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Considerations on Experience-based Learning*

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The importance of experience in human learning is justified by recourse to physiology, psychology, epistemology and pragmatism. Duality of action and reflection, as proposed by Revans, is chosen as a paradigm for effective experiential learning. Issues of selection of experiences, indeterminacy of outcomes, the development of emotional intelligence, appropriateness of assessment and buttressing against failure are canvassed. A list of desired qualities of an engineering graduate of the University of South Australia in Adelaide, Australia, is examined to identify qualities most associated with experiential learning. A method of systematising the development of those qualities is also described in the paper.

INTRODUCTION

From its beginnings, engineering education was a form of tutelage. The earliest engineers learned their craft through observation and practice, supplemented by whatever instruction was relevant and available. The writings of Vitruvius were handbooks for practitioners of civil engineering (military engineering, really), rather than textbooks for undergraduate students.

Prominent achievers, such as James Watt, learned by working on existing designs, using existing methods, before developing and applying new insights. The development of the high-pressure steam engine was as reliant on practical knowledge of precision machining as it was on inspired application of theory. However, one must dismiss the prevalent myth that Watt was unlearned. He is reputed to have complemented his wealth of experiential learning by reading the Proceedings of the *Ecole Polytechnique* in the original French! The significant fact is that for centuries, learning from experience was the dominant mode of engineering education.

Increasingly, the learning of engineering has been transferred from the workplace to the schools, theory has been substituted for practice, and the attempt has been made to prepare candidates for a lifetime of practice by a concentrated academic indoctrination. This follows a common tendency within human culture in which academic learning is esteemed (the meaning of *respectability*) because of its power and lofty detachment from the mundane, and experiential learning is sublimated, devalued or neglected. In contemporary universities, with their emphases on accountability, economies of delivery and promotion by research, experiential learning is generally under threat for other reasons.

However, there are some things that *can only be learned by experience*. Looking at Figure 1, one would not suppose for a moment that the happy group of bicycle enthusiasts learned to ride by just being told or reading how to do it, or more abstractly by grasping the relevant physical laws of gyroscopic motion, etc, that pertain to bicycle riding.

Learning derived from experience is commonly *persistent*. Once one can ride a bicycle, one can always do it, until physical powers have waned to a very low level. Learning from experience is *transferable*, so that it is possible to learn to ride a motorcycle or a unicycle, by adding extra experiences to the fundamental ones of balancing and manoeuvring.

Furthermore, the things we learn from experience are often *influential*. For example, emotions are the

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Figure 1: Example of a social occasion with bicycles.

manifestation of earlier experiences, triggered by contemporary events. Frequent falls learning to ride a bicycle may induce a reluctance to accept potentially beneficial risks in later life.

It seems then that there are special learnings obtainable through experience and corresponding reasons why we should resist the prevailing trend to continue to replace experiential learning by academic indoctrination.

WHY EXPERIENTIAL LEARNING IS ESSENTIAL

The case for experiential learning can be argued from theoretical considerations. Those considered here are the *physiological*, *psychological*, *epistemological* and *pragmatic*.

Physiological Considerations

Experiential learning affects us at a fundamental level. The ecologist Fritjof Capra identifies three key criteria of a living system. These are:

- Pattern of organisation
- Structure
- Life process

Living systems are not closed, and will absorb energy from their surroundings to survive and develop. Following the cyberneticist Bateson, Capra equates the life process with cognition, identified as a reordering of the pattern of organisation under stimuli. Lower life forms do not engage in academic learning, but all life forms change their pattern of organisation as a result of experience. For instance, a mushroom's growth will be distorted if a rock impedes its path to the light. If the rock is subsequently removed, the distortion remains: it is a learned artefact of the organism. A leg, which is broken while learning to ride a bicycle, will continue to exhibit evidence of the break and healing through life and beyond. This is also a learned response, albeit at a totally involuntary level.

Every cell in our bodies is replaced many times over during our lifetime. This includes those in organs considered to be the seat of our minds. Evidently, the mind consists in the pattern and organisation of the cells, which is preserved during the replacement process – and reordered by experience. Experiential learning will always alter our minds. Capra argues from chaos theory that the process will be pervasive, and often unpredictable and exponential [1].

Psychological Considerations

Psychology has always emphasised experience as the basis of emotions and instinctive behaviour. Opinions differ as to the physiological mechanisms of emotion, but collective experience demonstrates that emotions kick in more quickly than rational thought, colouring our responses to stimuli, and dictating our behaviour. This profoundly affects the effectiveness of people engaged in the intellectual professions, both individually and in groups.

The formation of emotional intelligence, as defined by Daniel Goleman, is a legitimate aim for educators aiming to form effective practitioners. Just as emotions are formed by experience, modification and control of emotions can, ultimately, only be learned from experience [2].

Epistemological Considerations

Jean Piaget, with others, believed that learning only occurred in novel situations in which previously learned responses were inadequate. At first, learners experiment with objects, and connect newer experiences with older ones. With a child, such learning is empirical and largely nonverbal. Piaget called it the *sensorimotor* stage. It is followed by a *preoperational* level, in which words come to represent objects and are also manipulated experimentally.

Children then enter *a logical operational* or *concrete* stage, in which they classify objects by their similarities or differences. Thereafter, learners begin to experiment with *formal logical operations* and thinking becomes a more flexible form of experimentation.

Piaget related the learning stages to physiological changes at two, seven and 12 years of age, but later claimed his theory held for adult learners too. This implies that, confronted with a completely novel situation, adult learners are as likely to learn from experience as they are by formal logical operations [3]. These alternate modes of learning have been highlighted in Figure 2.

- Sensori-motor stage
- Pre-operational level
- Logical operational or concrete stage
- Formal logical operations

Figure 2: Piaget's learning sequence.

Borrowing heavily from the classical model of scientific enquiry, Kolb proposed that learning took place in a cycle of *experience*, *reflection*, *abstraction* and *testing* [4]. Since Popper, we have come to understand the classical scientific model as a highly abstract view of a complex, value-laden process [5]. Investigators do not necessarily follow the steps of the scientific model sequentially, and nor do learners necessarily follow the Kolb cycle sequentially [6].

Realising that it is possible and probable that learners will move flexibly between the purported stages in the Kolb cycle, one can sensibly depict this as an alternation between an experiential group of activities, and a reflective or more academic group, as in Figure 3.

Honey and Mumford categorised learners according to their tendency to be *activists*, *reflectors*, *theorists* or *pragmatists*, according to their preferred learning style. Each of these corresponds to one of the four points on Kolb's supposed learning cycle. Plotting the styles on orthogonal axes leads to the identification of four quadrants, as shown in Figure 4 (NB: the order of these quadrants has been altered from the original to make the grouping of styles visually consistent with the other examples in this section). Although learners may have established preferences, Honey and Mumford advocated diversification to promote flexible learning and stated that:

> *(If you are) an all-round learner, you are likely to manage each stage of this process consciously and well. Your activist tendencies will ensure you have plenty of experiences. Your reflector and theorist tendencies will ensure that afterwards you review and reach conclusions. Your pragmatist tendencies will ensure that you plan future implementation* [7].

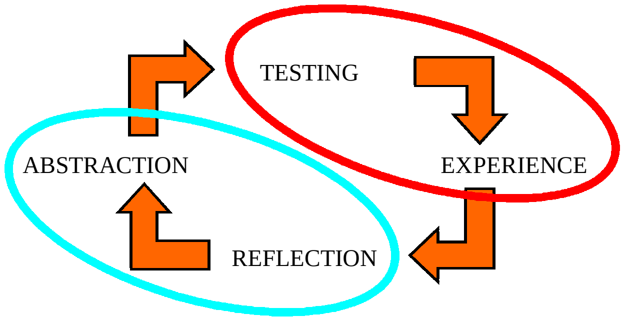

Figure 3: Kolb's learning cycle.

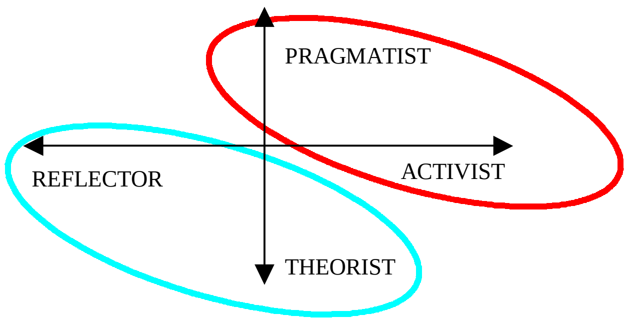

Figure 4: Honey and Mumford's learning styles.

As an interesting aside, most engineering educators are firmly in the reflector-theorist quadrant, and their preferred teaching styles reflect this. One might ponder what this means in the attempt to prepare students for a career in which activism and pragmatism are vital ingredients. Is it the reason for the endemic disease of the profession, *paralysis by analysis*?

Pragmatic Considerations

The quotation from Honey and Mumford not only reinforces the primacy of experience, it also suggests a polarisation of learning styles into only two phases, as depicted in Figure 4. The three epistemological models cited can all be grouped into alternate activities of *experimentation* and *reflection*. These two phases are the essential and complementary activities of the *action learning* approach [8].

Reg Revans established a reputation for turning around the fortunes of ailing enterprises in the 1970s, using a technique that would be recognised today as the creation of a learning organisation. Purpose selected teams (*sets*) would engage in specific industrial tasks, first deciding on and implementing experiments (*actions*), then gathering to reflect on what had been achieved before deciding on the next action to be taken. This process is depicted in Figure 5.

During the reflection episodes, structured means were used to heighten self and group consciousness.

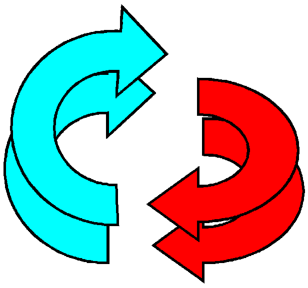

Figure 5: Revans' action learning approach.

Reports by set members indicated considerable modification of attitudes and behaviour, which contributed strongly to the effectiveness of the group. The set participants transferred what Goleman would have called *heightened emotional intelligence* to other areas of the organisation.

Some educational theorists have promoted Action Learning as an epistemology, and the particular means Revans used to heighten awareness have become inseparable from the method. Revans himself disapproved the academic analysis of his work.

> [Action Learning is] *so simple that it takes most experts ten years before they thoroughly misunderstand it* [9].

It is possible for the more pragmatic to accept and work with the principle of successive cycles of experimentation and group reflection as a stimulus to learning. This is particularly so for those preparing to enter a profession which itself emphasises intelligent, cooperative action.

The Issues For Experiential Learning

Academic learning is associated with pedagogical mediation [10]. Experience is direct, and does not permit mediation [11]. Its outcomes are not predictable. In many settings, the nature of the experience is itself unpredictable [12]. This creates tensions for Schools and teachers of engineering.

It also raises some serious questions. What objectives are to be realised through student experience? What experiences are appropriate to achieving those objectives? How can educators promote the likelihood that students will in fact receive those experiences? If they do not, is that important? If so, what can be done about it? How are outcomes to be assessed, given that many are non-theoretical, and that the outcomes must be non-deterministic? Indeed, is it ethically defensible to seek to modify students' intuitive or emotional behaviour?

Objectives to be Realised through Experience

Professional institutions, accrediting bodies and higher learning organisations have listed qualities or attributes expected in their graduates or beginning professional practitioners. The list of qualities reproduced below attempts to conflate the seven desired generic qualities of a graduate of the University of South Australia with the ten more specific requirements of the Institution of Engineers, Australia, the major accreditation agency in Australia. These qualities are:

- Body of knowledge:
  - Ability to apply knowledge of basic science and engineering fundamentals.
  - In-depth technical competence in at least one engineering discipline.
- Life-long learning:
  - Expectation of the need to undertake life-long learning, and capacity to do so.
- Effective problem solver:
  - Ability to undertake problem identification, formulation and solution.
  - Ability to utilise systems approach to design and operational performance.
  - Understanding the principles of sustainable design and development.
- Work alone and in teams:
  - Ability to function effectively as an individual and in multi-disciplinary and multicultural teams, with the capacity to be a leader or manager as well as an effective team member.
- Ethical action:
  - Understanding of professional and ethical responsibilities and commitment to them.
- Communicate effectively:
  - Ability to communicate effectively, not only with engineers but also with the community at large.
- International perspective:
  - Understanding of the social, cultural, global and environmental responsibilities of

the professional engineer, and the need for sustainable development.

Of these desired qualities, only the first is clearly and exclusively academic knowledge. All the others are either wholly or in part the fruits of experience. Of course, it would be foolish to decide from this that only one-seventh of time and effort should be devoted to achieving the first quality.

It should be noted that the list does not convey any weighting of qualities, nor of the effort required to attain them.

While recognising the weaknesses of such a simple listing, the Schools of Engineering have pioneered the use throughout the University of South Australia of a system that at least gives some idea of the extent to which programmes and courses fulfil these objectives. Each course outline has a table showing the proportion of the course devoted to each objective. These tables are summed for the programme and the results presented graphically. This acts as a coarse measure of intentions, at least, and the course content and assessment methodology can be compared with those intentions and modified as appropriate. A typical summary is given in Figure 6.

Contrasts between different programmes are both marked and interesting, and parallel the commitment of the various Schools to experience-based learning [13].

THE ACHIEVEMENT OF EXPERIENCE

Having identified, at least in broad terms, those qualities it is desired that learners should acquire through experience, and having refined the programme structure to reflect where that experience is to be incorporated, it is then possible to devise an experience scheme at the course level.

To expose learners to unmediated experience is to abandon control. Educators will view this prospect with trepidation. Perhaps this would be tempered if they reflected on the uncertainties involved in traditional academic teaching. If students are only paying attention 10% of the time in lectures, what are they thinking about in the remaining time? How are they changing as a result of that experience? If assessment examines 25% of a course's coverage, what have they learned about the remaining 75%?

Nonetheless, the loss of control is real, and does not sit well with the desired achievement of specific outcomes, amongst the many outcomes that the experience will undoubtedly produce.

There are significant variables beyond the control of educators. The actual experience will be different for individual students, and increasingly so to the extent it engages with professional reality outside the formal teaching establishment. Even if the circumstances were somehow identical, the experience of the students would differ because of the differences

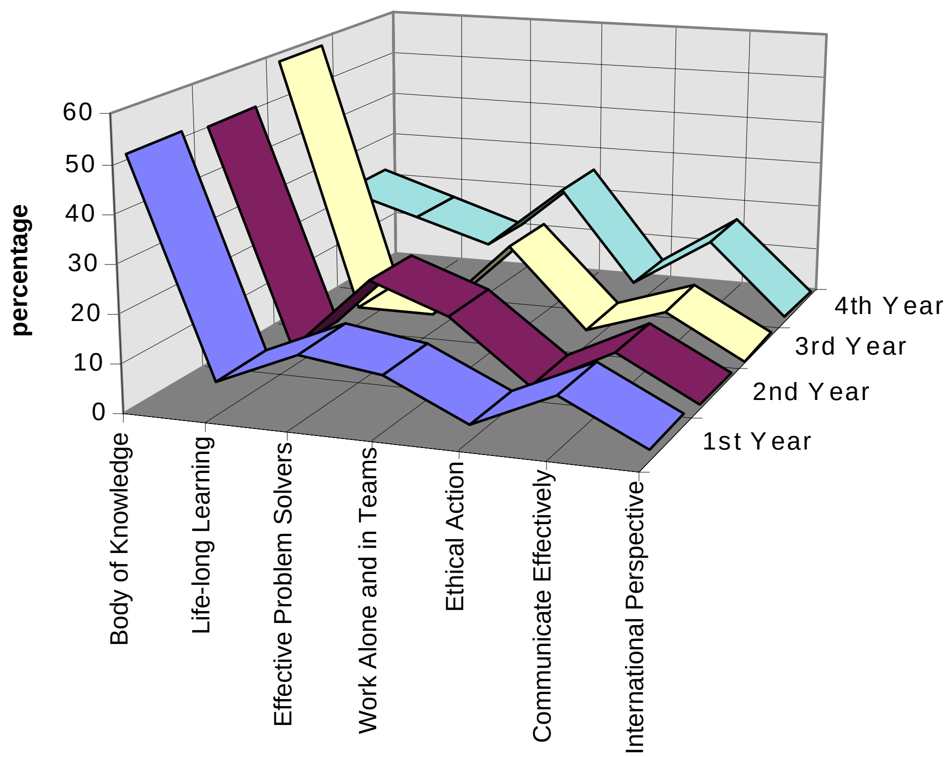

Figure 6: Typical summary of expected qualities (for Computer Systems Engineering in this case).

in their previous experiences and consequent learning. It is inevitable that some form of mediation will be imposed in an attempt to make certain that particular important outcomes are achieved.

In fact, experience-based learning, as opposed to experiential learning *per se*, will occupy some position along a range of direct experience vs mediation. It is suggested that a second axis, extent of experiential learning, be added (see Figure 7). Plenty of good experiential learning can come in heavily mediated situations, and the reverse is also possible. Well-planned experience-based learning will have such a representation constantly in mind.

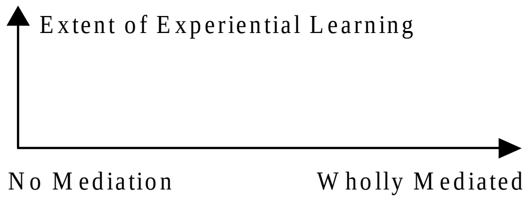

Figure 7: Planning and evaluation framework.

Even where a decision has been taken to minimise mediation, what Andresen calls *buttresses* must be in place to prevent catastrophe. These will frequently take the form of alternative experiences, or timely intervention. Experience must not be permitted to degenerate into learning of negative attitudes or time serving through lack of preparation or inattention by educators.

The most appropriate way to detect whether the desired objectives are being achieved, or negated, is to have scheduled opportunities for reflection. These range upward from the daily report, or diary, to formal meetings for – ideally – peer review and re-initiation.

The incorporation of such meetings is consistent with the successful Revans approach, and the epistemological rationale for it the authors have attempted above. By incorporating methods for raising self and group awareness, these meetings can also contribute to the achievement of the desired objectives and graduate qualities.

The use of self-evaluative instruments will assist considerably in determining whether non-academic objectives have been met. It is entirely appropriate that the self-evaluation should cover the entire range of possible behavioural, attitudinal and emotional developments which have occurred, and learners should be encouraged to identify and record these. Whether educators should be privy to the records is a matter of culture and degree of mentoring which occurs within institutions.

CONCLUSION

From physiological, psychological, epistemological and pragmatic considerations, experiential learning is seen to be essential. One method of identifying those parts of the curriculum where experience can be incorporated has been suggested. Other issues such as indeterminacy, assessment issues, and the need for rescue operations to be planned from the beginning, have been canvassed.

A stripped-down version of Revans' Action Learning approach has been suggested as a sound basis for the conduct of experience-based learning, and also for the design and evaluation of educational innovations. Examples of course development incorporating experience-based learning, with reports of outcomes, are given in other sources [14][15].

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REFERENCES

1. Capra, F., *The Web of Life*. London: HarperCollins, 156, 168, 185 (1997).
2. Goleman, D., *Emotional Intelligence*. New York: Bantam, 155-170 (1995).
3. McDermott, K., Piaget for engineers. *Proc. Australasian Engng. Conf.*, Brisbane, Australia, 171-174 (1980).
4. Kolb, D. and McIntyre, J., *Organizational Psychology: an Experimental Approach*. Englewood Cliffs, N.J.: Prentice-Hall (1979).
5. Chalmers, A., *What is This Thing Called Science?* Brisbane: Queensland University Press (1978).
6. McDermott, K.J., When less is more. *Proc. Pacific Region Conf. on Electrical Engng. Educ.*, Wollongong, Australia, 103-109 (1997).
7. Honey, P. and Mumford, A., *The Manual of Learning Styles*. Maidenhead: Honey (1986).
8. Revans, R., *The Origins and Growth of Action Learning*. Kent: Chartwell Bratt (1982).

9. Revans, R., *The Concept, Origin and Growth of Action Learning*. In: Zuber-Skerritt, O. (Ed), Key Contributions to the 1st World Conference on Action Research and Process. Brisbane: AEBIS Publishing (1991).
10. Lavrillard, D., *Rethinking University Teaching*, New York: Routledge, 13-29 (1994).
11. Coleman, J., *Differences Between Experiential and Classroom Learning*. In: Keeton, M. (Ed) Experiential Learning. San Francisco: Jossey Bass (1977).
12. Andresen, L., Boud, D. and Cohen, R., *Experienced-based Learning*. In Foley, G. (Ed), Understanding Adult Education and Training. Sydney: Allen & Unwin, 207-215 (1995).
13. McDermott, K., Göl, Ö. and Nafalski, A., Adding flexibility to engineering education. *Proc. Pacific Region Conf. on Electrical Engng. Educ.*, Wollongong, Australia, 97-102 (1997).
14. McDermott, K., Göl, Ö. and Nafalski, A., Cooperative education in South Australia. *Proc. 30th ASEE/IEEE Frontiers in Educ. Conf.*, S1B-1-S1B-5 (2000).
15. McDermott, K., Nafalski, A. and Göl, Ö., Active learning in the University of South Australia. *Proc. 30th ASEE/IEEE Frontiers in Educ. Conf.*, T1B-11-T1B-15 (2000).

BIOGRAPHIES

Kevin McDermott is a graduate of Adelaide University, Kettering University and the University of Southern Queensland. He is a Fellow of the Institution of Electrical Engineers, the Institution of Manufacturing Engineers and the Institution of Engineers, Australia. He worked in the electronics, telecommunications and automotive industries before being allured to the academic life in 1973. Amongst other positions, he was Chair of the Curriculum Committee of the South Australian Institute of Technology from 1988 to 1990. In 1996, he resigned from his position as Head of the Engineering Discipline and Deputy Campus Director of the Whyalla Campus of the University of South Australia.

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