A 'Chicken or Egg' Discourse: Do We Need Skills for Knowledge, or Knowledge for Skills?

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Introduction: Voice of Employers

This short paper suggests a paradigm shift in technical education that provides a new teaching-learning cycle for acquiring knowledge and skills required by engineering students in order to enhance the success of the industrialization process. This paper recommends the 'Start-at the-middle" (SAM) approach to provide non-traditional, inductive-based teaching-learning in engineering and technical education. The 'SAM' instructional designs emphasize skill development as more important for learning compared to the theory-based teaching orientation in engineering education.

The common expectation of stakeholders on educational outcomes is to have competent graduates who provide added value to the society and business organisations. In recent years however, unemployment issues and an increase in 'inappropriately-skilled' technical workforce have become a concern for many parties including governmental agencies, ministries, professional bodies, higher learning institutions, engineering employers and engineering students. There are numerous explanations made by different parties for this phenomenon, and among them is: graduates adapt poorly at the workplace due to the lack of employable skills such as communication facility, critical thinking and learning skills, and other important personal qualities.

In relation to this phenomenon, employers want a new kind of workers with a broad set of workplace skills and possess at least a strong foundation of basics that will facilitate learning on the job (Carnavale et al., 1989). According to Gow & Kember (1990) and Watkins and Hattie (1985), most students in most undergraduate courses have become increasingly superficial and lack depth in their orientation to learning. Industrial employers voice their concerns that the gulf between the university curriculum and the workplace expectations is becoming wider and acute. Mismatches occur. One of the ways to gain insight into this issue is to study the effectiveness of instructional practices being carried out at tertiary engineering faculties and workplaces.

Literature Review

Researches in science and engineering education reveal that the mismatch of curriculum and competency requirements at the workplace become worse because of mismatches of teaching-learning processes in academic institutions, especially in engineering education. Felder and Silverman (1988) report that these mismatches exist between common learning styles of most engineering students and traditional teaching styles of most engineering professors. Solomonides and Button (1994) also report there is often discordance between what learners think learning is and what teachers think learning is. Anderson (1991) and Felder (1988) report that teaching styles and student learning styles happen in opposite sides. Engineering students prefer active, inductive learning while professors prefer teaching styles that are reflective and deductive. Traditional engineering instruction tends to be heavily oriented toward intuitive individuals, emphasising theory and mathematical modeling over experimentation and practical applications in most courses. In addition, most engineering instruction is overwhelmingly verbal, emphasizing written explanations and mathematical formulations of physical phenomena over demonstrations and visual illustrations (Felder & Brent, 2005). Felder, et al. (2000) asserts if learners understand their preferences better, they can capitalize more on the strengths of their preferred styles and work at building their capabilities in their less preferred styles.

Why 'Start-at the-Middle' (SAM) Approach for Engineering Education?

In reality, the learning domain continuum is associated with multi-facet dimensions as shown in Figure 1. The diagram indicates that there are three distinguished hierarchical levels of learning structures in engineering learning.

This model corresponds with the Engineering Professors' Conference (EPC) Taxonomy (Sparkes, 1989) model. Learning commences with the acquisition of fundamental knowledge, then followed by 'Know-how', 'Skill' and finally 'Understanding'. Using this taxonomy, it is noted that the 'doing' (specialization) dimensions (Know-how & Skill) are embedded within the learning chain between knowledge (acquisition) and understanding (integration) continuum.

My research on learning styles of engineering students from three Private Higher Education Institutions (PHEIs) and engineers from 18 engineering organizations, interestingly show the distribution pattern results between local and foreign students are identical. See Table 1. In addition, for both the undergraduates and engineers samples, their dominant learning styles are also identical and they incline towards the dimensions: active, sensing, visual and sequential. The data shows that students tend to be active and sensing learners while professors tend to be reflective and intuitive learners. Active experimenters are pragmatic people. They want to do something with the information in the external world. Sensors like facts, data and experimentation, solving problems by standard methods and dislike "surprise", and patient with details and do not like complication. On the other hand, intuitive individuals prefer principles, theories, and innovation, dislike repetition, and are bored by details but welcome complications (Felder & Silverman, 1988).

Based on the implications of this result, it is worth discussing the effectiveness of the traditional teaching approach of engineering educators. As can be seen in Figure 2, the anti-clockwise learning cycle illustrates the traditional way of engineering teaching. This learning direction is in opposite direction to that of the styles preferred by the engineering students as well as engineers as indicated by the study above.

Why does 'SAM' appear to be effective for engineering education? Let us ponder at some daily examples. How does a child learn to ride a bicycle, play video games, or swim in a pool? Do we begin by coaching s/he with the theoretical knowledge, or more often, do we demonstrate how to perform the tasks?

Engineering classes in this era of democratisation of education comprise diverse learners and involve many abstract concepts. As engineering mainly deals with the psychomotor skill learning aspects, an inductive approach (clockwise) that incorporates more hands-on experiential learning activities instead of verbal delivery of theoretical ideas through deductive (anti-clockwise) approach is recommended for engineering educators. In traditional engineering teaching, long hours of lectures are conducted due to the notion of teaching that perceives that students must first fully understand underlying theoretical concepts before they are able to carry out coursework that involves high level thinking (such as analysis and design works). However, as illustrated in Figure 3 based on the EPC taxonomy, engineering learning phases of 'know-how' or 'skills' may occur without the need to undergo the phase of 'understanding' (lecture) first since through practices, theories emerge during the interplay process along the learning cycles. In other words, engineering learning can be seen as a form of theorizing practices as a more effective way to acquire expert knowledge and skills.

Concluding Remarks

In conclusion, learning could be considered a 'chicken and egg' discourse. Nevertheless, engineering lecturers may find it more effective if they constantly recognize the appropriate

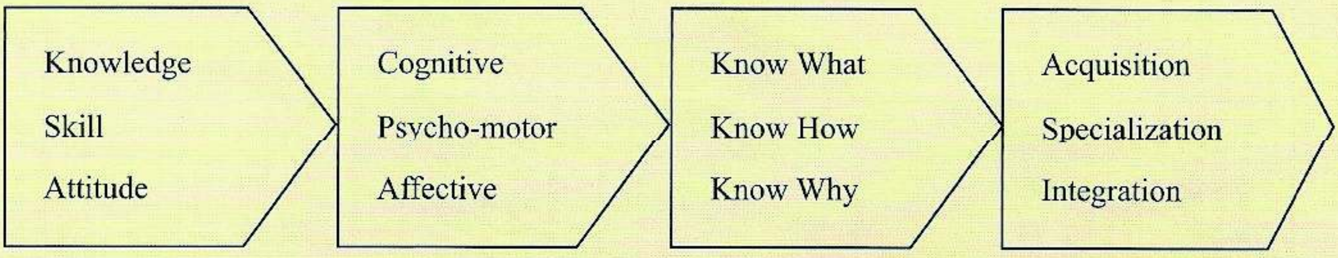


Figure 1: Learning Domains and their Continuum

entry points, and hence the use of 'Start-at the-Middle' approach to conduct hands-on and practical work to allow students to learn skill practices (learning by working) instead of depending heavily on the lecture. Knowledge and skills acquisition (theory and practice) interplay in a learning continuum process whereby an individual is continuously assimilating and accommodating information from the surrounding objects at different learning contexts. However, the quest to identify which one should come first is not important. Instead, identifying the 'middle' points and emphasising active participation with hands-on practice in the learning cycle of a particular topic area is crucial. As teaching is an art as well as science, the time to inject skill practices varies according to the nature of the courses, facilities and students' group characteristics. Ultimately, the outcome-based learning, which was implemented by the National Accrediting Board since July 2004 and the newly announced Malaysian Quality Framework (MQF), would help to address the employability and 'inappropriately-skilled' issues. The 'SAM' philosophy could be a notion of experiential learning, which is worth exploring to support the development of community colleges and continuing education in engineering. Sophocles said, "One must learn by doing things; for though you think you know it, you have no certainty until you try".

References

Anderson, M.R. (1991). Characterization of the graduate career change women in engineering: Recruitment and retention. "Proceedings ASEE/IEEE Frontiers in Education Conference, IEEE, New York, pp. 248.

Carnavale, Anthony, Leila, J. Gainer, and Amm, S. Meltzer. (1989). Workplace basics: The skill employers want. Alexandria, VA: U.S. Department of Labor Employment and Training Administration and American Society for Training and Development.

Felder, R. M. and Silverman, L. K. (1988). Learning and teaching styles in engineering education. Engineering Journal, 78 (8), pp. 674-681.

Felder, R. M., Woods, D. R., Stice, J. E, and Rugarcia, A. (2000). The future of engineering education II. teaching methods that work. Chemical Engineering Education, 34(1), 26-39.

Felder, R.M., and Brent, R. (2005). Understanding student differences. Journal of Engineering Education, 94(1), pp. 57-72.

Gow, L. and Kember, D. (1990). Does higher education promote independent learning? Higher Education, 19, 307-322.

Solomonides, I. P., and Button, B. L. (1994). Improving the quality of student learning: A system approach. Engineering Science and Education Journal, June 1994, 3 (3), pp. 131.

Sparkes, J. J. (1989). Quality in engineering education. Engineering Professors' Conference Occasional Papers No. 1, July 1989.

Watkins, D. A., and Hattie, J. (1990). Individual and contextual differences in the approaches to learning of Australian secondary students. Educational Psychology, 10, 333-342.

Table 1: Preferred Learning Styles for Engineering Students, Engineering Academia, and Engineers

Personality Style	Faculty Staff Abroad (12 universities)	Engineering Students Abroad (12 universities)	Engineering Students in Malaysia (n=140, three PHEIs)	Workplace Engineers in Malaysia (n=118, 18 organisations)
Active	45%	64%	62.9%	61.0%
Sensing	41%	63%	63.6%	70.3%
Visual	94%	82%	89.3%	95.8%
Sequential	44%	60%	64.3%	50.8%

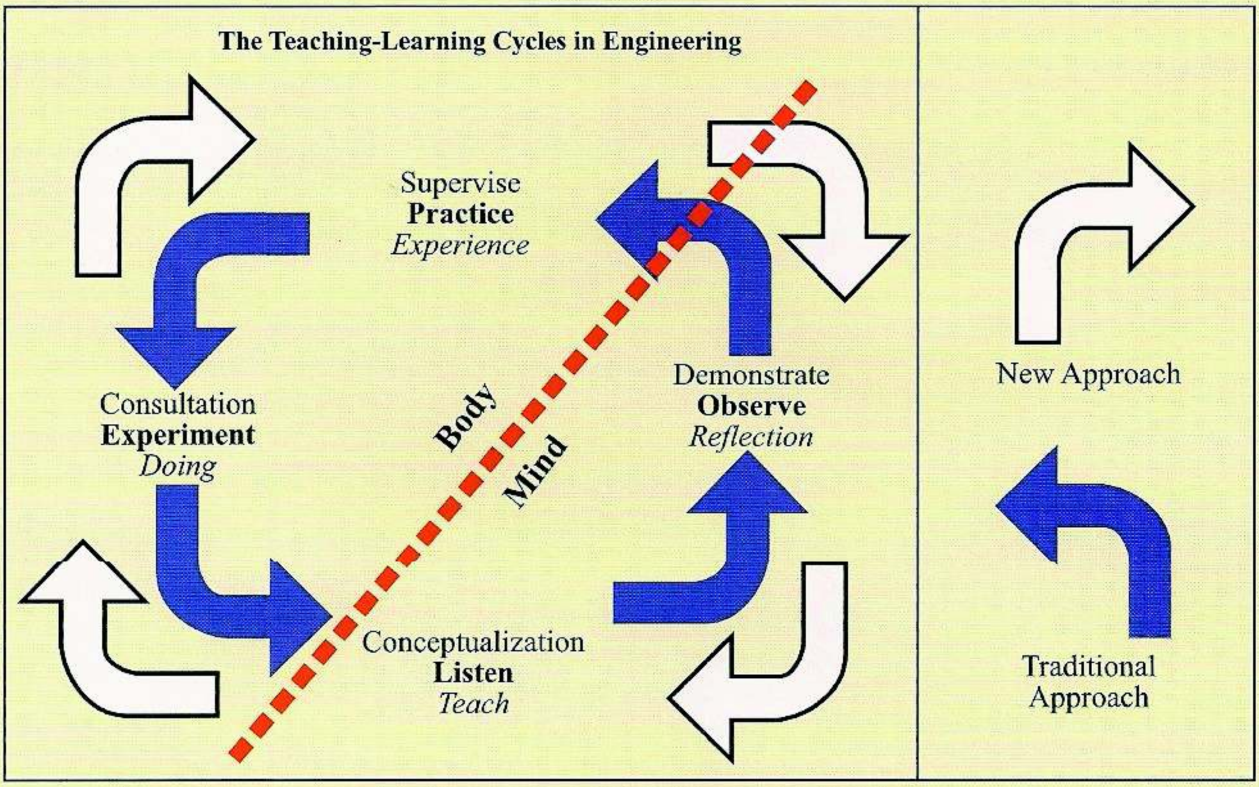
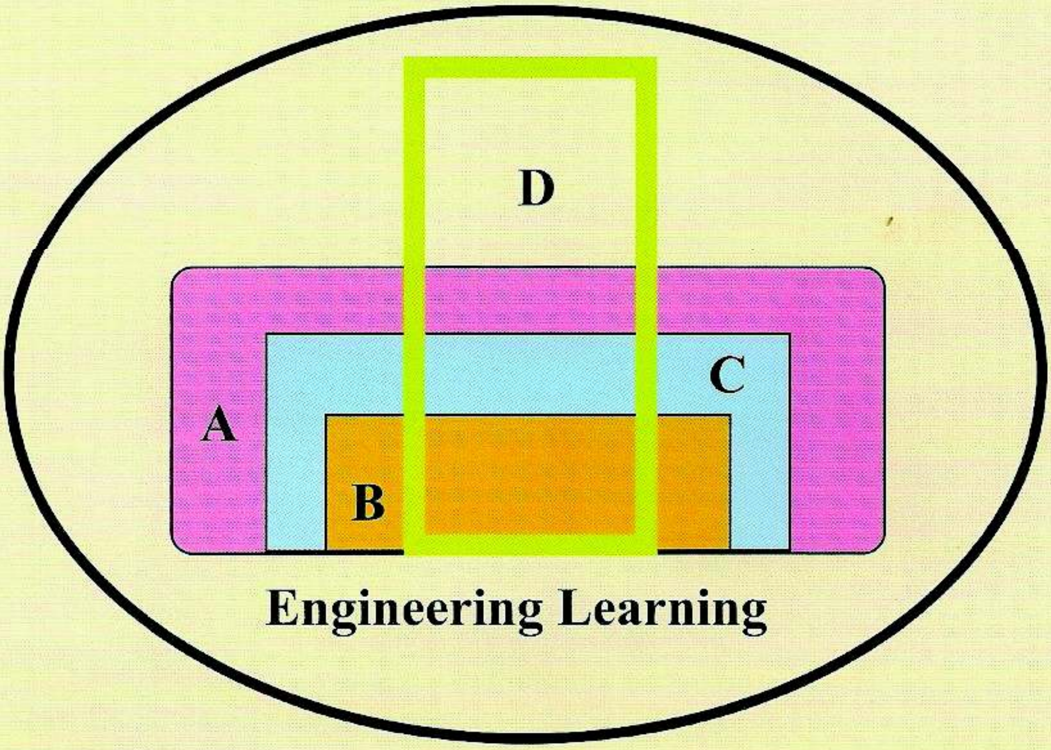


Figure 2: The Conventional and Newly Recommended Teaching-Learning Cycles



A = Knowledge
B = Know-How
C = Skill
D = Understanding

Figure 3: The Engineering Learning Continuum