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Modelling Research: A Collaborative Approach to Helping PhD Students Develop Higher-Level Research Skills

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Modelling Research: A Collaborative Approach to Helping PhD Students Develop Higher-Level Research Skills

A high proportion of PhD candidates in science and engineering fail to complete their degrees. This paper reports the results of a series of workshops where experienced researchers and supervisors were brought together with PhD students to discuss, and develop a model of the PhD process. The objective was to help students develop a more rounded and thoughtful approach to their work. The impact of the workshops was assessed by carrying out structured interviews and coding the results to determine the impact on participant perceptions. The analysis suggests that the approach is effective in helping participants to clarify their thinking about the research process in which they are engaged. A proportion of participants appear to have moved from a tactical to more strategic approach to their research. The study involved students in a postgraduate university but has implications for training of all research students in applied disciplines.

Keywords: research training, knowledge transfer, strategic thinking

1. Introduction

Only about half the students who start a science or engineering doctoral programme in the UK can be expected to complete (Ali and Kohun 2006, Haksever and Manisali 2000). Comparison with other European countries is difficult due to the lack of published data and differences in the process. For instance a period of industrial experience may be required considerably lengthening the time taken to obtain the degree (Park 2005, McQueen 1994).

Many reasons have been suggested for these high rates of non-completion including: running out of time or funding (Lovitts 2001, Golde 2000); problems with the student/supervisor relationship (Hockey 1994, Haksever and Manisali 2000, Latona and Browne 2001); and misconceptions of what research involves (Van Rossum and Schenk 1984, Elton and Pope 1987, Wright and Cochrane 2000). The last of these problem areas can be addressed by developing students' understanding of research and encouraging them to approach their work more strategically.

2. PhD students' misconception of research

There have been relatively few investigations into how experienced researchers approach their work (Brew 2001) though studies have been carried out into student conceptions of research. Meyer *et al*. (2005) found that postgraduate students sometimes had a poor understanding of research practice. Among the misconceptions were that research involves collecting data to support particular ideas, that contradictory findings never occur, or that there is usually only one way to interpret findings. It seems that students tend to focus on specific tasks such as data collection or interpretation rather than on more fundamental issues such as research design or formulating research questions. Their approach tends to be tactical rather than strategic.

A number of factors seem to limit the effectiveness of the training programmes which universities typically provide for PhD students (Frame and Allen 2002). Such programmes tend to focus on subject-specific issues and their generally traditional mode of delivery often fails to engage students (Laird *et al*. 2003). We suggest that it can be useful to help students develop generic skills such as research design, and to encourage them to look at the process in the round.

There are a number of delivery modes which could be used to do this including structured discussions or group work where participants learn from each others' experience. However, these approaches tend to be most effective in supporting material which has already been presented. This makes them less suitable for addressing the more diffuse issues related to generic research skills.

We outline an approach to PhD student training which encourages students to think about the research process itself. This change of focus is prompted by their participation in facilitated workshops with experienced researchers where a model of

the PhD process is developed. It has been found that a group effort of this nature leads students to think about research in terms of inter-linked stages, each of which yields different outcomes and involves distinct challenges.

3. Existing techniques suitable to address PhD students' misconceptions of research

Helping students develop a strategic view requires a method which looks at generic research skills cutting across disciplines. The authors believe this is best achieved by group techniques where students learn both from each other and from experienced practitioners. Such an approach ties in with the findings of Aman *et al*. (2007) who concluded that role-modelling and instructor support is particularly relevant for team-based learning in engineering. The authors considered using established participative techniques such as structured discussions, action learning, and traditional group work (Laird *et al*. 2003, p.153).

Structured discussions are aimed at a specific outcome or learning objectives and are usually facilitated. Focus groups are one variant where the objective is to ascertain group opinion and where the facilitator keeps the discussion focussed (Stewart and Shamdasani 1990, p.10). Brainstorming is another variant where participants contribute ideas openly, refraining from evaluating until everyone has had their say, and then voting on the ideas (Wilson 2006). It is often used where some creative input is required, for instance in developing new products or revising business processes (Osborn 1963). Although these techniques are useful for canvassing opinions or stimulating original thinking they do not directly address the problem of changing participant perceptions.

Action learning involves groups discussing their work, possibly supported by a learning coach, to draw lessons from experience (Iles 1994). Participants may be

working in distinct areas or have related jobs. A typical example of the approach is reported by Miller (2003) who describes an action learning project to help managers in a hospital. The exercise started with a seminar on performance management, followed by weekly meetings that built on the seminar. Later, managers piloted new performance management instruments with members of their teams and then reviewed the instruments after a period of use. The essential characteristic of action learning is that it focuses on reflective practice in the workplace (Yorks *et al*. 1999) and generally involves reviewing the outcomes of relatively short work-related initiatives. It is less appropriate to the longer timescales of PhD research where a student may not be able to modify and retry things.

Group techniques in education generally encourage students to look at different ways of approaching an issue (Benjamin *et al*. 1997). The main applications have been in social sciences, to develop teamwork or communication skills, and the acquisition of a second language (Long and Porter 1985). The potential of group work in science and engineering has also been acknowledged (Elliot & Higgins 2005).

Group exercises in engineering have generally focussed on learning from peer experience of subject-specific tasks such as design exercises. Raising research student awareness of strategic issues requires a broader scope to group discussion and needs to bring in experienced researchers since the long duration of research projects makes it difficult for students to learn from their own experience. Furthermore a series of meetings will generally be required since students will need time to reflect on what is said. It is also possible that some experienced researchers may not hitherto have reflected on and articulated their own research techniques. Involving participants with varied status and experience raises issues of group dynamics and

suggests the need for facilitation. Many of the requirements outlined here are similar to those which the authors encountered in an earlier project they carried out for a gas turbine manufacturer.

4. A knowledge transfer process - CoMEx

The problem of raising students' awareness of research processes and design has been approached by running workshops involving both novice and experienced researchers where participants collaborate to develop a model of the research process. A facilitator helps run these workshops and encourages experienced researchers to reflect on their working practices – something which they may not previously have thought to do. The approach was previously developed for an engineering organisation.

Prior to this work, the authors were involved in a project that aimed at understanding the process of diagnosing faults in gas turbines designed, manufactured, commissioned and serviced by a major engineering company. Customer help desk engineers had built up considerable experience in the operational behaviour of turbines. This expertise was seen as relevant to the design and manufacture of new equipment. However, attempts to transfer the help desk experience to other departments had yielded disappointing results.

The approach which was developed for the manufacturer involved running a series of facilitated workshops where engineers from the help desk and from other parts of the organisation worked together to model the process of fault diagnosis. Although the models developed were documented, the more important result of these workshops was that both help desk and non-help desk engineers developed a much richer awareness of the problem domain.

This approach was subsequently refined into a structured method that captures potentially relevant concepts, leads the group to the development of a model using some or all of those concepts, and finally assesses the relevance of such a model for individual participants. Facilitation techniques are used to encourage collaboration and knowledge sharing between learners and experienced individuals throughout the process. The method was called CoMEx (Concepts, Modelling and Experience), since participants are first encouraged to identify key concepts, bring them together into a model and finally compare the model to their experience.

There are four key stages in running a CoMEx exercise. These are:

(1) Project initiation. The facilitator and the organisation organise the knowledge sharing project, agreeing on participants, rooms to be used, times of meeting and so forth. These participants are drawn from among a group of experts whose knowledge is of interest to non-experts elsewhere in the organisation. The project is presented to participants as a series of collaborative meetings to develop a model of some organisational process or activity.

(2) Project preparation. The facilitator elicits key concepts about the knowledge domain and the relations between these concepts, as understood by individual participants. If participants themselves do not suggest an initial representation of the relations between concepts, the facilitator will suggest one or more simple models to use as a starting point.

(3) Knowledge sharing meetings. The experts and non-experts work together to develop a model of the activity or process which is the focus of the knowledge transfer. They use the initial models from the previous step as the starting point for these discussions. Later, they analyse how any models developed relate to the experience of individual participants.

Environmental, interpersonal and intrapersonal variables such as personal space, spatial arrangements and interpersonal distance among participants are carefully considered when setting up the knowledge sharing meetings.

(4) Post-process review. The facilitator encourages individual participants to reflect on their learning experience.

(Figure 1)

5. Using CoMEx to Transfer Research Skills

Three CoMEx exercises were run at Cranfield University in the course of 2008 to help PhD students develop their research skills. The panel of experts was drawn from experienced academic researchers and research supervisors as well as a Student Monitoring specialist from the Academic Registry, who was invited to clarify any misunderstandings of the formalities of the PhD process. All participating students were in the first or second year of a science, technology or management-related PhD. The ratio of experts to students for the three exercises was 3 to 5, 3 to 5 and 2 to 4 respectively. None of the participants was informed about any previous CoMEx exercise. One of the authors acted as facilitator in all three exercises which each ran for about one month, following the stages outlined above.

Stage one: Project initiation.

Once a panel of experts had been found, students who were in the first two years of their research were invited to take part and informed which researchers or academics would be involved. No-one participated in more than one exercise. Both experts and students were provided with a summary of the activities involved and a proposed timetable.

Stage two: Project preparation.

The authors interviewed each participant individually and a range of concepts was identified including: "*study*", "*devise a research project*", "*hypothesis generation*", "*carry out the project*", "*hypothesis testing*", "*data collection*", and so forth.

The authors organised these concepts to produce a basic model, such as the one in figure 2, which could be used as a starting point for discussion if needed.

(Figure 2)

Stage three: Knowledge sharing meetings.

Two meetings, each lasting about an hour and which were voice-recorded, were held in each CoMEx exercise. Each team produced at least one model of the PhD research process.

(Figure 3)

The team in the second CoMEx exercise developed the generic model shown in figure 3. The team involved in the final exercise produced the more detailed model shown in figure 4. This particular model was influenced by the participation of Academic Registry who provided significant input on expected progress at different stages and the corresponding deadlines. Experienced researchers then focused on the actions required to achieve the required progress. This group emphasised the role of the supervisor and the student-supervisor relationship at different stages.

(Figure 4)

After the models had been developed students identified and described the structure, challenges and opportunities of their research and related these to the model while experts commented on the progress of the research and issues arising.

In addition to capturing and documenting the models, the facilitator played a role in soliciting input from all the participants and keeping the discussion focused.

Stage four: Post-process review.
Approximately one week after the last knowledge sharing exercise the authors conducted a series of individual semi-structured interviews with the participants focusing on the impact on students' views of their research.

6. Assessing the impact of the exercise

The objective of the assessment was to determine whether participants considered the exercises useful and whether they affected conceptions of research, in particular by helping them to adopt a more strategic view of their work. Effects on the completion rate of students were also investigated.

A qualitative approach was adopted, largely based on analysis of semi-structured interviews with participants but supplemented by observation and information on outcomes of students' doctoral studies. Interviews would allow participant perceptions to be explored more deeply than techniques such as surveys which, in any event, would not give reliable results given the small sample size.

6.1. Data Collection

A total of 22 participants (14 PhD students, 8 PhD holders and 1 member of Academic Registry staff) took part in the exercises. They were interviewed at the end of the exercise and, where possible, at 18 and 30 months after the exercises had completed resulting in approximately 35 interviews. Interview data collected for student participants was less comprehensive with interviews being carried out for only 9 students. Semi-structured interviews were designed around a set of key concepts such as "*perceived learning experience*", or "*perceived value of participation*" which related to the objectives of the assessment.

Most of the interviews were voice-recorded and then transcribed for analysis. In transcribing no attempt was made to capture details such as pauses or side remarks

on the basis that the analysis was concerned with overall perceptions rather than thought processes during the interviews. Transcribed interviews were loaded to spreadsheets so that each phrase in an interview was assigned to a separate row and tagged with further information such as interview details and where it occurred. Tagging in this way facilitated subsequent analysis by allowing coded rows to be grouped or sorted.

6.2. Analysis

Analysis began with coding the data in line with the approach for qualitative data analysis outlined in Miles and Huberman (1994, chapter 4 part b). Descriptive codes were used which were designed to reflect the content of what was said with minimal interpretation on the part of the coder.

The coding scheme was developed inductively by the author who was not present at the workshops or subsequent interviews. This helped ensure that the scheme was based purely on the data rather than supplemented by personal memory of the interviews. An initial scan of the data led to an outline scheme where comments were coded as either not relevant, relating to the exercise, relating to the model, or general observations on research or the participant's own experiences. This initial coding scheme was refined by scanning a larger sample and extending the codes with sub-categories.

A sample of the data was then coded independently by each of the authors and a colleague. The same data was also coded by the same person on two different occasions several weeks apart. Initially these independent coding exercises produced an agreement rate of around 75%. The coding scheme was reviewed and code definitions revised to make them clearer. The coding scheme was reviewed in this way on several occasions until a match rate of over 90% was obtained.

The final coding scheme contained 24 codes and an extract relating to participant assessment of the exercise is shown in Table 1.

(Table 1)

For instance a participant comment that the exercise was "*informative for other people*" would be coded as Ex-pu, and a comment that "*the fact I shared ideas on different topics has helped me understand how people think on different things and yes, it has opened up some ideas*" would be coded as Ex-du-tp.

The data was analysed in three ways: looking at the relative frequencies of the codes assigned, grouping statements by code to uncover themes in what was said and finally looking for and exploring counter-examples. Particular counter-examples might be direct statements that the exercises were not useful or inconsistencies in the comments made by one participant.

6.3. Results

Both groups of participants found the exercise useful. Of the 9 students for whom data is available 8 said that the exercise was either useful or led them to reflect on the PhD process. The remaining student felt that the exercise would have been useful had he participated earlier in his research. Of the 8 expert participants 6 felt the exercise was definitely useful. Neither of the other 2 experts expressed negative views. One, a highly experienced supervisor, commented that he thought the exercise might have been useful for students but had not affected his own ideas.

Several experts commented that even though they had their PhDs it was interesting to discuss the research process. Comments included: "*I know some people who have completed a PhD some time ago and would still benefit …*" and "*it was a useful exercise … it has opened up some ideas*." More than half the students

commented that it was simply good to discuss their work. One said "*it showed me that my problems are the problems of my colleagues which was a huge relief*."

Results on whether the exercise changed participants' conception of research are more equivocal. About two thirds of participants said that the exercise had helped them to clarify their thinking. For instance, one participant commented "*the model (that was developed) reflects pretty much what I thought at the beginning but having to argue it made it much clearer*." Interestingly both experienced researchers and students commented that it helped to clarify their ideas. There may be a tendency for researchers to do research rather than discuss it – only 2 of the participants recalled having ever participated in similar discussions on the overall research process though about half had discussed issues relating to specific stages of research. Nevertheless about a quarter of the participants felt their conception of the research process had changed and some commented that they had a more strategic view as a result.

One issue that did come out for one group was that of the profile of participants. Students felt inhibited when expert participants were very certain in their views and when this did happen the discussions tended to be quite limited, though still useful for students.

Two and a half years after these workshops were held it seems that at least 70% of the participants are likely to complete their research within 4 years of having registered as PhD students. Four of the participants asserted that the knowledge sharing exercises had 'definitely' had a positive effect on their performance as PhD students.

7. Conclusion

The CoMEx exercises held at Cranfield University appear to have been successful in developing engineering PhD student's research skills. As a result the University is

considering how such workshops can be integrated into research student training. Of course there are issues such as whether the approach will transfer to other subject areas, whether repeated participation of experts will lead to the workshops losing vitality and becoming standardised, and what considerations to take into account when selecting the participants. For instance, a very forceful expert may shut out the very discussion which is integral to the approach.

The study was based on a small sample in one institution. Similar studies need to be carried out in other institutions to determine the generalisability of the conclusions. Nevertheless the authors believe the main findings are likely to be replicated. Cranfield is a post-graduate university so all the student participants did their first degrees in other institutions. Consequently although the study sample was small it is unlikely to contain the bias that might occur if all the students had done their first degrees in the same institution or subject area. Furthermore the focus of the discussions was on the research process rather than the subject-specific issues. The study showed that the process of research is not explicitly discussed as often as one might suppose.

There are some broader issues which the study raises. Firstly it seemed that many of the student participants, although having a good understanding of their subject area, had a poor appreciation of how difficult it is to know things for sure. This ties in with the findings of Geraniou (2010) which suggests that although research students typically know their subject area well they generally have little exposure to the process of finding things out. They had little appreciation that much of research involves persistence, coping with setbacks, methodically going through alternatives and so forth. Perhaps there is a need for students to be exposed to much more unstructured and “messy” problems as part of their undergraduate programmes.

The other main issue was that the students benefitted from the ability to discuss and compare their experience in a relatively unstructured setting. It raises the question of whether opportunities for more open discussion and reflection among groups of students could usefully be incorporated into both graduate and undergraduate engineering programmes. This would also address the problem, identified by Lee (2008) that supervisors generally focus on particular aspects of research work. Facilitated discussions of the kind undertaken in this study would help to broaden research students' experience.

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Tables

Table 1. An extract of the final coding scheme, particularly relating to participant assessment of the knowledge sharing exercise.

Ex	Comments relating to the PhD process modelling & discussion **exercise**
Ex-du	The exercise was **definitely useful** (or would be useful to others doing a PhD)

Ex-du-mo	Respondent considered that it was enjoyable or **motivating** and reassuring to compare notes with others on doing a PhD and what was involved
Ex-du-tp	The exercise was interesting or **thought-provoking** (led respondent to think about the process) but may or may not have changed his or her ideas about the stages in doing a PhD.
Ex-du-tp-cla	Exercise led the respondent to refine or **clarify** his or her ideas about the PhD process though probably not to change them significantly. Possibly getting a broader perspective by being made aware of other research approaches.
Ex-du-tp-cng	The exercise led the respondent to **change** his or her ideas about the PhD process, for instance by taking a more strategic view of the process
Ex-nu	Respondent considered that the PhD modelling exercise was **not useful**
Ex-pu	Exercise was **potentially useful**. For instance respondent felt it was not useful for him or herself but may have been useful for others or might have been useful at another stage in their PhD studies.

Figures

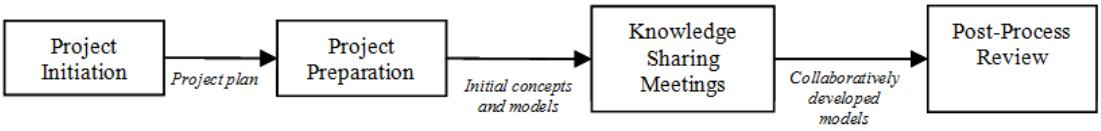


Figure 1. Key stages of the implementation of CoMEx.

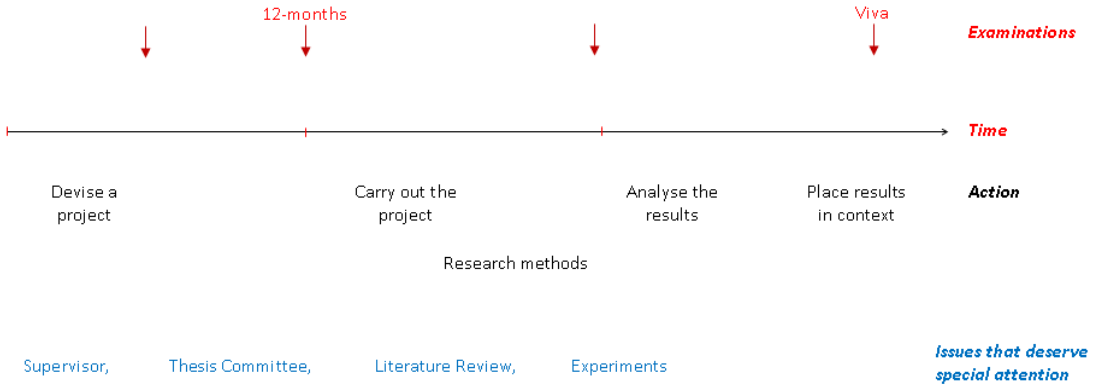
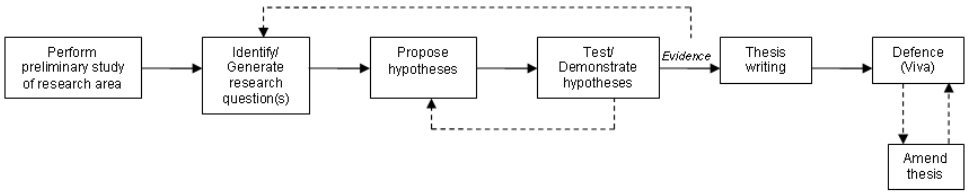


Figure 2. Initial model of the PhD research process, designed by the facilitators using the initial set of concepts extracted from participants in the second CoMEx exercise.

The PhD process: A research training process based on successfully investigating a research question.



Key concepts associated with the PhD process:

Research:
- Study
- Hypotheses
- Hypotheses generation
- Hypotheses testing
- Research questions
- Evidence
- Thesis
- Writing
- Defence
- Amendments

PhD involves:
- A research project
- Generation of new knowledge
- Research training
- A problem-solving process
- Critical thinking
- Independent research
- Presenting results
- Communication
- Understanding of research
- Deep understanding of research area

Figure 3. Model of the PhD process developed by the team in the second CoMEx exercise.

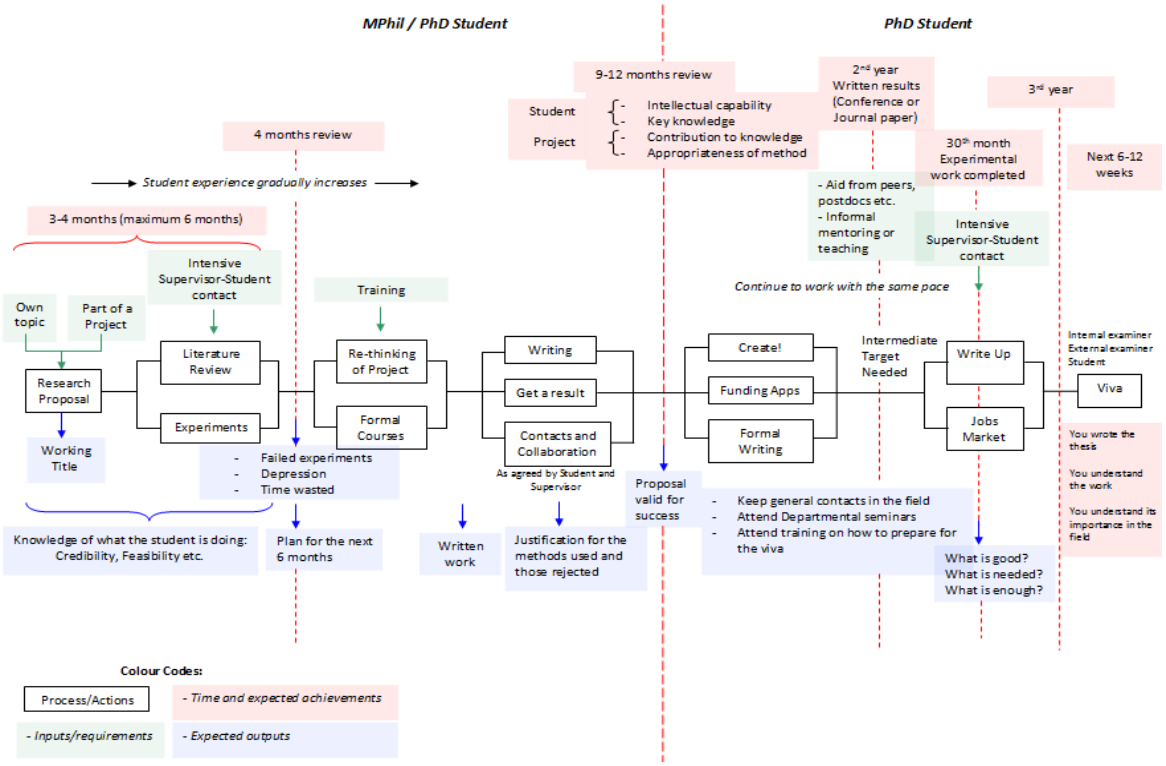


Figure 4. Model of the PhD process developed by the team in the third CoMEx exercise.