

Facets of experiential learning in engineering

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ABSTRACT: Epstein identified two independent, yet interactive, modes of human processing, namely: experiential and rational. According to Howard, the experiential mode can be described as *learning feelings and behaviours through schemas* and the rational mode as *learning attitudes and beliefs through language*. Sternberg has defined intelligence as *the capacity for mental self-management*. He defined three domains of intelligence, namely: componential (academic), experiential (creative) and contextual (*street-smart*). The *experiential* domain is characterised by the quest for originality/novelty, uniqueness, innovation and insight, and is reflective of the originality of the mental effort. In this paper, the authors describe work-based approaches to experiential learning that have been used in engineering programmes and how such approaches can demonstrate the effectiveness of the defining characteristics as described by Epstein, and the value of the experiential (creative) domain described by Sternberg in improving *the capacity for mental self-management* of engineering students.

INTRODUCTION

Learning is not separate from reality [1]. This paper is divided into essentially four main sections. Following this very brief introduction, the authors first summarise what is considered to constitute *experiential learning*. This is followed by an examination of the work of Epstein, who identified two independent, yet interactive, modes of human information processing (learning), namely: *experiential* and *rational* [2]. Howard has described the experiential mode as *learning feelings and behaviours through schemas* and the rational mode as *learning attitudes and beliefs through language* [3]. Each of these modes has defining characteristics that are discussed in some detail.

The third section reviews Sternberg's model of the *Triarchic Mind* where he first defines intelligence as *the capacity for mental self-management* and then goes on to define three domains of intelligence [4]. These are as follows:

- Componential (academic);
- Experiential (creative);
- Contextual (*street-smart*) [4].

The fourth and concluding section describes work-based approaches to experiential learning that have been used in engineering programmes and how such approaches can demonstrate the effectiveness of the defining characteristics as described by Epstein and the value of the experiential domain described by Sternberg in improving *the capacity for mental self-management* of engineering students [2][4].

EXPERIENTIAL LEARNING

What is experiential learning? According to Oscar Wilde, *Experience is the name everyone gives to their mistakes*, but there are other explanations:

- *… experiential learning is a learner centred approach which starts with the premise that people learn best from experience* [5];
- *Others might simply say that experiential learning is learning by doing* [5];
- *We take in information through our senses, but we ultimately learn by doing. First we watch and listen to others. Then we try doing things on our own. This sparks our interest and generates our motivation to self-discover* [6];
- *Experiential learning involves a direct encounter with the phenomena being studied rather than merely thinking about the encounter, or only considering the possibility of doing something about it* [7];
- *Experiential learning is education that occurs as a direct participation in the events of life* [8].

A comparison of the descriptions of experiential learning given in the last two quotations (refs [7][8]), reveals how writers in the field of experiential learning tend to use the term in two contrasting senses [9]. The first description is the sort of learning that is sponsored by an institution, whereas in the second, learning is not sponsored by some formal educational institution but by people themselves [7]. As noted by Smith, *It is learning that is achieved through reflection upon everyday experience and is the way that most of us do our learning* [7].

The Wikipedia entry for *Experiential Learning* states that:

> *Experiential Learning occurs when individuals engage in some activity, reflect upon the activity critically, derive some useful insight from the analysis, and incorporate the result through a change in understanding and/or behaviour. (David A. Kolb, Experiential Learning: Experience as a Source of Learning and Development, 1984, 3-4)* [10].

This entry highlights the contributions made by Kolb to experiential learning and the experiential learning cycle [11]. This entry also contains a note of caution, though:

> *Experiential learning is often mistakenly used synonymously with experiential education. Experiential learning is a necessary but not sufficient part of experiential education. Experiential learning occurs naturally for all learners, experiential education structures the educational process to take advantage of experiential learning. Experiential learning does not require an educator to be a part of the mix, whereas experiential education involves the transactive process between educator and student (other terms could be substituted e.g. teacher/learner)* [10].

Another fairly well recognised contributor to experiential learning theory is Rogers [12][13]. Rogers' theory of learning evolved as part of the humanistic education movement and applies primarily to adult learners. An excellent short overview of Rogers' learning and instructional theory can be found in the article by Kearsley on the Theory into Practice (TIP) database [14]. The first paragraph of his overview is given below:

> *Rogers distinguished two types of learning: cognitive (meaningless) and experiential (significant). The former corresponds to academic knowledge such as learning vocabulary or multiplication tables and the latter refers to applied knowledge such as learning about engines in order to repair a car. The key to the distinction is that experiential learning addresses the needs and wants of the learner. Rogers lists these qualities of experiential learning: personal involvement, self-initiated, evaluated by learner, and pervasive effects on learner* [14].

SEYMOUR EPSTEIN: MODES OF HUMAN INFORMATION PROCESSING

As noted in the Introduction, Epstein identified two independent, yet interactive modes of human information processing, namely *experiential* and *rational* [2]. The experiential mode has been described as *learning feelings and behaviours through schemas* and the rational mode as *learning attitudes and beliefs through language* [3]. A schema, which was first proposed by British psychologist Frederick Bartlett in 1932, *is an outline, a skeleton, a map that defines the essential structure, the logic, for a particular type of experience* [3]. It should be remembered that *our schemas differ from each other's just as our experiences do* [3]. Also, as pointed out by Howard, *when schemas are similar to an actual experience, they render our memories of that experience accurate: if they are different, they colour our memories accordingly* [3].

Epstein has identified the defining characteristics of the experiential and rational systems and these are summarised in Table 1 [2]. These are discussed later when examining the approaches taken to experiential learning that have been used in engineering programmes.

A range of descriptor (synonyms) has been used at various times to identify the experiential and rational modes of learning [3]; these are summarised in Table 2. Once again, these are referred to later in the article.

Table 1: A comparison of the experiential and rational modes of learning (adapted from Table 1 in ref. [2]).

Experiential	Rational
Holistic	Analytic
Affective (what feels good)	Logical (what is sensible)
Associationistic connections	Logical connections
Behaviour mediated by past experiences	Behaviour mediated by the conscious appraisal of events
Encodes reality in concrete images, metaphors and narratives	Encodes reality in abstract symbols, words and numbers
Slower to change (changes with repetitive or intense experience)	Changes more rapidly (changes with the speed of thought)
More rapid processing (immediate action)	Slower processing (delayed action)
More crudely differentiated (broad generalisation/ stereotypical thinking)	More highly differentiated
More crudely integrated (dissociative/context specific)	More highly integrated (cross-context processing)
Experienced passively and preconsciously (seized by our emotions)	Experienced actively and consciously (in control of our thoughts)
Self-evidently valid (experiencing is believing)	Requires justification via logic and evidence

Table 2: Traditional synonyms used to identify the experiential and rational modes of learning (adapted from Table 21.1 in ref. [3]).

Experiential	Rational
Unconscious	Conscious
Non-verbal	Verbal
Procedural	Declarative
Contextual	Propositional
Prototypical	Logical
Episodic/procedural	Semantic
Tacit/implicit	Explicit
Mythos	Logos
Natural	Extensional
Automatic	Reflective
Heuristic	Effortful
Direct, behavioural experience	Indirect, non-behavioural experience
Narrative	Propositional
Biological	Conceptual
Implicit	Self-attributed
Biological	Linguistic
Prewired	Intentional

STERNBERG AND THE THREE DOMAINS OF INTELLIGENCE

Sternberg defined intelligence as the capacity for mental self-management. As noted by Howard:

> *I suppose that this is the sort of thing Jean Piaget had in mind when he defined intelligence as* what you use when you don't know what to do. *These definitions obviously include more than the traditional word, number, and space problems of current IQ tests* [3].

Sternberg saw three domains of intelligence, namely: componential (academic), experiential (creative) and contextual (*street-smart*) [4]. These three domains are illustrated in Figure 1. The *experiential* domain is characterised by the quest for originality/novelty, uniqueness, innovation and insight.

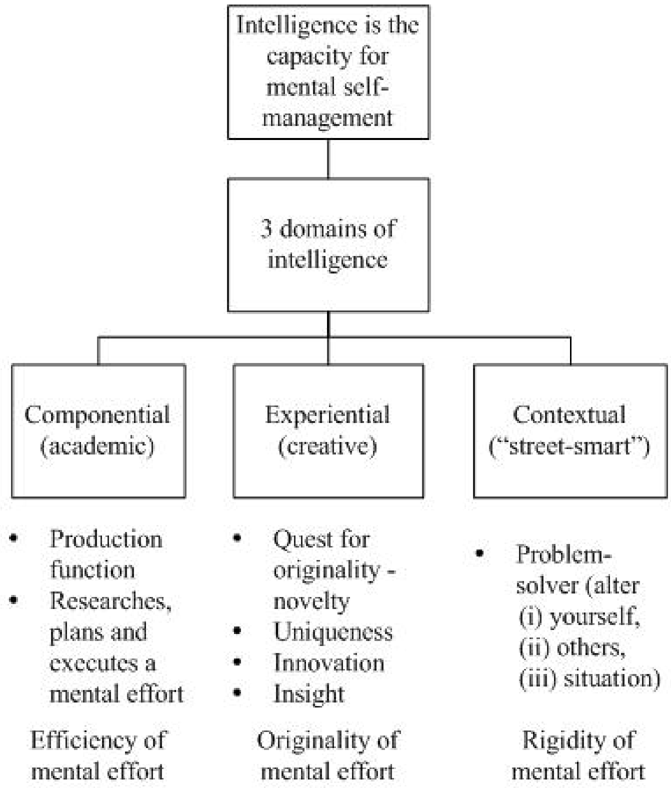

Figure 1: Sternberg's theory of the *Triarchic Mind* [4].

The importance of insight has been clearly outlined by Epstein [2]. It provides a linkage between Epstein's modes of learning and Sternberg's views on intelligence, stated as follows:

> *It is also widely recognized that there is a difference between intellectual knowledge and insight. Information obtained from textbooks and lectures is of a different quality from information acquired from experience. Experientially derived knowledge is often more compelling and more likely to influence behavior than is abstract knowledge. Psychotherapists have long recognized the importance of this distinction. They widely regard information gained through personally meaningful experience as more effective in changing feelings and behaviour than impersonal information acquired from textbooks and lectures. The observation that there are two fundamentally different kinds of knowledge, intellectual and insightful, is consistent with the view that there are two kinds of information processing, analytic-rational and intuitive-experiential* [2].

There has been an awareness of the distinction between experiential and rational learning for some time and can be found in the writings of Aristotle:

> *While young men become geometricians and mathematicians and wise in matters like these, it is thought that a young man of practical wisdom cannot be found. The cause is that such wisdom is concerned not only with universals, but with particulars, which become familiar with experience, but a young man has no experience* [15].

WORK-BASED APPROACHES TO EXPERIENTIAL LEARNING USED IN ENGINEERING PROGRAMMES

In this section, the authors describe five work-based approaches to experiential learning that have been used in engineering programmes and how such approaches can demonstrate the effectiveness of the defining characteristics as described by Epstein and the value of the experiential domain described by Sternberg in improving *the capacity for mental self-management* of engineering students [2][4].

WORK-BASED LEARNING (WBL)

Work-based learning is a learning methodology that can be adapted to address engineering education at the pre-university, undergraduate, postgraduate and continuing professional development (CPD) stages of education [16]. There are a number of different models to be considered.

Model 1 is based on a programme of study that is totally associated with activities in the workplace [17]. Programmes using this model are normally based on a three-way partnership involving the host organisation, academic institution and student. The programme of study is developed as a series of learning or research goals depending on the level of qualification being sought (a learning contract or learning programme) [18]. Usually, this defines a programme that leads to a Master of Science (MSc) or Doctorate level award. At the doctoral level, there would be an expectation of new knowledge production that increases the knowledge capital of the organisation, with such knowledge also having transferability within the field of professional practice. The MSc level may produce new knowledge, but would place greater emphasis on acquiring both the explicit and tacit knowledge associated with specific areas of study.

Model 2 is not wholly defined by workplace activity. In this case, programmes may be a mixture of taught modules and experiential work-based activity. Programmes like this can be used to accommodate postgraduate and undergraduate level study. Postgraduate awards will generally be at the certificate, diploma or MSc level [19]. Undergraduate programmes offer the potential to address wider issues in the engineering curriculum, such as the development of new knowledge based on the integration of explicit knowledge from taught modules with the experiential or tacit knowledge gained from the work-based activity. Most undergraduate programmes tend to follow this model. The taught modules provide the explicit subject knowledge, particularly in the early stages of the programme, and address the issue of increasing the skills base of organisations through increasing the knowledge base of the participants.

Model 3 enables the recognition of skills and knowledge gained as a result of workplace activity. Programmes in this category will normally involve significant elements of Assessed Prior Experiential Learning (APEL) involving elements of both explicit and tacit knowledge, and some study of defined modules [20]. This model gives recognition to explicit knowledge and skills of the individual, and allows an organisation to identify existing knowledge capital and enable its growth.

Model 4 refers to programme structures that enable experiential work-based learning to be adapted for groups of students. In this context, the programme is normally up to the Masters level. The concept used is the development of a programme that has core content studied by all participants followed by differentiated experiential work-based projects, or where the programme in its entirety is studied by all participants with everyone completing the same programme of study and assignments. These programmes are often referred to as *themed* programmes and, although the basis is a common theme, each student is involved in the delivery of a distinct experiential learning agreement, but within a thematic programme [21].

Model 5 involves Structured Industrial Placement Studies (SIPS) the concept of which is developed with the support of government grants [22]. An industrial placement facilitates giving undergraduates an experience through which they are able to gain an appreciation of the drivers that are important in the industrial environment. Engineers in the company provide an engineering problem that requires solutions and they also provide a technical brief for students to consider prior to the experiential study placement. On-campus students are taken through a plan of the main objectives and what is expected from them in respect of the outcomes from the placement study. The experiential work-based study is conducted by engineers in the company, who also contribute to the student briefing during the placement. After the placement, students are expected to complete reports on the outcomes of the study project. Students are expected to gain an understanding of professional work practice and what is expected of an engineer in the workplace through experiential learning within the organisation. The experiential knowledge gained from involvement in work-based projects, together with the foundations of explicit knowledge, enables the engineering student to develop tacit knowledge skills.

These various models all reflect aspects described by Sternberg and Epstein, and all models support an approach that develops in the student the capacity for mental self-management. This has been found to be particularly relevant for experiential-based professional doctorates where the main driver is the experiential (creative) domain, which helps in combining explicit with tacit knowledge. To deal with this combined knowledge, the engineering student needs to improve his/her capacity for mental self management.

All models are essentially based on a learner-centred approach, and involve practice-based studies, a journey of self-discovery and learning that results from direct involvement in real world environments. The approach to work-based learning is also underpinned in all cases by a reflective analysis in the real world environment. In this respect, the models adopt the approaches recorded by the HRD Group, Connor, Smith and Houle [5-8].

The models also develop experiential learning that directly relates to the needs and requirements of the learner, while delivering outcomes suitable to the organisation that provides the work-based environment. These reflect the approach described by Rogers where the experiential learning has a focus on professional practice outcomes deriving from self-initiated and evaluated studies driven by the learner [12][13]. Model 3 is particularly supportive of the learner where previous experiential learning is given recognition alongside the development of further experiential learning in appropriate work environments.

Much of what is described by Epstein is reflected in model 4 where a cohort of students works together in the same learning environment to deliver similar learning contracts [2]. The cohort develops *learning feelings and behaviours through schemas* [3]. Since each individual schema is unique in the cohort, this leads to a separate experiential learning experience for each student driven by in-depth reflection. This aspect becomes increasingly important at the postgraduate level, particularly the professional doctorate level.

Other models, such as 2 and 3, reflect both the experiential and rational approaches described by Epstein [2]. In this case, the learning is derived through a combination of the experiential and rational synonyms identified in Table 2 and the attributes shown in Table 1. Again, an examination of Sternberg's domains of intelligence, shown in Figure 1, reveals that much of the componential and experiential domains form the basis of learning in work-based models 1 to 5. Where the models involve campus-based courses and modules, the componential approach is reflected, and where the modules involve experiential study, this is driven by an experiential-based study environment. The work-based models also take account of the need for elements of information being obtained from textbooks and lectures, but only as a support for understanding and using experientially derived knowledge. Where such book-based knowledge is sought, it is set in the context of drawing knowledge that can directly underpin the experiential learning experience.

The basis then of the work-based models from the undergraduate through to the postgraduate level is to have students believe in the value of the experiential knowledge gained as opposed to feeling the book and lecture knowledge gained is abstract and not related to real world environments. This appears to be very much what is being supported by Epstein where he indicates that experientially derived knowledge is of a more compelling nature and more liable to influence behaviour than knowledge derived from explicit teaching [2]. Epstein appears fully supportive of the need to seek, reflect and understand tacit knowledge, which can only derive from an experiential approach to learning. Engineers develop their careers through working in the real world environment, so experiential learning is a key component in developing effective graduates who are able to understand the value of the experiential learning approach as a basis for life experience in their careers.

CONCLUSIONS

In this article, the authors describe how experiential learning in work-based approaches is valuable in improving the *capacity for mental self-management* of engineering students. These approaches are used from the pre-university through to the undergraduate, postgraduate and continuing professional development stages of education.

The value and importance of experiential learning has been recognised for some time, as is evidenced by the following quote:

> *Pure logical thinking cannot yield us any knowledge of the empirical world; all knowledge of reality starts*

from experience and ends in it. Propositions arrived at by purely logical means are completely empty of reality.

Albert Einstein (1879-1955)

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