Experience and expertise: Is it all that good?

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Abstract: *This paper discussed the impact of experience and expertise on problem solving performance. Interview responses from 22 novice to expert engineers were considered in this paper. The results suggested that experience and expertise though favourably viewed can impact the problem solving process adversely especially when facing new problems. The two main areas discussed in this paper are the impact of experience and expertise on problem identification and learning. Prior experience and expertise may result in narrow problem diagnosis. Expertise may also slow down learning impacting skills and knowledge development. We propose that open-mindedness and self-efficacy can help to negate these detrimental effects. Findings in this paper can add to existing theories on the education and on-going professional development of engineers in the field of innovative problem solving.*

Keywords: problem solving, detrimental effect, expert, experience, life-long learning

Introduction

In engineering, problems are seldom defined and a problem may have many solutions. Engineers are expected to be capable of identifying the technical nature of the problem, achieving a solution and also evaluating the impact of the solution to the whole system (Engineers Australia, 2009). Despite significant research on teaching problem solving to engineers (Adams, Kaczmarczyk, Picton, & Demian, 2010; Alexander & Izu, 2010; Belski, 2009; Benjamin & Keenan, 2006; Kurfess, 2003; Litzinger, et al., 2010; Paton, 2010), a standard evaluation has yet to be devised. Moreover, the standard of good problem solving is often up to the researchers' interpretation (Sobek II & Jain, 2004). This paper is part of a PhD study that addresses the issue of developing a measure and the transferability of innovative problem solving skills within the field of engineering.

A good problem solver should have the ability to solve problems holistically (Harlim & Belski, 2011b). This requires the ability to scope problems properly. The difference between a strong versus an average problem solver lies in the problem identification stage. Open-mindedness is highly valued as the understanding of a problem is impacted by personal assumptions of the problem solver. The conscious awareness of assumptions, knowledge, strategy and problem solving enables the problem solver to build on his or her knowledge. These ensure better transfer when faced with a new situation. Self-efficacy (Bandura, 1997) was also found to be important for transferability of problem solving skills (Harlim & Belski, 2011b).

Problem solving behaviours of experts is usually considered as the benchmark for "goodness". The implication is that when a novice behaves like an expert when solving a problem, he or she has truly become a good problem solver. Such assumptions resulted from findings of current literature where it is evident that experts and novices behaved differently when solving problems (Bilalic, McLeod, & Gobet, 2009; Chi, Glaser, & Rees, 1982; Gick, 1986). Experienced problem solvers tend to perform better than those who are less experienced (Atman, Chimka, Bursic, & Nachtmann, 1999; Gobet & Simon, 1996). These imply that experience and expertise have a significant impact on one's ability to solve problems well. However, in most of these studies experience and expertise were found to result in better performance in one specific field. The question arises if an expert of particular field faces a completely new problem beyond his or her domain of expertise, how would prior experience contribute to his or her problem solving ability? The type of problems that an engineer might face is not always the same. The development of technology results in the growing complexity of knowledge and an engineering problem does not exist in isolation (Grasso, Callahan, & Doucett, 2004). In the pursuit of solving engineering problems, different areas of engineering and even non-engineering factors such as the environment and people need to be considered. Furthermore, the idea of the multi-skilled engineer is also highly valued (Kurfess, 2003). Recent studies from the cognitive science perspective have discussed that there is a possible adverse impact of expertise on problem solving in new situation (Belski & Belski, 2008; Kalyuga, Ayres, Chandler, & Sweller, 2003; Kalyuga, Renkl, & Paas, 2010). This paper discusses the impact of experience and expertise in the transferability of problem solving skills from the perspective of engineers.

Methodology

An exploratory qualitative approach, Grounded Theory (Glaser & Strauss, 1967) was utilised in this research as a quantitative approach may not be sufficient to capture complexities and numerous inter-dependent factors contributing to problem solving performance (English, 2008). Out of the many inter-dependent factors that may arise from the research, we were concerned the most with aspects that impact the transferability of problem solving skills. In this paper we wanted to investigate emerging themes on the impact of experience and expertise on the transferability of problem solving skills when facing a completely new problem.

The data presented in this paper was collected using taped semi-structured interviews conducted between 2009 and early 2011. Initial participants were recruited from a problem solving elective in RMIT University and also from various engineering organisations. These participants helped to recruit other participants via snowball-sampling. The interviews were carried out in cycles as in theoretical sampling. In theoretical sampling 'the researcher takes one step at a time with data gathering, followed by analysis, followed by more data gathering until a category reaches a point of "saturation"' (Corbin & Strauss, 2008, p. 146). The focus of theoretical sampling is to follow up on emerging leads that surfaced from the data until no new themes are identified. In this research, after each cycle, the interviews were transcribed and analysed by the main author. Interview questions were then adjusted to ensure that better data acquisition can be achieved in the next cycle.

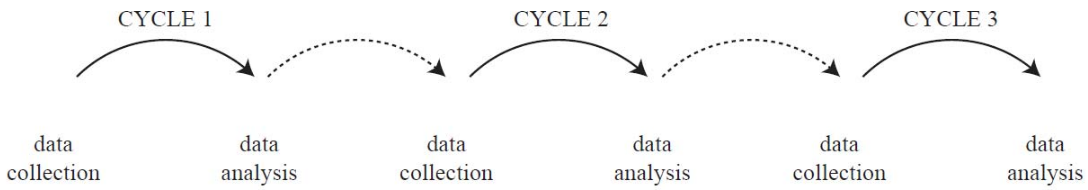

Figure 1: Data collection and data analysis process

Table 1 Participants demographic

No. of participants	**No. of work experience in full-time engineering field.**	**Classification**
6	0 years (Students and recent graduate with no work experience in the engineering field.)	Novice Class 1 (N1)
6	1-5 years	Novice Class 2 (N2)
3	6-10 years	Mid-level (M)
7	>10 years	Experts (E)

The first cycle included 7 participants, the second 6 participants and the third cycle involved 9 participants. Data saturation was observed when carrying out the third cycle, resulting in a total of 22 engineers interviewed, ranging from novice to experts (students to professionals with more than 10 years working experience), including 15 male and 7 female engineers. Refer to Table 1 for the participants' demographic breakdown.

Interview questions were used as guides but the participants were encouraged to talk as freely as possible about the topic. Questions included were how they went about solving problems, examples of good problem solvers and how problem solving can be learned or taught. As the interview progresses, additional questions were adjusted to probe deeper for some of the underlying meaning of the issues that the participants had raised in the interviews. For example questions like, 'why did you say that?' or 'what do you mean by that?' Throughout each interview, the main author would also paraphrase to check with the participants that her interpretation of what the participant was saying were accurate.

On top of carrying out analysis after each cycle, an overall analysis was also carried out when the cycles concluded. This was done to ensure validity in the data analyses. Analyses were carried out in different ways and a number of times to get better depth of understanding of the data and to ensure rigorousness. For example, the transcripts were initially micro-analysed with the help of NVivo software to identify common themes. The main author also listened to all the recording again to get an overall understanding. Once emerging themes have been identified, the main author went through the transcripts to extract the relevant quotes. The use of memos, diagrams and reflection journal were integral to the analyses (Corbin & Strauss, 2008). Verification was carried out by discussing the findings with participants. All these processes are consistent with the practice of ensuring rigour and validity in a qualitative approach.

Results

Experience was certainly valued by our participants when solving problems. Participants generally suggested people are good problem solvers because they have experience. One young engineer in our research indicated:

> *'I can say that good thinkers are the people who already faced the problem before. So they have more experience in the problem, facing problems.'* (N1-4)

The above statement indicated that experience would be a benefit when facing similar problems. Another young engineer in describing good problem solvers suggested:

> *'[good problem solvers] are really wise, and like they are really bright and saying that, I found them to* ***quick*** *thinkers. Their mind is just switched on and they can always come up with suggestions, ideas and saying that, they also know a lot, as in what is happening around them…. their mind seemed to be switch fast… maybe they can sometimes when you ask them questions they can just mentally work out a solution. I guess they have* ***really strong conceptual mind****. They* ***can picture the problem inside their head and just solve it in their mind****…. it's more to do with* ***the way they structure the image****. It's something that they have seen and they can picture it into a ...like a roadmap in their mind****… they would have a picture in their mind and so they can just follow it, and visualise it and then come up with a solution****….it's also about how you think oh that's actually related to something that I have heard or have seen before, or talked to people about before.'* (N2-4)

The participant above suggested that due to experience and expertise, a problem solver can quickly recognise a problem and that translates to a quicker solution. This was reiterated by one of the senior engineers interviewed who commented:

> '*... experience teaches you to recognise what to expect.*' (E3)

On the other hand, this comment also highlighted how experience may result in creating biases when identifying a new problem. This concept was also supported by a comment from one of young engineers:

> *'... you can have someone with lots of experiences and they might have a lot of knowledge on something but* ***once it comes down to something new they might not be able to just to tackle it at all because they've got their head set in the same spot****'* (N1-1)

Another area suggested by the participants to be impacted by experience and expertise was the development of problem solving skills. The younger participants in the research believed that the amount of experience gained is equivalent to better problem solving skills:

> *'… I guess you develop those skills [problem solving] as you have the experience.' (M2)*

> *'…of course [how we developed it is] from experience. If we face more problems and we come up with lots of solutions, it will help us with that skill.' (N1-6)*

Interestingly, senior engineers highlighted experience and expertise can be detrimental to learning. This was exemplified when one of the senior engineers interviewed commented:

> *'[learning problem solving] I want to qualify only to a point… one thing I noticed is many people including myself, you learn and you learn and then **you saturate yourself and you don't learn beyond that**. I don't think you keep on learning all the time. **You do learn things but the slope of the curve becomes slow**…'* (E4)

The expert, E4 suggested when one is over-saturated with knowledge, learning slows down. One other senior engineer even went further to attribute this to the malleability of personality:

> *'I think probably **as you get older your personality tends to solidify more** and maybe to put it crudely maybe become more of an extreme personality type. And so if that personality type is a personality that is a problem solver, you'd probably become better at it. Whereas if you are not you probably become worse at it.'* (E6)

Discussion

While experience and expertise was valued by our participants, their responses also highlighted the adverse impact these may have on the transferability of problem solving skill in two areas: increasing biases and slowing down learning.

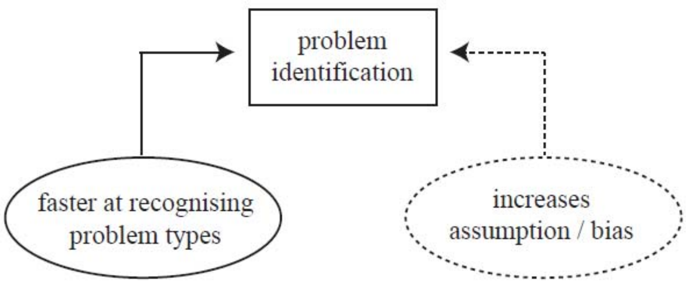

Figure 2: Possible impact of experience and expertise for problem identification.

Experts are considered to be better problem solvers due to the schemas that they have built in their long-term memories (Belski & Belski, 2008; Chi, Glaser, & Rees, 1982; Gick, 1986). Experts are more likely to by-pass the search process when facing a problem (Kalyuga, et al., 2003; Kalyuga, et al., 2010) thus enabling them to solve problems better and at a much quicker rate. However, when facing a new problem, experts are more likely to diagnose the problem narrowly and suggest solutions from their domain of expertise (Belski & Belski, 2008). Results presented in this paper supported this idea. Participants in the research indicated prior experience and expertise may result in the inability to approach new problems in new ways. Previously, we found that the problem definition stage is crucial to good problem solving (Harlim & Belski, 2011b). This in turn is impacted by personal beliefs and assumptions. The way one views the world is shaped by prior experience and expertise. We propose experience and expertise may reduce problem solving performance due to increase of bias and assumptions when faced with new problems.

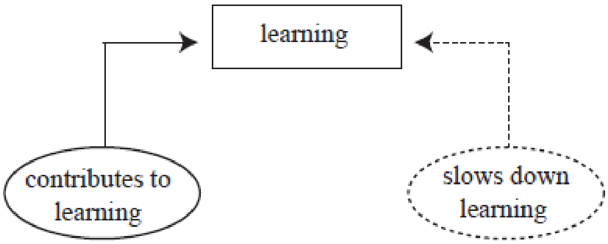

Figure 3: Possible impact of experience and expertise on learning.

Learning is important as the professional engineers are expected to continuously learn to be able to cope with the challenges of the engineering role (Engineers Australia, 2009). This is also driven by the development of technology which in turn impacts the engineering profession (Grasso, et al., 2004). The possibility of the adverse impact of expertise on learning was also raised by the participants in our study. People learn from their past experiences. However, when expertise is achieved, the experts in our research reported the slowing down of learning due to over-saturation of knowledge. Another reason for this as suggested by the participants is the solidification of personality which increases resistance towards change. This could be supported by Atman et. al. (1999). The senior students, considered to be more experienced in their research were dismissive of alternative steps when resolving new problems. They were also critical of prescribed steps suggesting less flexibility compared to freshmen. When facing new problems, new knowledge and approaches may be required. We posit an expert is more likely to report lesser improvement after learning something new. We believe this influences the performance and future development of problem solving skills.

How can these detrimental effects be negated? We suggest open-mindedness may assist in reducing biases when solving new problems. The value of open-mindedness for problem solving is discussed and supported by Adams et. al. (2010). The ability to consider problems from different aspects was also discussed in depth in our previous publication (Harlim & Belski, 2011b). Though not fully explored in this paper, experts in our study also tended to value open-mindedness more compared to our younger participants. Kalyuga et. al. (2003) suggested that as experience and expertise are developed, different strategies are required for learning. It is also worthwhile considering how learning can be tailored as one develops expertise. In our previous paper, we also proposed self-efficacy is the driver of transferability (Harlim & Belski, 2011b). Self-efficacy drives a problem solver to seek out new knowledge. This is supported by Bandura who argued that self-efficacy 'contributes to the acquisition of knowledge and development of subskills, as well as drawing upon them in the construction of new behaviour patterns… through the proactive exercise of efficacy belief in self-development, capacity is converted to capability' (Bandura, 1997, p. 61). We believe self-efficacy can impact the motivation of the experienced and expert problem solvers to continuously learn.

Conclusion & Future Research

While experience and expertise are highly valued in problem solving, it was also suggested by our participants that these may also impede good problem solving. Prior experience and expertise may increase bias in problem identification, leading to solutions that may not fit new problems. In addition, experience and expertise may also impact the learning process adversely. In educating young engineers to be good problem solvers, perhaps it is not sufficient to just expose them to as much problems as possible to give them more experience. Qualities of open-mindedness and self-efficacy should also be fostered so young engineers can cope with the complexities and varied engineering problems they may face in their professional lives. We propose that teaching students specific problem solving methodologies can assist with the development of these two qualities. In fostering these qualities, course and assessment design can become crucial. These were supported by our earlier research (Belski, 2009; Harlim & Belski, 2010, 2011a).

As this research is part of an ongoing PhD research, findings are continuously refined. The use of qualitative research allows the capture of in-depth and rich data. It was not possible to discuss all the data findings within this paper. More themes emerged from the rich data pool such as comments that suggest experience may even increase conservatism thereby reducing creativity. Indications of misconceptions that young engineers have about the practice of good problem solving were also identified in the data. While the interview data has helped us deepen our understanding of problem solving from the perspective of engineers, further verification needs to be carried out. We have collected additional data as means of triangulating the interview findings using Repertory Grid Technique but it was not possible to include the findings in this paper. Currently a pilot questionnaire is also being designed. This will be disseminated to capture data from more engineers. Results from the questionnaire will then be analysed using confirmatory factor analyses and compared against the interview. Triangulation of data is planned to ensure that findings are not just limited to the interview sample only.

Findings in this paper have provided new hypotheses which can be addressed by further tests in future research. While this paper has suggested means of fostering open-mindedness and self-efficacy based on the authors' experience, further exploration is required. Future research direction can also investigate other specific ways qualities of open-mindedness and self-efficacy can be fostered in young engineers. Investigation into different strategies for expert development can also be carried out. Despite the limitations and future research direction required, findings in this paper have implications for the education and on-going professional development of young and senior engineers in the field of innovative problem solving.

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