Identifying Risks for Cross-Disciplinary Higher Degree Research Students

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Abstract

Managing attrition rates and completion times of higher degree research students are key considerations for Universities as they are directly tied to future funding for research places. Even where higher degree research students are focused within a single discipline there are a number of risks that can impact on completion. However, there is also evidence of an increase in cross-disciplinary research within Australia. The nature of cross-disciplinary research raises further issues concerning the supervision and progression of PhD candidates and the examination of their works. We discuss a number of issues from a case study of the authors' own PhD experience, which spanned the computing and business disciplines. We conclude by drawing on some experiences in project management from the software engineering community and finally recommend that all participants in higher degree research consider a strategy of preventive risk management.

Keywords: cross-discipline, attrition, doctoral supervision, risk management, software processes.

1 Introduction

Completing a research higher degree can be a difficult task, and may require both the student and supervisor to possess good project management skills. Failure to complete a higher degree, or a slower than expected completion, can place further pressures on students. There are also greater demands placed on supervisors to manage completion rates since the Research Training Scheme[1] (RTS) relies on a funding formula that allocates postgraduate research places to universities using a formula based on completion rates. Currently, 50% of the amount of funding a university receives for RTS places depends on the completion rates for higher degree students at that institution. A further 40% of funding depends on research income and the final 10% on publications. Better management of completion rates should be a key concern anyway for postgraduate supervisors, but this importance is further emphasized because of the funding impact it can have on the university as a whole. Currently within Australia, and also internationally, PhD completion rates are typically around 50-60% (McAlpine and Norton 2006, Sinclair 2004, Lovitts 2001).

There have been numerous studies that attempt to uncover the main cause of attrition in PhD study (e.g. McAlpine and Norton 2006, Golde 2005, Bourke et al. 2004, Sinclair 2004, Lovitts 2001). These studies help to identify risks within a single discipline research project. However, there is some evidence of an increase in cross-disciplinary research projects in Australia (ARC 2005, Grigg et al. 2003). The recent move toward a research quality framework (RQF) for assessing the impact and quality of research occurring in the Australian higher education sector has highlighted this trend. In a response by the Australian Research Council (ARC) to the preferred RQF model, a 7.2% increase in cross-disciplinary proposals received by the ARC in the period from 2001 to 2004 was reported (ARC 2005). This represents an increase from 29.5% to 36.7% in the total number of cross-disciplinary project proposals submitted for funding.

We expect that this increase in cross-disciplinary research could further impact on PhD completion rates. Although PhD completion rates are typically around 60%, some disciplines are troubled by completion rates as low as 50% (McAlpine and Norton 2006, Sinclair 2004). Given that these disciplines are also the ones reporting the highest proportions of cross-disciplinary funded projects, possible correlations between these activities should be considered. We might also expect some different problems associated with such cross-disciplinary research projects. For example, communication issues could easily arise, as there is a reputation for research in different academic disciplines to adopt different methodologies and styles, or even exhibit large "cultural" differences.

One simple example of risk identified in the case study is differences in terminology that exist in different domains.

A student in a cross-discipline project may need to be aware that some words can have totally different meaning or even subtle differences in significance when encountered in different disciplines. Even the term ‘cross-disciplinary’ itself introduces some insight into difficulties that arise at a definitional level. The terms cross-disciplinary, multidisciplinary, interdisciplinary and transdisciplinary are often used interchangeably to describe a single research project which spans more than one discipline (Grigg et al. 2003).

Formally, cross-disciplinary is an umbrella term for multi-, inter- and trans- disciplinary studies. Transdisciplinarity is an approach that “transcends” traditional disciplinary boundaries, and is defined as “… the construction of knowledge directed towards addressing societal issues and involving the representatives of society in its formulation and construction” (Grigg et al. 2003, p.10). In their guide to interdisciplinarity, Graybill et al. (2006) define a ‘multidisciplinary approach’ as one that “involves researchers from two or more disciplines working collaboratively on a common problem, without modifying disciplinary approaches or developing synthetic conceptual frameworks” (p.757). This is in contrast to an ‘interdisciplinary approach’, which “involves the use of an innovative conceptual framework to synthesize and modify two or more disciplinary approaches to deal with a research problem” (ibid). The case study described in this paper, is more correctly described as ‘interdisciplinary’.

An interdisciplinary approach requires students to be conversant not only in the individual disciplines being covered, but also to break through disciplinary cultures to develop a new frame of reference. As we have already stated, the notion of academic cultures is well recognised. Different disciplines have different ways of doings things, and in turn recognise different methods of obtaining and communicating research outcomes as valid contributions to knowledge (Becher and Trowler 2001). Thus, a PhD candidate embarking on an interdisciplinary PhD journey should recognise the complexities of the cultural landscape to be traversed. We will later recommend trying to manage these complexities using a preventive risk management approach that derives from a consideration of processes within software engineering projects. Firstly, however we discuss some specific problems arising from our case study.

2 Issues

Much of this work is informed by a case study from a cross-disciplinary PhD entitled “*Predicting Organisational Resource-Needs Change: A Case in SMEs and Information and Communication Technologies*” (Blackmore 2006). Perhaps a “case study” implies a greater intent then exists; the authors of this paper acted as student and supervisor for the PhD in question and the motivation for this paper is really the result of reflection on their experience. However, it does serve the purpose of providing further context and identifies some specific risks in an actual interdisciplinary research project.

This particular dissertation spanned the management and computing disciplines. A conceptual model of organisational resource-needs change was developed from existing relevant theories. This model considers the strategic orientation of organisations as a concept that moderates between stimuli and resource responses. The explanatory and predictive capability of this new conceptual model is evaluated using analysis of survey data, and then simulated using agent-based software that is grounded in concepts from complexity theory. Outcomes from a series of experimental simulation scenarios that capture an organisation's decision-making strategy and their activity patterns within the context of overall market conditions reveal predictive patterns of changing resource-needs.

The thesis work required negotiation of the “cultural” differences in the diverse fields of marketing, management, complex systems and computing. The presence of different disciplinary cultures leads to different languages and expectations in conducting and presenting research that spans multiple disciplines (Becher 1994; Becher and Trowler 2001). The extent to which these different disciplines “have their own way of doing things; deeply embedded ontological, epistemological, and methodological assumptions; and different specialized languages” (MacCleave 2006 p. 2) impacted on the research presented in the thesis, and they also have implications for future work.

To help structure the discussion we have broken the issues up into the different phases of the PhD process. The phases considered in this section are the proposal, candidature, write-up, examination and post-PhD. Each phase presents a unique set of issues to be considered and addressed. Additionally, each issue has associated risk(s) to progression and timely completion of the thesis work. These issues are discussed in terms of the phases of the PhD process, and the issues and associated risks for each phase are summarized in Table 1.

2.1 Proposal

When project proposals for interdisciplinary research are developed, care must be taken to clearly articulate and recognise the interdisciplinary component of the project as a piece of research work, and as an outcome of the research, in its own right. There is a tendency to recognise the approach as novel, but not to recognise that the development of an innovative framework to address a problem is considerably more work that to use an existing approach. Thus, the new approach is “sold” as a benefit of the research but not explicitly accounted for in the work to be done.

Cross-disciplinary research requires expertise in more than one discipline area. This expertise must either pre-exist, or as in the case of this candidate, needs to be developed. When sufficient expertise in the disciplines does not pre-exist the potential for the development of overly ambitious proposals is evident. This problem increases if a full understanding of the complexities of building a new framework, spanning the separate disciplines is required. This issue can lead to unrealistic expectations for the candidate, supervisors, and as is often the case, external partners.

The potential exists from all the issues in this phase of the research to well and truly set things up for failure. The more ambitious, novel and innovative the proposal, the more risk involved in succeeding within the nominated timeframe. Scoping issues that are unaddressed in the proposal phase are carried forward into the actual candidature.

2.2 Candidature

The potential exists for a number of issues to arise during the actual PhD candidature in an interdisciplinary project. The different expectations among disciplines, breadth of content to be covered, shortcomings of supervisory models and issues obtaining feedback are all key issues that arose during the candidature.

Disciplinary expectations: Different disciplinary expectations can be incommensurable (MacCleave 2006). Throughout the thesis work, a major challenge was to reduce the problem to its essential characteristics so that it could be appropriately addressed by the agent-based modelling approach. Thus the conceptual model that was produced followed the tenets of a complex systems approach and captured essential, rather than all, characteristics of the problem domain (Holland 1995). Operationalisation of these concepts also followed this approach; that is, where a number of operationalisations were possible preference went to the one that relied on the simplest "rules". This abstraction is a key benefit of the cross-disciplinary approach adopted in the thesis, however, it is noted that this simplification of the domain lies at the very heart of the "cultural" differences between the computing and social science (marketing and management) disciplines (Becher 1994). Conceptual models in the marketing and management disciplines are generally complex in contrast as they attempt to account for most, if not all, characteristics of the domain. This incommensurability should be noted and considered explicitly in future work.

Breadth and Depth: The thesis was ambitious in terms of the breadth and depth of discipline areas it covered. Mastery of the theory, concepts, language and methods of a single discipline is a hefty task. However, interdisciplinary research undertaken by a doctoral candidate typically requires this individual to obtain such mastery in two or more discipline areas. Obtaining fluency in two or more discipline areas requires additional time (Golde and Gallagher 1999) and may leave the candidate feeling overwhelmed by the sheer enormity of the task. This was indeed the situation in this case; considerable skill was required on the part of the supervisor to assist in "delimiting" the project.

Discipline Based Supervisory Model: In this case, the research was undertaken using a typically PhD supervisory structure. That is, the candidate "belonged" to a single Faculty, with a single principal supervisor responsible for helping develop and guide the research. Additional co-supervisor(s) may be used to provide further guidance to the student. This single discipline based model raises some interesting issues.

The workload allocation system causes issues. A single academic is considered as the principal supervisor with the option of one or more associate or co-supervisors. There is a tendency for this structure to be mirrored in the workload allocation system, with principal supervisors receiving an allocation and co-supervisors receiving lower or no workload allocation.

Additionally, academic reward systems tend to only recognise principal supervisor roles. This recognition and reward for successful PhD completions is balanced more highly toward principal supervisors. These administrative organisational arrangements do not translate to interdisciplinary projects well.

Consider the scenario where research spans two disciplines. In the absence of a single supervisor with expertise in both disciplines, common sense would suggest that the supervisory team should consist of academics with expertise in each of the disciplines, who together would provide the student with guidance to broach both discipline areas. This equality is not however reflected in administrative structures and thus the nominated co-supervisor may not contribute sufficiently to the research, or alternatively will do so without due recognition or reward.

In the case considered in this paper, the cross-disciplinary nature of the research was addressed by having representatives of each of the two key discipline areas bridged on the supervisory team. Meetings were held throughout the candidature with each of the supervisors individually. Contradictions, and indeed criticisms of other members of the supervisory team, occurred throughout the candidature. Joint meetings between all supervisors and the candidate to resolve disciplinary issues were not held and thus the task of reconciling the different discipline perspectives fell solely on the candidate. Addressing these issues detracted from the task of actually conducting the research, in terms of both the time and the intellectual energy required.

Feedback: The presentation of "work in progress" is encouraged, and indeed often a requisite component of the doctoral process. In addition to developing communication skills, presenting the thesis work in progress allows the candidate to obtain and integrate relevant feedback. However, forums for presenting doctoral work typically mimic organisational structures. That is, faculty based forums are organised at regular intervals to allow doctoral candidates to present their proposals or intermediate results. The implications for the cross-disciplinary student concern how to best present their cross-disciplinary work to single discipline audiences to solicit appropriate feedback. The risk exists that students will not find support for the research within the "home" faculty (Golde and Gallagher 1999) and crucial feedback on the research will be lacking.

2.3 Write-Up

The way information is communicated can vary dramatically between discipline areas (Becher 1994, Becher and Trowler 2001). From obvious differences in referencing styles, to different terms having different meanings, as well as general expectations on the length, content and purpose of sections in a thesis, variations in communication styles can present significant issues to the candidate and supervisor. In essence, all of the underlying ontological and conceptual differences that may have surfaced during the proposal and candidature phases are now made concrete in nature.

Addressing different stylistic expectations in the write-up phase of the research proved difficult in this case. The research presented in the thesis spanned the marketing, management, complex systems and computing areas. In keeping with the interdisciplinary approach adopted, every attempt was made to present the research in a way that represented these areas equally; not favouring the approach of one discipline over another. For example, a diagrammatical style consistent with expectations of the computing discipline (i.e. unified modelling language (UML)) was used throughout the thesis, rather than just in those sections detailing the computer simulation. Similarly, research questions were evolved to propositions which were considered by both the statistical and simulation analysis, following expectations in the marketing and management areas. While deemed appropriate by the candidate and supervisor, these decisions resulted in issues in the examination phase.

2.4 Examination

The issues that arise during a cross-discipline candidature tend can be exacerbated during the examination phase of the process. Significant differences in the expectations of different disciplines, discussed in the previous sections, have the potential to create issues in the examination process.

Even within a single discipline, the lack of standards for theses and their assessment are identified issues (Lawson, March and Tansley 2003; Powell and Green 2003; Holbrook et. al 2004). Despite the lack of standards, the examination process focuses on the intellectual endeavours reported in the thesis and the communication aspects of the work. Issues in communicative aspects can taint the way the way intellectual contributions of the work are perceived and examined.

Similar to issues surrounding the ability of supervisors to be “experts” in all disciplines spanned, examiners of cross-disciplinary theses that are not themselves sufficiently familiar with the expectations of the different disciplines may encounter issues. That is, examiners may be confronted with stylistic and methodological differences that, while appropriate for one discipline, are considered inappropriate in their own. What constitutes a contribution to knowledge in one discipline may be completely unacceptable in another (Becher and Trowler 2001, Golde and Gallagher 1999).

Thus, the danger exists in the examination phase for the research work to confront examiners who are not adequately familiar with all the discipline areas spanned. The potential then exists for examiners to focus too heavily on their own area of speciality covered in the thesis, or to be distracted by stylistic differences (to what they expect from a doctoral thesis within their own area of expertise).

This was the case in this thesis project. Comments received from one examiner focussed entirely on the length of the final chapter, going so far as to note that the final chapter presented was only about 25 pages when it should be “at least 50 pages or more”. The expectations for the content of the final chapter of the thesis vary dramatically between the commerce and computing disciplines bridged in this thesis. This had been evident during the write-up phase where it was impossible to satisfy the expectations of all supervisors; the chapter was too long for one and too short for another. In the end, a “middle of the road” approach was conscientiously decided upon and considered to be in-keeping with the interdisciplinary nature of the research. This issue and decision resulted in the examiner recommending a “3” for the thesis.

2.5 Post PhD

Having successfully navigated the interdisciplinary landscape during the doctoral process does not signify the end of issues. Communication of findings from the research via the thesis document is but the beginning not the end. Difficulties in locating appropriate examiners whose expertise spans multiple discipline areas can signify that similar difficulties may also arise in finding avenues for publishing out of the research project.

Although many potential outlets for publishing research outcomes expressly identify cross-disciplinary research as a valuable contribution and worthy of publication, if difficulties arise in locating suitable examiners for the PhD thesis, then one must assume that similar difficulties will arise in locating reviewers for articles to be published.

Disciplinary involvement in cross-disciplinary work varies (Qin, Lancaster and Allen 1997). As a result, the temptation exists to publish modified aspects of the work in disciplinary publications. This option has the potential to devalue the thesis work (as a major outcome of the research is the interdisciplinary approach) and consequently, may impact on the success and reputation of the researcher. Golde and Gallagher (1999) note the vulnerability of interdisciplinary researchers “to feeling intellectually homeless, without a place to share interests and long-term goals” (p.284). Thus some of the difficulties faced during the PhD process present risks to the successful and timely completion of the project. These issues may pose continuing risks to the career development of the candidate.

We have highlighted in this section some problems with defining requirements, scoping, analysis, design, implementation and testing. This raises some obvious analogies between software project management and the management of a higher degree research project. Of course generic management skills are relevant in both cases. However, specific approaches from software engineering are interesting to raise as project failures, cost overruns and late delivery are typical problems with software delivery that have been well documented since 1970. Since that time, many approaches have been developed to help support software projects, including better process modelling and risk mitigation strategies. In the next section we will review some of the major process models that have been used in developing software and try and link them back to the research higher degree process. We hope to draw from this discussion some insights that may assist with better management practices for postgraduate students, and particularly for those embarking on a cross-discipline project.

Phase	Issues	Risks
Proposal	* Failure to identify and account for the task of bridging discipline areas as part of the thesis work * Supervisors may lack cross-disciplinary expertise to appropriately formulate the problem * Candidate may lack sufficient expertise in either or all disciplines to be spanned	* Proposal may be overly ambitious, as the full complexities of differences in discipline areas to be spanned in the research are not fully appreciated * Supervisors may develop unrealistic expectations * Candidate may fail to appreciate the time, effort and "intellectual work" involved in coming up to speed on theory from multiple disciplines * Where external partners are involved, unrealistic expectations may be propagated
Candidature	* Current single discipline supervisory model * Different expectations among disciplines * Breadth of content required to be covered * Candidates own context and approach to the research problem * Obtaining feedback on progress	* Lack of appropriate guidance from supervisors * Potential for conflict between supervisors, and/or candidate * Candidate may become overwhelmed or "bogged down" by vast bodies of literature (links back to the first point) * Appropriate feedback may not be obtained
Write-Up	* Differences in disciplinary expectations * Obtaining a "template" or structural model to follow	* The thesis document may fail to meet the expectations of single discipline supervisors * Candidate may need to invent a document structure in the absence of a "norm" * Stylistic issues may occur
Examination	* Difficulties finding appropriate examiners * Disciplinary differences in what constitutes a PhD * Over emphasis on stylistic issues	* Appropriate examiners may not be located * Examination may tend to focus on stylistic issues rather than content
Post-PhD	* Identifying appropriate outlets for information dissemination (including conferences and journals) * Similar issues that arise in the examination stage reappear when publishing in terms of the review process * Graduate may lack a disciplinary identity	* Outcomes from the research may not be published and/or are published in a modified form to appeal to a single discipline audience * Graduate may lack disciplinary credibility and/or experience limited employment opportunities

Table 1: Issues and risks to timely completion of a cross-disciplinary PhD

3 Development Processes

Risk is inherent in most projects of any complexity. Projects that develop software systems have developed a particular reputation for failure. In a well-known comparison between bridge construction and software development, Spector and Gifford (1986) note that bridges are normally built on-time, on-budget and do not fall down. Software, by contrast, is never on-time or budget and always breaks down. This is an exaggeration of course, but even in the year 2000 it was reported that only 28 percent of all software projects in this year were on time and budget and contained the features that had been planned (Murthi 2002). PhD completion rates are around 60% (Grigg et al. 2003), although for some disciplines and particular institutions this figure may be much lower. Perhaps if we describe research projects in terms of bridge building we would concede that the planned bridges are rarely completed in the way they are envisioned or often fall well short of the mark. At some stage in a higher degree's candidature it may well be a case of sink or swim.

The approach taken in the software industry to address issues of attrition and timely completion were to focus on defined and repeatable processes that could be monitored, controlled and improved. The focus on improving processes can be linked back to the Total Quality Approaches (Deming 1986, Juran and Gryna 1988) used more generally for improving business processes. By the 1990s a number of different process models were being used to develop software and they include: the waterfall model; the prototyping model; the iterative model; and the spiral model (Kan 1995).

The *waterfall model* (Royce 1987) (Figure 1) uses a defined set of steps. These steps are considered to follow each other in a staged logical fashion with predetermined deliverables and sub-goals to be achieved at each stage. The focus is very much on the intermediate deliverables and the major criticism of the waterfall model is that it does not reflect the reality of software development where frequent changes often occur (Pfleeger 1998). This is arguably the case in most research projects as well, where requirements, deliverables, tasks and resources are often difficult to define at the beginning of the project. Indeed they tend to undergo many changes during the project lifecycle. While the supervisor, or the University itself may prefer this model, as it has explicit deliverables that mark progress, making is manage friendly, the reality for the student is more likely a constantly moving target.

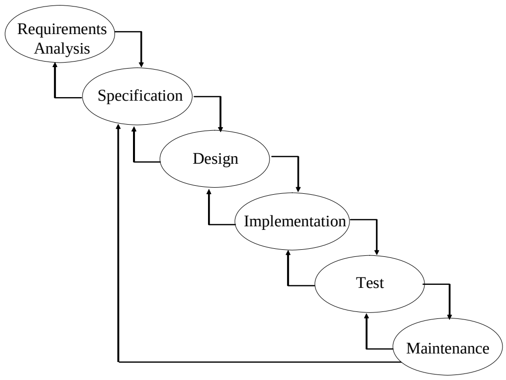

Figure 1 The waterfall model of software development

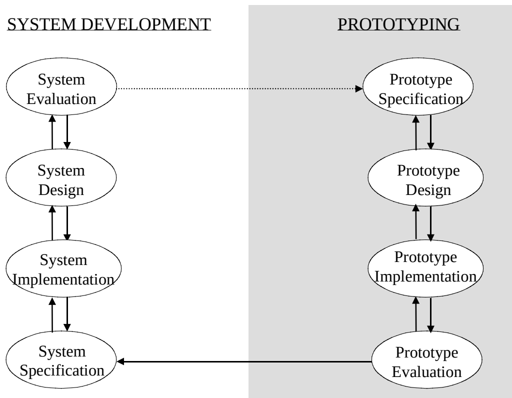

Figure 2 The prototyping model of software development

The *prototyping model* (Figure 2) is based on the *waterfall model* but it addresses the issue of developing software where the requirements are not known or are poorly understood (Budde 1984). Developing a partial implementation of the product allows customers to provide early feedback about the requirements. The advantage of using prototypes is that the requirements can be more accurately identified. This can alleviate the need for costly changes during the actual system development. However, the success of this approach relies on rapid production of prototypes (Kan 1995). Publishing during the course of the research project is akin to developing prototypes of the thesis, and conference publications can provide a reasonably quick way to do this during the normal lifetime of a PhD project. Although even in conferences that are peer reviewed, the feedback may not always be of a quality that assists the direction of the project.

Iterative process models (Figure 3) tend to better reflect the reality of software development from the programmer's perspective. The system is modified over a series of iterations as the needs of the customer become better understood. The early iterations through the process serve as a learning experience for both the customer and the developer (Basili and Turner 1975). This learning approach is the major advantage of this model and is particularly useful when it is difficult to produce a well-defined statement of the software requirements (Pfleeger 1998). The reality for the post graduate student may also be better reflected by an iterative model, as a number of visits through the research questions, designs and solutions and contributions occur as learning and discovery take place.

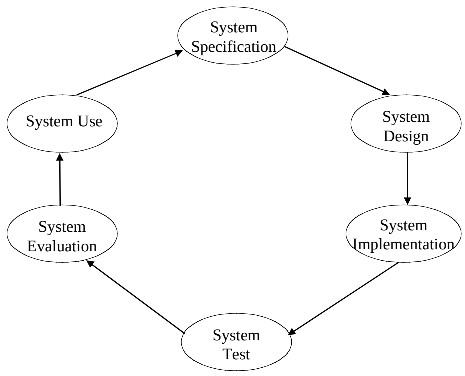

Figure 3 The iterative model of software development

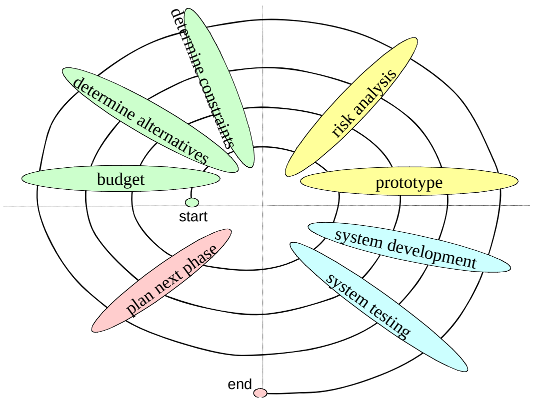

Figure 4 The spiral model of software development

The *spiral model* (Figure 4) is a refinement of the *iterative model* and was developed by Boehm (1988). This model also uses a number of iterations, although the focus of these iterations is not to learn about the system but to alleviate risks associated with the project. The spiral model also incorporates prototyping into the process, with early iterations using these prototypes to help assess the high-risk items in the project. During successive iterations the resource requirements increase while the project risks are reduced (Kan 1995). Reducing major research risks early in a research project would seem to be a sensible approach to take. For higher degree research projects the focus of risk reduction should be on technical issues in the research. However we might imagine all types of risks that could occur in the different phases of a candidature and a preventive risk management philosophy does suggest itself as a sensible management tool. Some risks may be generic to PhD study, while many others would be specific to the research topic and also depend on the actual student and supervisors involved.

Before concluding the discussion on software development process it is appropriate to highlight more recent approaches that are collectively described as *Agile* methodologies (Cohen 2004). These approaches are lightweight and adaptable and tend to focus on **smaller** teams with rapid iterations through very short stages (sprints). They have been designed to reflect the evolutionary nature of many software projects, notably in industries such as computer games. A typical example is the SCRUM method (Murphy 2004), where a backlog of small, prioritized tasks are used. Tasks and outcomes are reviewed over short periods (i.e. 24hrs) of time. Daily standup meetings address key questions such as, "What have you done since yesterday? What are you planning to do by tomorrow? Do you have any problems preventing you from accomplishing your goal?" (Murphy 2004). Of all the processes used in software development, these agile evolutionary processes are perhaps the closest analog to some higher degree research projects and suggest very flexible management approaches that may help to improve completion rates. Once again risk identification and mitigation is a feature of these newer agile methods.

Unfortunately the question of what process model most PhD research projects should use cannot be answered in an absolute way. As with software development we might expect managers or supervisors to prefer a waterfall type model where clear progress can be measured and outcomes better monitored. Were research is simply extending the boundaries of known knowledge in a very clear way, building slightly on existing work then this process model may also be most appropriate for students to describe their research. The experience for the student, like the programmer, may be somewhat different to a manager's viewpoint and the more iterative model or even an evolutionary model may be more akin to what actually occurs in research. Certainly if research is in some way ground breaking we might expect these more agile processes to be closer to what actually occurs. We might also expect processes to vary across discipline boundaries.

The key point about processes is that they are effective ways to manage projects and produce repeatable outcomes lending themselves to reuse, measurement, and improvement. We note that risk management is also a feature of software processes and discuss this further in the next section. We believe there is a role for a clear project management approach to guide the PhD process. This is the case for single discipline PhD's and especially true for multidiscipline projects where the issues, and therefore the associated risks, are higher and more complex.

4 Recommendations

Risk management for software projects is now a common practice and the authors would recommend adopting a proactive approach to managing risks in cross-discipline research projects. For example, prioritising completion risks based on their likelihood and potential impact, plus developing mitigation strategies and then top-ten risk tracking (Schwalbe 2006) suggest themselves as effective practices which can be used by supervisors and students to help manage PhD completion.

We note that Schwalbe defines risk as "*uncertainty about meeting project objectives*" and suggests managing for both positive and negative risks (Schwalbe 2006). Positive risks are good things that may occur, such as completing a project objective ahead of time. It may be appropriate to mitigate for, rather than against, such risks.

As a starting point for identifying risks we have included two tables from the well-known "CHAOS report" by the Standish Group in 1994 (CHAOS Report 1994). Using a survey of 365 respondents and covering a total of 8,380 software projects the major success factors (Table 2) and (Table 3) factors that caused the project to be challenged, were identified. Referring the reader back to the risks we identified in our case study (Table 1) we also note there are some obvious correspondences. We note that some challenge factors such as "Lack of User Support" may be irrelevant unless the research project has a strongly applied factor. Many of the challenge factors such as "Incomplete requirements and specifications", "Changing requirements and specifications", "Unclear objectives" and "New Technology" seem to almost define the nature of research itself. Other challenge factors such as, "Lack of Executive support", "Technology incompetence", "Lack of Resources", "Unrealistic expectations" and "Unrealistic timeframes" highlight factors that could be mitigated against in research.

Of course previous work has tried to address some specific risks with PhD supervision. One major focus seems to be in developing more effective strategies for managing the relationship between supervisor and student (Gurr 2001, Ives and Rowley 2005, Pole 1998, Shannon 1995). For example, encouraging open communication by using a simple tool such as the "Supervisor/Student Alignment Model" (Gurr 2001). While these models are valuable as they address team-working aspects of PhD projects, they often assume issues will arise and provide strategies for minimising the impact of these issues.

We also identified communication and relationships between stakeholders as a potential issue. Though it is our opinion that focusing on the project rather than the people involved is a more proactive approach to managing project outcomes, and that relationship problem between students and supervisors is often a symptom rather than cause of project problems. It is certainly the nature of projects that the likelihood and types of risks can vary between projects. Other types of risks may be more critical if they are more likely to occur, or to have greater impact on project completion. For example, a good relationship between student and supervisor may not overcome the problem of a supervisor that lacks technical competence or a student with a shortage of appropriate technical skills. Mitigation of these risks may require appointing an appropriate co-supervisor with the technical experience or providing appropriate skill training for the student.

Rank	Top Ten Success Factors	% of responses
1	User Involvement	15.9%
2	Executive Management Support	13.9%
3	Clear Statement of Requirements	13.0%
4	Proper Planning	9.6%
5	Realistic Expectations	8.2%
6	Smaller Project Milestones	7.7%
7	Competent Staff	7.2%
8	Ownership	5.3%
9	Clear Vision and Objectives	2.9%
10	Hard-working, Focused Staff	2.4%

Table 2: Success factors for software projects (CHAOS Report 1994)

Rank	Top Ten Challenge Factors	% of responses
1	Lack of User Input	12.8%
2	Incomplete Requirements and Specifications	12.3%
3	Changing Requirements and Specifications	11.8%
4	Lack of Executive Support	7.5%
5	Technology Incompetence	7.0%
6	Lack of Resources	6.4%
7	Unrealistic Expectations	5.9%
8	Unclear Objectives	5.3%
9	Unrealistic Time Frames	4.3%
10	New Technology	3.7%

Table 3: Challenge factors for software projects (CHAOS Report 1994)

The authors would argue that the aim of any good research is to address the highest risk items as quickly as possible. While drawing analogies with software engineering projects may be instructive, it does not replace targeted analysis of risks that occur in PhD work for both single and cross-discipline research areas. In future work, the authors plan to use focus groups and questionnaires to identify and categorise major risks in doctoral research (both single and cross-discipline). From this we also plan to develop a risk management framework, and risk-identification tool to be used by students and supervisors. In the longer term this tool will also allow for more data to be collected for analysis.

5 Conclusion

We have reviewed a number of issues that arose in the lifecycle of a single cross-disciplinary research project. We are happy to report that, after a few trials, tribulations and delays the process ended with a successful completion. In hindsight however a number of potential pitfalls with the process were identified.

While some particular problems for cross-disciplinary research have been identified in this paper, it is important to note the potential for interdisciplinarity to provide the educational paradigm for the future (Leshner 2004). The increase in funding to these types of projects can be interpreted as a general recognition of the value of this type of research to further our understanding of many of the problems confronting society. However, if the path forward is through interdisciplinary research, then we must acknowledge that this type of research brings with it new management issues that require modified approaches to those used in single discipline work.

Important strategies to move forward with include reframing the supervision roles in cross-disciplinary research and explicitly considering the complexities of the various discipline areas to be covered. Where apposing traditions are to be brought together to address a research problem, then the synthesis and modification of approaches, as well as the additional effort required to adequately communicate the new approach to examiners, reviewers and the broader academic community, should be explicitly acknowledged as part of the thesis “work”.

We concluded the paper by drawing some analogies between software engineering projects and higher degree research projects. We are working to adapt some standard approaches from software engineering, and in particular think that a better focus on preventive risk management (Schwalbe 2006) throughout the process would be advantageous to all parties involved. Even though risk identification is often subjective and qualitative in nature, our view is that some risk management is better than none. Perhaps a generic risk identification framework may also encourage the development of future quantitative techniques to better model the risk associated with higher degree completions. Or perhaps that is the topic for some future PhD student.

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