Early Career Learning by Novice Engineers

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While there is extensive literature on engineering science (technology) the process through which useful products and services emerge from that technological foundation, engineering practice, is not so well understood. In particular, a detailed survey concluded that there had been few reliable reports of research on engineering practice (J. P. Trevelyan, 2007; James P. Trevelyan & Tilli, 2007) that provide sufficient detail about what engineers do in their work to guide educational priorities, especially work performed by novice engineers within a year or two of graduation. There are few detailed and reliable observations that have been reported, for example, on the actual work performed by engineers, technical managers, planners, technologists and technicians. Certain processes in engineering practice such as design and project management have been extensively studied, yet many other aspects such as maintenance have hardly received any attention at all.

There has been little research into the links between what is taught in engineering institutions, what graduates learn early in their careers and what training engineers undertake while in the workforce. Martin et al (Martin, Maytham, Case, & Fraser, 2005) provide some insights, for example, but most reports are limited to a small sample or a single discipline group. Understanding more about the transition between engineering education and practice could provide highly relevant guidance for curriculum development.

There have been many concerns expressed by employers on the apparent gap between engineering education and professional practice (Dillon, 1998; Florman, 1997; Pascail, 2006). These concerns continue even after fundamental changes to accreditation criteria have been introduced worldwide. On-the-job learning and industry specific training will always be needed but this takes time. A detailed understanding of engineering practice could be helpful in helping graduates make an easier and more productive transition into their careers and also help make employers understand which training will be most effective. It could also help educators explain the relevance of coursework to students, helping provide appropriate motivation for learning. Such an account would provide a stronger foundation for all aspects of engineering education. Here we should note that a significant number of engineering graduates work in occupations unrelated to engineering or associated areas of management. The relatively high proportion of these graduates (approaching 50% in Australia in recent years) motivated this longitudinal study of our own graduates.

Research Questions

There is a clear need for empirically based research to fill gaps in our understanding of the relationship between engineering education and practice by studying novices: graduate engineers in the first few years of their career. We have posed several relevant questions:

What do novices do?
The kinds of training do they receive?
What do they learn by other means?
What adjustments do they have to make?
What are their perceptions (and those of their supervisors) on deficiencies in undergraduate education?
What are their career trajectories?

Methodology

This research builds on results from an ongoing parallel qualitative study to establish a systematic framework to explain engineering practice in the majority of engineering disciplines based on seventy semi-structured interviews, extensive experience and confirmatory field studies (James P. Trevelyan, 2008). This framework study revealed that engineering work is very complex, and also showed that technical and social skills are inextricably intertwined. It also showed that engineers need to acquire a large amount of technical skills, generic skills and technical know-how, very little of which is learned at university.

Given this comprehensive and detailed background data on engineering practice, we can use simpler qualitative and quantitative surveys to answer the research questions. We chose to undertake a longitudinal study of a cohort of our own graduates to do this. Although there have been 6 other reported longitudinal studies on engineers, these have sought to address different subjects and questions than those in which we are interested (Artemeva, 2008; Ashforth, Sluss, & Saks, 2007; Boxall & Steeneveld, 1999; Eraut, 2007; Sheppard et al., 2004; Western, Haynes, Durrington, & Dwan, 2006). We reject positivist ideas that it is possible to measure or record an objective reality of work engaged in by our study participants. We share the view commonly held by sociologists that work is socially constructed, and our understanding of what constitutes work is influenced by social, economic and institutional factors (Bills, 2003; Taylor, 2004). However, we can provide useful answers to the questions we have posed through questions based on our framework study. That study has provided descriptions for aspects of engineering which are meaningful in any discipline, also contexts in which the specialized terminology used in different disciplines can be understood.

The longitudinal study involves surveying 204 of our own engineering graduates, all of whom graduated in 2006. The graduates complete a short web-based survey every three months containing mostly short answer open-ended qualitative questions such as “Tell us what you have been working on in the last 4 weeks.” From the survey responses we collect information from participants on their job history and career trajectories, the nature of the work they are performing around the time of the surveys, their training and other learning, their perceptions of the working environment, and their future plans as they evolve over time (Tilli & Trevelyan, 2008). We also collect quantitative data on their perception of the amount of time spent on different aspects of their work. A sub-sample of the participants are interviewed as well by telephone from time to time to triangulate survey data.

Findings and Conclusions

Data from the first twelve months of the study has allowed us to learn much about what novice engineers do and what training they receive, particularly about how novice engineers spend their work time. In particular it shows that novices spend more time on tasks that involve interactions with people (around 60% of their time) than on other tasks. This result agrees remarkably will with qualitative data from the framework study and data from other published studies on more experienced engineers (e.g. Kilduff, Funk, & Mehra, 1997). A group of more experienced novices (2 – 5 years out) incorporated in the study sample originally as a pilot cohort to test the survey questionnaires report exactly the same proportion of time spent interacting with people. This result questions ‘accepted wisdom’ and many previous accounts of engineering work that suggest that novices mainly engage in technical work and gradually transition to more management-oriented organizational work.

The data also allowed us to test several hypotheses about the training received by novice engineers, where they learn the information they need to do their job, and in what type of self-learning they engage.

The novices working in formal company-sponsored graduate development programmes receive more generic skills training and less technical training than the others. Their formal training exposure is, surprisingly, only slightly higher, with an average of 1.5 training courses (apart from safety and induction courses) whereas the other novices receive around 1.2 courses on average.

There are several potential causes of bias in our study. Restricting the study to our own graduates, representing the upper academic ability in the spectrum of students in Australian engineering schools, is one source of bias. Another bias is caused by circumstances: Australia is experiencing unprecedented demand for engineers, so it is easier for graduates to enter engineering work than at any time during the last 50 years. The response rate after 5 surveys in the study is steady at about 70% (n=130) of the group that initially signed up for the study (n=190) which in turn represented approximately 60% of the total graduating cohort (approx 330). A higher proportion of mechanical, civil and environmental engineers joined the study than electrical, electronic engineers, and no software engineers are participating (though they form only 3% of the total graduating cohort). The proportion of females is 20%, significantly higher than their proportion in the graduating cohort: females tend to respond to surveys more than males in many published reports. Finally, the surveys are sent by E-mail and participants respond via the internet: this is not easy at many remote engineering sites.

As part of on-going work to validate the results and triangulate data from the framework and longitudinal studies, we have held detailed discussions on several detailed findings from the studies with engineers responsible for training and supervising novices. These discussions have revealed a high level of qualitative agreement from the engineers: there seem to be no significant disagreements with the study findings.

Together with the background provided by the framework study, the longitudinal study is helping us to understand more about misalignments between engineering education and practice. These results could provide guidance on fundamental improvements to formal engineering education objectives and curricula. Suggestions and recommendations will be presented with another paper at the same meeting.

Acknowledgements
The authors would like to acknowledge the support of the Faculty of Engineering, Computing and Mathematics and the School of Mechanical Engineering for this study, as well as private donations. The authors would also like to acknowledge contributions from colleagues in the Engineering Learning and Practice Group and Dr. Lesley Jolly of the University of Queensland for invaluable help with survey design and methodology.

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