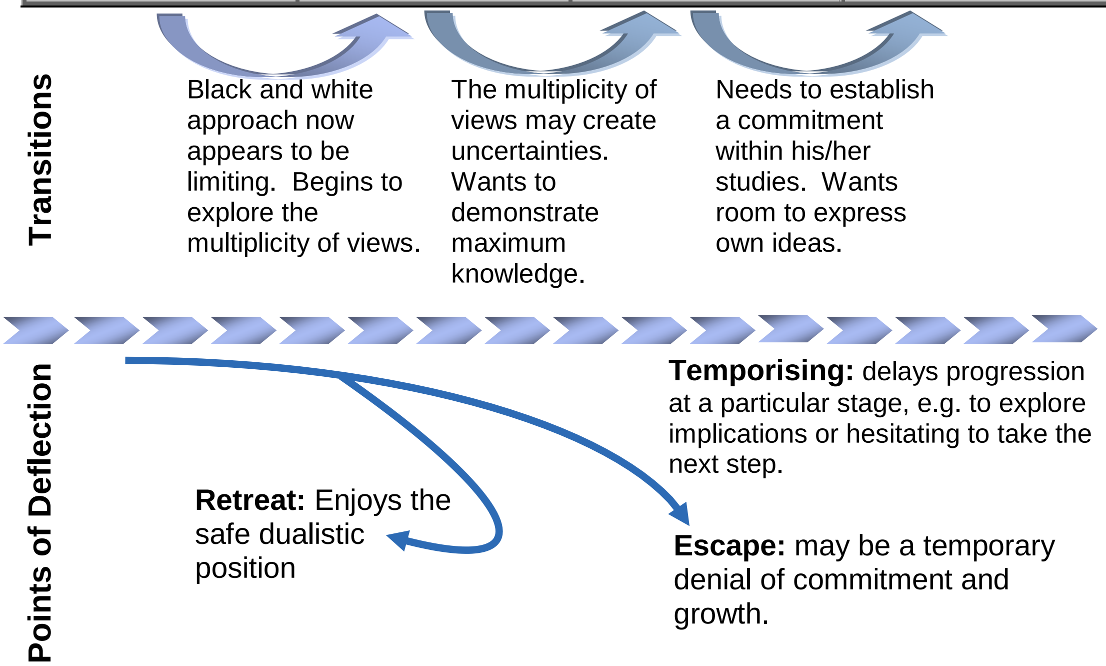
Whilst the Kolb model discusses how an adult learner may like to learn, the Perry scheme of ethical and intellectual development (Perry, 1999) is often used as a framework for characterising cognitive development. In short, the Perry scheme suggests that student's progress from a dualistic position, towards the turning point of generalised relativism. Thereafter a student usually requires some sort of personal commitment in his/her studies in order to move forward.

In terms of assessment (Figure 2), students at the early stages of learning might prefer assessments in which they have to regurgitate the correct answers. At this stage there is no room for grey areas or alternative points of view. As a student progresses in his/her learning, the distinct absolute categories become unclear, such that, for example, there is often more than one method to obtain the desired outcome. A significant transition occurs when a student realises that questions and answers are context bound. Here, a student will begin to express his/her own ideas with some evaluation. At the more developed stages of learning and assessment, a student can critique and evaluate various answers and affirms his/her own point of view, perhaps after experiencing some dissonance.

Figure 2: Progression and development through assessment.

Main line of development

Dualism	Multiplicity	Relativism	Commitment
Student regurgitates clear cut, absolute knowledge, based solely on class work. Objective testing and recipe style practicals welcomed.	Student encounters the diversity of answers, although needs the 'final say' from the lecturer/textbook. Structural communication grids welcomed.	Turning point in that student perceives knowledge as relative and suggests some personal analysis and evaluation. Portfolios and concept mapping welcomed.	Student appreciates the quality in assessments. Within a specific context, displays critical thought and evaluation. Essays and open research practicals welcomed.



Using the above scheme as the determinant of cognitive development, a small group of Higher National Chemical Process Engineering students were invited to indicate their self perceptions on assessment. These students are at the earlier stages of their learning with a small majority intending to complete their degree at university. Preliminary results indicate that students hold both dualistic and developed views of assessment. For instance, students at this early stage of learning appreciate short answer questions based on class coverage. In terms of dualism, this recall of information (or the ability to carry out memorised procedures with new data) gives students confidence in their learning due to the safe application of the underpinning knowledge. The developed viewpoint is illustrated by the need to express some of their own ideas in answers and that quality is more important than quantity. In addition, the majority of students indicated that feedback other than solely overall marks was important to them; this perhaps reflecting real life scenarios. Indeed, detailed and individual feedback provides students with the opportunity to develop further. Students can therefore become engaged in their learning (e.g., by trying out other similar questions) thus offering ownership and empowerment in learning.

Discussion and Conclusions

Many employers require that graduates entering the workforce possess a variety of skills such as analytical and critical thinking, problem solving, the ability to use information resources effectively, good communication skills and ethical judgement (Hull, 2009). Knowledge in action is often paramount, such that graduates should have the ability to apply the theoretical knowledge and laboratory skills gained from their courses to the world of work. In the context of practicing chemical engineers, some might be engaged in making significant decisions that involve strategic ethical issues, the allocation of budgets and the reconciliation of grey open ended problems. In addition, the defence and justification of these decisions often requires good interpersonal and communication skills. Employees need to cover this in a cost effective manner and in accordance with the required standard operating procedures and quality regimes. Thus potential graduates need to have more than mere knowledge of their subject.

Chemistry assessments should reflect the overall aim of the course in question and particularly, in the later stages of learning, can be related to real life complex scenarios. Learning *through* chemistry itself has the potential to illustrate the transferability of knowledge, in addition to developing ethical thinking and problem solving skills. Whilst success in open ended problem solving might be related to cognitive factors, such as the degree of field independence, (Overton and Potter, 2008) it has been suggested that the ability to solve problems successfully (in physics) is an indication of meaningful learning (Austin and Shore, 1995). Hence it is vital to encourage the development of higher order cognitive skills when learning and assessing – this is particularly important at the advanced stages of a course. 'Problems' that are algorithmic in nature and thus utilising a lower order cognitive skill set (Bennett, 2008) are essential for the 'know how' of the job, but does not wholly demonstrate the open ended working environment that will be encountered by potential chemical engineers. Thus at the beginning of a course, students require structured learning that provides the scientific underpinning of their potential profession. As students progress through their course, assessments can be set such that different views can be presented, evidence is analysed and evaluation can be considered.

Education and assessment in chemical process engineering courses should be led by the overall aims of course. Various assessment formats (e.g., objective questions, essays, portfolios, structural communication grids, concept mapping, verbal presentations, group work and open research), will enable the development of various, highly sought after skills (e.g., conceptual understanding and evaluative thought, team cooperation and delegation of tasks, application of ideas into novel situations and ethical and critical thinking). The aptitude of carrying out valid experimentation, obtaining and evaluating empirical evidence, presenting data and working in teams are all important and can be encouraged through various assessment procedures.

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