7. Conclusion

Addressing not just start-ups but all companies in technology- intensive industries, Teece et al. (1997, 523) suggest that "It is well recognised that how far and how fast a particular area of industrial activity can proceed is in part due to the technology opportunities before it".

The exploitation of new market opportunities created by advancing technology requires engineers who can work effectively with professionals in finance, marketing and other fields (Chorev and Anderson, 2006; Serarols-Tarrés et al., 2006), and one of the more successful forms of learning from both theory (Bandura, 1997) and practice (Rasmussen and Sørheim, 2006) involves the performance of tasks similar to those to be encountered in the future.

If **authenticity of experience** is important to the development of self-efficacy, actual work experience that tests one's skills and results in performance feedback in an industry environment could be the most important experience engineering students will have until they leave the university.

On the one hand this seems to be widely recognized by the number of students taking a "gap year", working a year before entering university, and other placement offerings: Jones (2004) estimates that in the UK there are between 200,000 and 250,000 young people between the ages of 16 and 25 who undertake gap years of one kind or another, and that number is rising.

Yet the first finding of this research is that on average industry work does not automatically contribute to engineering student confidence in their venturing and technology applications skills.

> It would appear that placements are more successful when students have some skills to test, suggesting that a programme begins with preparing students for placement so that they have skills to offer.

This view suggests that mid-university and post- graduation placements would be more beneficial than "gap year" or other early placements in science, engineering and other fields that require consequential education.

Findings suggest that to realize some of the highest levels of personal and professional development, the students should be placed in companies and positions **where the work is authentic**, related to a career track that holds some interest for them. They should be given meaningful and achievable tasks, but those activities should encourage the placement students to reach beyond their current level of skills. A final, but vital part of the process is that students should be provided **with feedback on their performance**, during the period of their placement as well as at the end, so that there are opportunities to reflect upon and modify current performance and engage in new behaviors and activities whilst still in the placement.

For their part, companies recognize a number of key benefits arising from placements. They serve as extended, 'informal interviews' that benefit both company and student, and provide an invaluable window on sectoral career opportunities both within the company in which they are placed and in other organizations. On a wider level, placements play an

important role in the development of a pool of skilled labour essential for innovation and industry growth.

If an incentive is needed to capture national attention for a review of the role of undergraduate (or graduate student) work experience, an immediate benefit might be a reduction in the number of engineering students leaving the field for other pursuits.

Many graduates from SET disciplines do not pursue careers in related fields; a large number in the UK, for example, secure employment in the financial services sector where their high levels of numeracy are well rewarded. In the UK it is clear that the trend of technically-trained graduates leaving their fields will inevitably represent a significant loss to the economy (Roberts, 2002). Yet there is evidence that engineering students who study on programmes with work placements show higher levels of employment 6 months post-graduation than those who are on program with no such period of authentic work (see for example, Bowes and Harvey, 1999). Using industry experience in technology-dependent firms to enhance student understanding of technology-related work, and to increase their self-efficacy that they can perform the tasks such work involves, seems an obvious opportunity to enhance the numbers of those who remain within the field.

The open question is what roles are to be played by the university, industry and government policy and funding in finding attracting, educating and providing the practice necessary to prepare young engineers for innovative careers at a sufficient scale to make a difference.

Many large companies that once were major providers of employee training have been cutting back on their programs, not expanding them, particularly in recessionary times. Indeed, a 2008 survey of 120 training and development managers revealed that 44% expected their budgets to be cut (Charlton, 2008) whilst results of a recent survey in the US showed that corporate training spend had declined by 11% (www.elearningcouncil.com). Companies may not have appro- priate tasks for students to perform, and good ideas for student work have a way of disappearing under the pressure of day-to-day business. At the university, the engineering courses are already demanding to the point of discouraging students, and most engineering departments in universities are already facing more competing demands for student time than they can accommodate. Successful university-led placement programs are time consuming and should not be mounted on a large scale by the faint-hearted. Such programs must be well resourced and supported and it is often difficult for universities to allocate the resources on the scale that is needed.

Yet it remains that competitive economies will require engineers with strong skills in product design and new business development both in start-ups and in established technology- intensive companies. Despite the barriers, it is difficult to imagine how one could prepare the many thousands of engineering professionals who will be needed to produce competitive products and services for a world of open innovation and volatile technology-based markets without more successful industry placements than have been found here.