# Multidisciplinary Solutions for Multidisciplinary Problems

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## Abstract

The implications and challenges for Empirical Software Engineering (ESE) are increasing. The entire software design and development process is affected by the impact of human, organisational, and social issues. Collaboration with different disciplines is becoming necessary in order to fully understand issues that do not obviously fall within the remit of software engineering practices. ESE can draw upon the knowledge and experience of other disciplines not only to understand ethical issues to protect human participants, but to become more familiar with research methods that investigate organisational and human development processes and behaviours. The first part of this paper looks at guidelines from psychology to guide the establishment of a code of ethics suitable for ESE practices. As ESE turns its attention to human issues, it is important to establish such an agreed code of ethics to protect human participants and the ESE community during research practices. The second part of the paper summarises a recent research project carried out to investigate research methods used in Software Engineering (SE) and Information Systems (IS) research and presents some of the findings.

**Keywords:** Empirical Software Engineering, Code of Ethics, Research Methods

## Background

Whilst it is generally accepted that software engineering (SE) is still a young field when compared to other scientific and engineering disciplines, considerable progress has been made in a remarkably short time. Technologies are rapidly evolving and changing and new ones are being introduced at an equally fast rate. These new technologies are being used by an ever-increasing number of people in support of their work and leisure activities, which impacts heavily upon the design process. An emergent property of this technology evolution manifests itself in a new area of design activities that now need to take account of the integration of social, human and organisational factors as they necessarily synthesise with the purely technical issues of system design. In today's world of design and development of systems and software, not only are software engineers expected to provide state-of-the-art technology, but also to simultaneously tackle the inherent issues concerned with human cognitive and social behaviours that will affect the ultimate behaviour of the technology. As the software engineering field matures, software engineers need to utilise knowledge specific to such disciplines as psychology, social science and human computer interaction, whilst listening to management and end-users within an organisation, in order to design useful and usable systems. Without this combination of knowledge it is becoming increasingly difficult to provide systems, tools and methods that support a diverse range of human and technical requirements. This additional complexity further complicates the already highly complex business of ESE within an industrial environment, where time and expense must be justified to managers and the end results must still be applicable within the rapidly changing business and technological environment.

**Position**

As with other scientific disciplines attention within the SE community is turning toward empirical research. Basili et al. [2] propose that progress is not made until an actual truth can be separated from what is only believed to be true. Although many software engineers in the research community are applying research methods to evaluate and design software technologies, frequently the software engineer will focus on a tool's technical abilities to improve a development process to the exclusion of its usefulness, usability and other non-functional requirements. ESE can provide quantitative and qualitative results that may facilitate organisational decisions concerned with process and product improvements [5]. But it is becoming increasingly important to use empirical methods that also investigate the human issues in software and system design. For example, the usefulness and usability of a tool will be dependent upon an understanding of the context in which it will be used and how it will be perceived and used. This involves cultural, organisational, social and cognitive issues within a real world context, adding to the difficulties of valid empirical research. But reliable and valid research will increase acceptance of software engineering as a scientific discipline that generates and provides support for theories and practice within SE. The use of research methods needs to be augmented with methods that increase knowledge of human processes as humans interact with technology and work practices. Research in psychology and social science disciplines focuses largely on human behaviour, and, consequently, these disciplines are more familiar with investigating human ability, and how the variety of these abilities can obscure experimental effects, thus affecting the reliability and validity of results and conclusions. Such disciplines have developed qualitative research methods to study the complexity of human behaviour and so can provide valuable help to the ESE community as it moves to include the investigation of human issues.

As a result of this necessity to use human participants in SE research, it is important to draw up a code of ethics that protects not only the participant, but also the SE community itself. Currently there does not seem to be an agreed code of ethics for SE researchers and this needs to be addressed urgently [6]. The American Psychological Association (APA), the British Psychological Society (BPS) and the Canadian Psychological Association (CPA) have drawn up a code of ethics by which they must conduct their research. The first part of this paper presents a brief summary of APA and BPS guidelines for conducting research using human participants and suggests they may be 'borrowed' for ESE research. The second part discusses some results from an investigation of multidisciplinary research that highlight some of the problems of such research.

## 1. Code of Ethics

As a result of the need to use humans as participants in empirical studies, the SE discipline incurs a responsibility for the welfare of these participants and to be sensitive to ethical issues that can arise in the conduct of such research. Accordingly, it is important to establish an agreed code of ethics to protect both human participants and the SE community during research practices. The adoption of high ethical standards not only protects the participants, but will also serve to protect the reputation of the SE discipline, as researchers must abide by certain moral principles and rules of conduct. Many areas of ESE research may not give rise to ethical

problems at all, but there will be some areas of research where there will be certain costs to the participants particularly when human issues are the focus of the research.

The following guidelines are summarised from the APA and BPS [1], [3] and whilst they may not appear immediately to be applicable to ESE, they are presented here to guide the establishment of a code of ethics suitable for ESE practices.

1. *Minimal Risk*. The researcher must protect participants from physical or mental harm. Risks greater than those likely to be encountered in everyday life should be avoided. Participants should be asked to reveal any medical conditions which might put them at special risk. Deciding how much psychological stress is ethically justified in a research project is not always clear cut. Maintain participants' dignity, by ensuring procedures do not make them feel uncomfortable in any way. Great care must be exercised where research involves children.
2. *Obtain Informed Consent.* Participants must enter a study voluntarily and be permitted to withdraw from it at any time without penalty if desired. Participants must be warned beforehand if there are any aspects that may later influence their willingness to co-operate. A consent form should include: a statement of informed consent, sufficient information about the study (purpose and design) to ensure participant's consent is truly informed, the participant's signature and the date. Difficulties arise when maintaining a balance between fully informing the participant and keeping them in ignorance of the purpose of the study to ensure valid results.
3. *Debriefing*. If it is necessary to avoid informing the participants fully beforehand, then the reasons for doing so must be explained immediately afterwards. Experimenters have a moral (and sometimes a legal) obligation to debrief participants. Debriefing should be informative and non-technical. As well as informing participants of the nature of the research, procedures should be discussed if required. Researchers must ensure participants leave the research situation, as far as possible, in the state in which they entered it. Participants who are unhappy about the situation after debriefing, have the right to require that their data are withdrawn and destroyed in their presence.
4. *Right to Privacy*. Information about a participant acquired during a study must be treated as confidential and must not be made available to others without his or her consent. Participants' identities must not be revealed unless they have given prior consent (Data Protection Act, 1984).
5. *Observational Research*. When you do not have informed consent, it is important to respect people's privacy and well-being. Observation should only take place where people would normally expect to be in public view.

## 2. A Meta-analysis of Multidisciplinary Research

Recent research [4] investigating research methods documented in both the SE and Information Systems (IS) literature came across some problems related to research methods and the reporting of studies. The focus of this research was a meta-analysis of journal and conference paper reviews carried out by members of the Software Engineering and Information Systems Network (SEISN). The meta-analysis aimed to gain some understanding of the research approaches and methods used by each discipline and to identify areas where one discipline could inform the other to assist the process of systems and organisation co-evolution. However, it is important to

understand that the papers reviewed were a random selection chosen by members of the network according to individual preference and cannot be viewed as a truly representative sample of published research. Further difficulties concerned with validity included a lack of criteria to ensure consistency throughout the process and lack of a single framework within which the reviews were performed. But the reviewers are experts in their fields, and consequently we believe the chosen papers are typical together with the problems they highlighted as described below.

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a). We found it was difficult to draw comparisons between SE and IS research methods not only because there is such a diversity of terminology, but also because different disciplines have different understandings and definitions of terms for research method classification, particularly with regard to case studies and field studies. There is a potential for a confusion of terms, between (and possibly within) disciplines: it is possible that one discipline's case study may be another's field study. Such differences can lead to misunderstandings between disciplines and hinder progress of multidisciplinary work. A common understanding of research methods is needed to facilitate a multidisciplinary approach to software and system design.

b). Many of the papers reviewed during the research alleged to be reporting a task of evaluation or measurement, but frequently failed to report the experimental design clearly and so reduced the impact of the paper. Unless studies are clearly and fully reported, again using agreed guidelines [9] important research will become meaningless as readers will be unable to assess the reliability and validity of the research. Reliability refers to the consistency of a measure, so that we may be reasonably sure that given the same conditions, the same behaviour or outcome would occur. Research validity enables us to be confident that the measuring instrument has actually measured what it is supposed to measure. In order to be accepted as worthwhile research and to move ESE forward, all research needs to be rigorously reported, detailing all aspects of the design to demonstrate that the research methods were reliable and the conclusions drawn from the results of the data analysis are valid. For example, it is not possible to assess or demonstrate validity when only a limited number of exemplary instances are reported or used, when criteria for including only certain instances are not offered and the materials in their original form are not available [8]. This is as applicable to qualitative research as quantitative research and just as much care and thought should be given to the design of the former as the latter (e.g. Questionnaires and Interviews). It should not be assumed that quantitative research techniques are the only ways of providing reliable and valid results.

Both qualitative and quantitative research has strengths and weaknesses. Choice of approach is dependent upon the aim of the research and can only be justified and explained within the context of the study. Quantitative research generates data that can be expressed numerically. Whilst it is accepted that numerical support for a hypothesis can be rigorous and objective, it is also possible that too much significance can be assigned to a numerical result obtained by statistical analysis. Quantitative data only relates to particular phenomena within a study. It does not enable participants in the research to express opinions or experiences in their own words as quantitative research methods are usually designed to investigate a limited number of pre-defined variables. However, it can produce results more quickly than qualitative research, which can take varying lengths of time to collect data concerned with understanding the world from the participants' perspective. But such qualitative data,

although tending to be more subjective, provides a much richer picture of the research domain which can be important when investigating the interaction of social, technical and organisational issues.

Qualitative research provides an overall picture rather than simply measuring specific phenomena, but the analysis of the vast amounts data collected can be difficult and time consuming. The collection of both quantitative and qualitative data within one research project may be beneficial. This is known as *triangulation* [10]
As each community tends to create and use measuring instruments and data collection techniques specific to its own discipline, research that involves perspectives from more than one discipline ideally requires the researcher(s) to understand data collection techniques of all the disciplines involved [7] or to collaborate with members of the other relevant disciplines. ESE is now in the position where its relevant research community may need to familiarise itself with the tools and techniques used by psychology and social science disciplines to measure or understand human behaviour. This would enable ESE to research human issues in a valid and reliable way using qualitative or quantitative techniques or to collaborate with other relevant disciplines. A strength of qualitative research is its capability to focus on actions and interactions as they are executed *in situ,* which can be important when gathering information about human behaviour, enabling researchers to see how human participants *do* things rather than just relying on what they *say* they do and to understand work practices as they *really* happen. However, our research showed that software engineers rarely adopt qualitative methods for research.

**Summary**
In line with other disciplines that use live participants for research purposes, a code of ethics dealing with the issues raised by the use of human participants in research and evaluation methods is necessary. The dissemination of knowledge between disciplines makes increasing sense as varying phenomena evolve to include emergent perspectives. This is true of system development and design as it evolves to include human issues in its activities. Other disciplines have developed and used quantitative and qualitative research methods and evaluation techniques for investigating issues of human behaviour, and it makes sense for ESE to avail itself of this knowledge. There is a danger that the choice of research method may be influenced by the culture of a discipline to the extent that the worthiness of other methods is overlooked. Being aware of and looking to other disciplines to understand the approaches and methods they use to understand a phenomenon can build a greater shared knowledge of the world in which we live.

Enormous problems of reconciliation between pace of change of technology and business environments and the time it takes to conduct valid ESE research can understandably lead to short cuts, but sometimes a holistic view of the problem under investigation can be more cost and time effective in the long term. The availability of previously tried, tested and documented research from other disciplines may provide ready to hand foundations upon which ESE can build and understand trends and relationships in socio-technical issues and this combined with SE's existing knowledge of research methods could help in the fight to keep up with the rapid pace of change.

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