Experiences of an inter-university final year research group in Engineering education

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Structured abstract

BACKGROUND
To contribute to a national project aimed at enhancing industry engagement in engineering degrees, a research group was formed to supervise six final-year engineering students from two urban Australian universities. By establishing a community of practice, specifically a learning community (Wenger, 1998), and by investigating the experience of researchers in the group, in this study we developed and tested an approach to support students and supervisors who might otherwise be vulnerable due to isolation and the new and insulated status of engineering education research relative to research in technical engineering. Whilst graduate engineering research groups and engineering education research groups have been studied previously (e.g., Crede & Borrego, 2012 in the US; Mann, Brodie, Chang, & Howard, 2011 in Australia), this study is the first of its kind because it is rare for final year students to participate in inter-university research groups, or to undertake research in this field.

PURPOSE
The study reported here sought to inform the efficacy of inter-institution research groups by investigating both supervisory and student experiences of an inter-institution learning community. This paper focuses on the experience of the supervisors. It describes the experience of a research group designed to support final year students and supervisors undertaking engineering education research.

DESIGN/METHOD
We established an inter-institutional research group with weekly group meetings. The data collection and analysis was informed by the theoretical framework of possible selves (Markus & Nurius, 1986) in which people are understood to be influenced by their awareness of possible future selves that are perceived as desirable, disconcerting, and/or achievable. These possible selves influence people's perceptions of hopes, fears, goals and threats. This paper reports our investigation of the researchers' and students' experiences of hopes and fears, and their realisation, based on the reflections of the researchers. At the start of first semester and again after first semester, the researchers completed two questionnaires about hopes, fears and challenges. We independently analysed these reflections for themes relevant to the theory and to informing future development of similar research groups. Our findings were formed through discussion of our independent analyses. The six students also provided written reflections on their identities and hopes, fears, and expectations of the research experience, reported separately.

RESULTS
The research group emerged as a successful learning community. Students and supervisors learned about research, theories, identities, relationships, and teamwork skills. We also learned from the students' research data, which related to exposure to engineering practice during engineering degrees. Learning and supervision was enhanced by supervisors supporting and extending each other.

CONCLUSIONS
We recommend inter-institutional research groups to support final-year engineering students undertaking engineering education research and also their supervisors. We recommend weekly, open, non-hierarchical group meetings; a community learning management system; diverse experience among supervisors; the support of department heads and other engineering education researchers; and pre-empting administrative and inter-institutional challenges.

KEYWORDS
Research groups, learning communities, engineering education research

Introduction

This research contributes to encouragement and support for trail blazers in the field of engineering education research. Few engineering students undertake final year (FY) projects in the field of engineering education, and therefore the experience can be isolating for students and their supervisors. There is potential for students and supervisors to perceive undertaking research in the field of engineering education as taking a risk, because the culture within engineering faculties is one in which technical research has assured status and education research can be unfamiliar and misunderstood, and its credibility doubted (Mann et al., 2011). In 2013 we formed a research group comprising three main supervisors and six FY engineering students undertaking research projects in engineering education. By establishing a community of practice, specifically a learning community (Wenger, 1998), and investigating the experience of researchers in the group, in this study we developed and tested an approach to support students and supervisors who might otherwise be vulnerable due to isolation and the new and insulated status of engineering education research relative to research in technical engineering.

Significance and originality

This study will improve our future development of similar research groups and we hope it will encourage and help others to build inter-university research groups with FY engineering students researching engineering education. In this way we hope to enhance the broader community of engineering education researchers. Whilst graduate engineering research groups, and engineering education research groups for engineering and other academics, have been studied previously (e.g., Crede & Borrego, 2012 in the US; Mann et al., 2011 in Australia), it is rare for FY students to participate in inter-university research groups. It is also relatively rare for engineering students to undertake research in engineering education. Thus this study is the first of its kind.

Background

To contribute to a national project aimed at enhancing industry engagement in engineering degrees (Academic Resource Network for Engineering and ICT Australia, 2013), a research group was formed to supervise six FY engineering students from two urban Australian universities: one in the Group of Eight and one in the Australian Technology Network. The FY students each undertook a project to investigate undergraduate engineering students' development through a specific opportunity for exposure to engineering practice. Three FY students investigated students' development through units in which students were exposed to engineering practice. These units included work-related learning (Knight & Yorke, 2004, p 103) with features such as industry-based guest lectures, industry-based demonstrators and tutors, and problem-based learning. Two FY students investigated students' development through vacation employment, and one FY student investigated students' development through industry-based projects managed as part of a 'CEED' program (Anon., 2013). All FY projects were undertaken as individual projects. The students developed the research design, prepared a literature review, collected and analysed data, and wrote either a thesis or a final report to meet the requirements of their universities.

While the focus of the FY students was the impact of engineering students' exposure to engineering practice, as researchers we investigated the experience of the FY students and supervisors in the inter-university research group. The FY students were from three engineering disciplines: electrical and electronic engineering; mechatronic engineering; and chemical engineering (Figure 1). The three supervisors, all women aged in our forties, were all experienced in engineering education research and student supervision. In addition we have backgrounds in identity development and education; literature and chemical engineering; and electrical engineering.

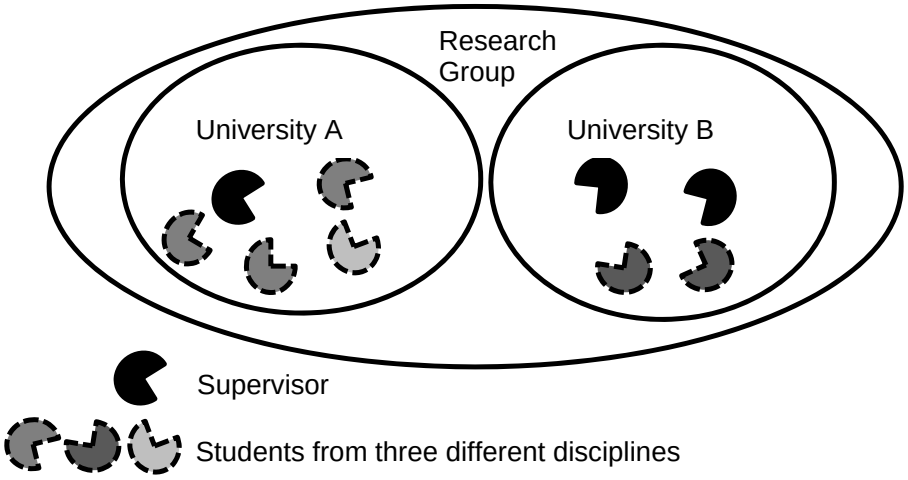

Figure 1: Research group composition

In this study we worked with students in a community of researchers. The group met each week, and students also had weekly individual meetings with at least one supervisor. From week six, when a common time became available, the group meetings were held in supervisors' offices at each university, connected via Skype™. Students shared a learning management system (LMS) community unit to enable group members to share ideas in a discussion forum, and students were able to access all three supervisors by email and via the LMS.

In the early meetings we discussed proposals, and two engineering educators from outside the group presented their research. Another early meeting featured interviewing practice. Later, we independently analysed one-minute paper responses collected by a student and coded transcripts. Later again we discussed our independent analyses of an anonymised student interview. In the group we also talked about the presentation of research; shared and critiqued written drafts; and considered how education research design and language compare with the engineering experiments and reports with which the students were familiar. During these discussions we learned from each other and from the students.

Methodology

Here we outline our research design and the theory that informed the investigation. The approach was informed by the theoretical framework of possible selves (Markus & Nurius, 1986) in which people are understood to be influenced by their awareness of possible future selves that are perceived as desirable, disconcerting, and/or achievable. These possible selves influence people's perceptions of hopes, fears, goals and threats. Where much identity research is focused on antecedents to present identity, possible selves is focused on the planning and implementation of strategies toward realisation or avoidance of possible future identities. The thinking behind the possible selves framework aligns with other established development theories, which accept that the ways in which students approach their career and life planning influence their engagement with their higher education learning. This is the first study to apply this theoretical approach to the learning of undergraduate engineering students.

Early in first semester, and at the end of semester, the three main supervisors completed structured reflections on their hopes, fears and expectations for the study and the community. We then shared these documents with each other and independently analysed them, providing the basis for a group discussion. This paper reports our investigation of the researchers' and students' experiences of hopes and fears, and their realisation based on the reflections of the researchers. The six students also provided written reflections on their

identities and hopes, fears, and expectations of the research experience, reported separately.

We supported students and ourselves, as the supervisors, by developing a learning community. Wenger (pp. 214-21) describes this as a specific community of practice in which "learning involves an interaction between experience and competence". All members, experienced and novice, learn through engaging in a shared enterprise as new knowledge is developed. In the process they also reappraise their learner and professional identities.

The small number of participants enabled us to work closely with each other and "enhanced the validity of fine-grained, in-depth inquiry" (Crouch & McKenzie, 2006, p 483). Our analysis employed analytic induction at each phase of the study. Whilst this approach was originally seen as a search for universals, we utilised it as a means to enhance data by examining similarities and differences that might help develop new concepts and ideas (Ragin, 1994, p 124). Therefore, all initial themes were derived from the data and interrogated in light of other participants' responses and previous phases to determine essential characteristics.

A similar research approach was taken by Harrison, Pithouse-Morgan, Conolly, and Meyiwa (2012) in their self-study of practice in an inter-institutional, trans-disciplinary learning community involving supervisors and postgraduate students in South Africa. Their study was based on reflexive logbooks, workshop evaluations and the researchers' reflections and communication (p 12). Akin to our possible selves framework, their theoretical framework was '*Ubuntu'*,

> *which demands consciousness of our developing 'selves' as researchers and supervisors and of our relationships with other people (p 12).*

Method

Reflections were amassed from two questionnaires completed by each of the research supervisors. The first, which included the participant information sheet and consent form, was completed early in first semester; the second was completed at the end of semester. Students' reflections were also collected in two surveys, reported separately.

Supervisor questionnaire 1 (Q1)

1. *Why did you choose to be involved in this cross-institutional project?*
2. *What are your expectations about this experience?*
3. *What, if any, fears do you have about the project?*
4. *How would you describe the kind of learning that might happen in this project?*
5. *What makes honours projects work well?*
6. *What contextual (environment) factors make life easier or harder when doing this kind of work?*
7. *What kinds of assessment/documentation/activities might help us to share these experiences and learning with others at our universities and elsewhere?*

The second questionnaire (Q2), completed after the semester, first probed the initial themes emerging from Q1. Questions asked: 1) what we and others had learned; 2) about initial expectations and fears and whether they were realised; and 3) about challenges, factors for success, and recommendations. In Q1, each of us had given different accounts of what we expected, hoped and feared to encounter during the project. In order to build on those earlier narratives, Q2 was customised so that it was unique to each supervisor. Embedding each supervisor's early reflections into her second survey instrument enabled us to seek further comment on those reflections.

Findings

Textual data were transcribed, coded and analysed for emergent themes using inductive coding (Denzin and Lincoln 2011). The three researchers conducted this initial coding independently, after which coding was compared and refinements applied. This analysis revealed three key themes from which we generated the structural description contained in this article: namely, the learning community; the learning that took place within that

community; and the collaborative research supervision. We present these themes below, discussing the factors that contributed to success, the hopes and fears we had initially, and the lessons learned. Examples of our reflections are included as quotations.

Learning community

The success of the learning community was in helping all of us to develop understanding, skills, and importantly a sense of belonging to a community. “The community provided both support and extension.”

Factors that contributed to the success of the learning community were the weekly meetings, our diverse individual strengths, the common interest, and the LMS. The weekly, open, non-hierarchical meetings, using Skype™ to enable everyone to attend, were an essential part of the learning community. In the meetings, in addition to updates and planning, we developed our research skills, and relationships. A supervisor reflected:

> *A participatory approach was essential… Whilst we were the ‘experts’, we encouraged a team approach without hierarchies.*

The LMS allowed supervisors and students to share resources and students’ work. Students used the LMS as a tool to share their draft questionnaires and interview questions along with questions to the group members about how the drafts could be improved. Students and supervisors tested and reviewed these.

At the start of semester as supervisors we hoped to learn from each other, experience collegiality, share diverse perspectives, and establish something that would last beyond the project. We experienced satisfaction and enjoyment from the learning community, described by one supervisor as: “The only meetings I really enjoyed all semester.” A fear was that our different use of language in our diverse disciplines could be problematic. This did not prove to be a problem and indeed we hope to continue with this work. We quickly realised the value of meaningful meetings in establishing a sense of community:

> *Community/team meetings should encourage open discussion and experimentation. They need to be long enough, and open enough, so that concerns and ideas are voiced without fear.*

Finding a common meeting time was difficult but proved important. Although we were all in the same city, travel times made it too difficult to meet face-to-face with the whole group, whereas meetings with students sitting in two offices connected online were convenient.

Learning within the community

The second theme in our reflections was the learning that arose from the collaboration within the community. We hoped that both supervisors and students would learn from the experience, but of course we were not sure what forms that learning might take. In fact, we learned both from and with each other. The most critical factor for students’ learning was undoubtedly attendance at the meetings:

> *[Students learned] through participating in a social environment, with many decisions to make and much management and self-discipline and new language to learn. If they attend the meetings they learn much and find them motivating.*

One of the key factors was the diversity of the supervisors and of the students, who represented a number of engineering disciplines: “The collaboration with people having different experience and expertise and the sharing of the ideas and recommendations made the learning more effective.” We have realised that in future projects we need to impress on students how important it is that they attend all group meetings.

Our learning was vast. Through our diverse academic and disciplinary backgrounds we expanded or improved our research skills, learning about theories of learning, curriculum, identity, and engineering practice; research design; data collection and analysis applications and techniques; and academic language, writing and presentation. Additionally, we learned about working in teams, about our strengths and weaknesses and those of other members,

and about our identities and how we belonged to the wider academic community. As a group we learned about the common theme that formed the core of students' research: namely, exposure to engineering practice in the curriculum, and students' experiences of this. As one researcher noted, students gained "confidence in themselves as engineers [as] they learned about engineering practice." As supervisors we also learned much about supervision.

Supervision

Our hope that we would learn from each other and strengthen our supervisory skills was met. Our initial fears about supervision were numerous and included time and energy expectations, use of different language, giving contradictory advice, lack of discussion before semester started, different systems and processes at the two institutions, responsibilities of supervisors in this field, students taking on non-traditional engineering projects, and concern about finding suitable examiners.

The first lesson we learned from the group supervision was "the enormous value of undertaking FY projects as a research community." The group meetings were critical, in part because we were able to act as observers and learners as well as actively supervising:

> *During the weekly meetings, the students' questions helped me to see their change in identity and their challenges. The [other] supervisors' answers to their questions showed the different research perspectives.*

Some of our initial fears were alleviated during the project. Through the group we were able to support each other with our supervision responsibilities, and to enhance the quality and breadth of our supervision: "Students had sounding posts for their ideas and questions, as did we. We were able to cover staff absences and to offer multiple perspectives." As another researcher wrote:

> *Because of the close interaction and the weekly meetings, I got to know my students well and understand their challenges. At the beginning, they were scared of the new area and workload… but I could see they were motivated when they realised that the supervisors were very supportive and the [university 1] students were very happy to share their experience. I think this sense of community helped them through semester.*

Other fears, however, were realised: for example, time expectations were high and sometimes difficult to meet. Also, the two institutions had different expectations of student workload and reporting, with the project being at honours degree level at only one of the institutions. Consequently one student was overwhelmed by the expectations discussed in an early group meeting, not realising the difference between institutions. The supervisors had not discussed this diversity in advance and the potential for confusion had not been pre-empted. Similarly, we encountered a need to support students in their choice of research topic: students in our learning community expressed their concern that students and academics outside our group might perceive engineering education research as non-rigorous. To avoid similar bias within the examination process, at one university thesis and presentation examiners with relevant experience were recruited from outside the school to overcome the lack of engineering education experience found within. Furthermore, although the university where the LMS was established had the facilities for a community LMS, the staff with responsibility to establish it were unaware of this possibility, creating delay.

Several factors emerged as critical to enhancing the student experience and our ability to offer shared supervision. These factors included: 1) weekly meetings during which students asked questions and learned from diverse perspectives, practiced research techniques and presentation skills, and gave and received peer feedback; the common theme which ensured shared interest among all participants; supportive supervisors; and regular encounters of 'success' in such forms as observing students experiencing light bulb moments, sometimes as a result of peer-to-peer interactions. Voluntary support from colleagues who had engineering education research experience and were not part of our group was also essential, including as examiners. As supervisors we learned the need to discuss and pre-empt potential administrative and inter-institutional difficulties well ahead of future projects.

In making recommendations, we were mindful of the need for sustainability of projects. Our projects were offered with approval from deans or heads of school. In one case this support was not automatic. We hope that the success of our experience will help others in seeking similar approvals. We also recognise the need to continue offering engineering education research projects in order to establish a culture in which such projects are normalised.

Model for an effective research learning community

Our findings revealed three themes that together comprised the success of the research community. These were: learning community; learning within the community; and supervision. Each theme is supported by the components that contribute to its development and success. Our initial model for an effective research group is proposed in Figure 2. We do not seek to generalise this model to other settings; our goal is rather to share the elements we found to be central to a successful research learning community involving both students and supervisors. The initial model will form the basis of our future research.

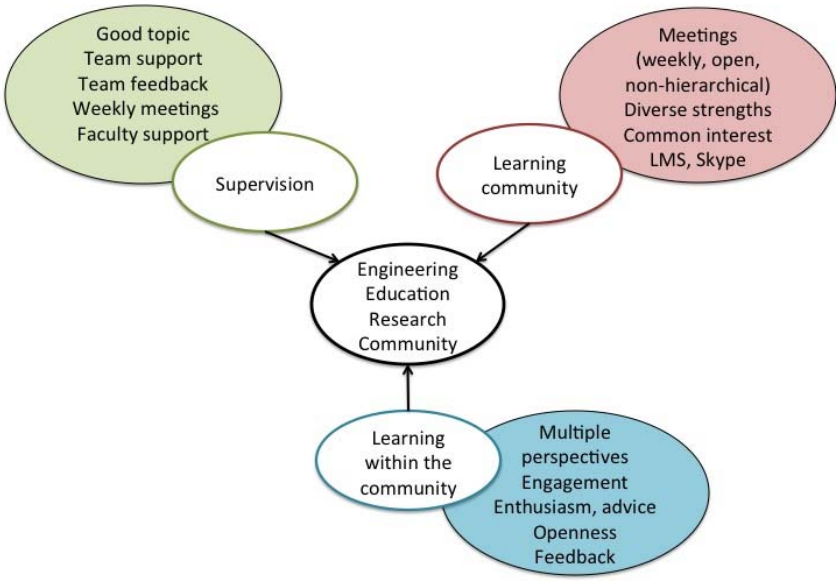

Figure 2: Model for effective engineering education research community

Discussion

Our findings are consistent with Dineen's (2006) observation that staff-student research relationships increased the motivation of both students and staff. With a focus on the student perspective, Tosey (2006) notes that increasing student staff ratios and other factors lead students to increasingly highlight their appreciation of personal staff contact. Our experiences were consistent with this observation. The appreciation and sense of belonging was reflected in students' actions. Academics found that the students in the group grasped opportunities to talk with them after events unrelated to the group, and two students chose to attend group meetings even after submitting their final reports. The community was palpable, even beyond its academic focus: for example, one student cooked birthday cake to share with the group, and a student announced her engagement.

Learners in small groups are known to have dual roles as students and collaborators in their personal, professional and social development (Griffiths, 2009). This could account for the high levels of motivation and solid academic performance seen among the students who attended regularly. Harrison et al.'s (p 29) finding that "participants reported feeling stimulated by and enjoying the interaction with colleagues from their own and other institutions", was consistent with our findings. Indeed, the group meetings provided all five of

Adams and Hamm's (1990) criterial elements for cooperative learning: namely, face-to-face promotive interaction; individual accountability in relation to personal and group goals; frequent practice with small-group collaborative skills; positive interdependence; and regular group processing and reflection.

Our experiences regarding diversity were consistent with Wenger's (1998, pp. 75-6) theory that diversity is important to people engaging in communities of practice and that,

> *each participant in a community of practice finds a unique place and gains a unique identity that is both further integrated and further defined in the course of engagement.*

One aspect of our diversity, as participants in the community of practice, was diversity in the educational theories with which we were familiar. We learned from each other about theories and approaches from other disciplines. Tummons (2012) critiques the idea that theory can become a common, binding repertoire for an educational research community of practice. He concludes by asking why the use of theory is positioned as central to a new educational researcher's development, whereas experienced educational researchers use theories in diverse ways. In our case, the theory of 'possible selves' became our common repertoire while we maintained diverse uses of the theories relevant to each student's research study.

Limitations and further studies

Whilst the research study reported here was conducted at two institutions and across two different FY programs with very different requirements, this paper reports only the supervisors' reflections. The students' reflections will be reported elsewhere.

Transferability of our findings will depend on comparison with our context. One of Harrison et al.'s (2012) study requirements was that their funding for face-to-face meetings was essential because in South Africa, where their study was undertaken, electronic meetings were unreliable. In the case of our study, although the two universities were in the same city, it was convenient for the meetings to be held in an office at each university connected via Skype™. This highlights the importance of considering the context of the study when assessing transferability.

Conclusions

The findings of this study, drawn from supervisors' reflections early in semester and after the semester, lead us to recommend an inter-institution research group as a means to supporting FY engineering students and their supervisors in engineering education research. Through our group, we developed a learning community in which students and supervisors supported and extended one another. Students and supervisors learned about research, teamwork, personal and research findings. Critical factors in the community's success were: experienced supervisors with diverse but relevant backgrounds; weekly, open, non-hierarchical group meetings connected electronically; an LMS on which students could share and review their work and thinking; support from deans or heads of school, and from other engineering education researchers; and a meaningful common research theme.

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