PhD Status Report

General information

<table>
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<tr>
<td>Stage of PhD</td>
<td>Third Year, Second Semester (11 months left)</td>
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<tr>
<td>Title of PhD</td>
<td>What gets measured gets done: An action research study of quality management systems design</td>
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Papers

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<tr>
<th>Title of the paper</th>
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<tr>
<td>Using internal benchmarking as a strategy for cultivation: A case of improving COBOL software maintenance</td>
<td>IRIS 29</td>
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<td>Improving research methodology as a part of doing software process improvement</td>
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<tr>
<td>Designing quality management systems with minimal management commitment</td>
<td>Systemist, (3), 101-112.</td>
<td>-</td>
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<td>Software Process Improvement: What gets measured gets done</td>
<td>IRIS 31²</td>
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<tr>
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<td>-</td>
<td>Systemist (accepted)</td>
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<tr>
<td>Measurements, feedback and empowerment: Critical systems theory as a foundation for software process improvement</td>
<td>NEON 5</td>
<td>ECIS 17 (submitted)</td>
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<tr>
<td>Is information infrastructure design theory consistent with participatory design?</td>
<td>15th PhD Days</td>
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Research Description

Background and motivation for your research

Quality management, both as originally evolved in industrial engineering (Taylor, 1911; Shewhart, 1933; Deming, 1986; Turner, Mize & Case, 1987) and as applied and adapted for software engineering (Watts, 1989; Sommerville, 2001), deals primarily with the question of how to design standards and how to make people follow standards.

![Diagram: People Standards Terra incognita People following standards]

Figure 1: The practical problem of making quality management work

¹ My PhD proposal of a three year research project was accepted in March 2006, but due to parental leave from August 2007 to August 2008, research is expected to be delayed with one year (thesis submission: December 31st 2009).

² Best paper award
The diagram above is based on what Berlinski (1976, p. 110) describes as the "the systems analyst’s system", a graphical illustration of the core problem to be investigated through the constraints of input, output and a black box in the middle.

Some researchers in industrial and organizational psychology (e.g. Spector, 2006) believe that the black box in the problem formation can be opened through the use of goal-setting theory and control theory. The diagram above shows a control theory model suggesting how people set goals and then evaluate feedback about how well their performance is achieving their goals (ibid., p. 210).

![Figure 2: Motivation model according to control theory in I/O psychology](image)

The management principle “what gets measured gets done” (Peters & Waterman, 1982) sums up some of the essence of control theory. By focusing on performance measurements and feedback, action will follow. The principle is much quoted in both popular and academic literature.

In the area of software quality assurance, however, Sommerville (2001, p. 548) suggests that systematic use of software measurements and metrics is relatively uncommon: “There is reluctance to introduce measurement because the benefits are unclear. One reason for this, is that, in many companies, the software processes used are still poorly organized and are not sufficiently mature for measurements. Another reason is that there are no standards for metrics and hence limited support for data collection and analysis. Most companies will not be prepared to introduce measurement until such standards are available”.

Such ideas seem to be supported by the fact that the CMM capability maturity model for software development (Watts, 1989), only require systematic use of measurements when the organization has reached one of its upper maturity levels (level 4).

There seems to be a conflict between the theories of what motivates people at work and how to design quality management systems for software engineering. Is it possible to improve the methods for designing quality management systems by a more systematic use of the principle “what gets measured gets done”, or are there reasons that might lead us to believe that the control theory model above is contra-productive or not relevant in the context of designing such systems?
Research questions
The main research question is:

- How can we improve our current understanding of the way the intervention principle “what gets measured gets done” can be used in designing quality management systems?

Through the use of the control theory model illustrated in the figure 2, the research question can be investigated by looking at the processes of goal setting and feedback, thinking specifically about the complexities inherit in Sommerville’s reasoning on why systematic use of software measurements and metrics are relatively uncommon.

- RQ1: How to focus measurement interventions (quality planning) in a complex organization?
- RQ2: How to select, interpret and design quality standards for making measurement interventions work?
- RQ3: How to design feedback structures in a way that will have impact and create improvement?

Research approach

Theoretical ideas informing the research
How to effectively design quality management systems can be investigated both from the point of view of industrial engineering (IE) and I/O psychology. The first perspective focuses on technology, while the latter perspective is mainly concerned with human issues. In order to bridge these two perspectives, an additional philosophical perspective of systems thinking has been included in the theoretical framework I used for discussing control theory in the software engineering context.

![Diagram]

Figure 3: Coarse classification of theories informing research

1. General systems theory
One of the fundamental ideas in general systems theory (GST) is that most phenomena
cannot be understood in isolation as they are always a part of a larger system. Systems theory has been particularly popular in biology and engineering. Biologists understand the organism as a system, as an ecology, and systems thinkers from the biological tradition have often suggested that systems thinking should provide a general ontology of science (Boulding, von Bertalanffy, E.O. Wilson etc). The world consists of systems. The epistemology of systems thinking is primarily mathematical. The way to understand and reason about systems is through mathematical modelling (Bertalanffy, 1968), thus linking systems thinking to structuralism (Piaget, 1968).

However, not all systems are easy to model mathematically. In both systems thinking and structuralism, natural language and verbal models are used as well. Latour’s actor-network theory (ANT) is probably a good example of a modern systems theory where reality is understood as a network (system) of more or less stable connections between actors and artifacts, and where the connections themselves are described through a post-structuralist (Foucault-like) emphasis on power.

On the other hand, this post-structural or post-modernist perspective, based on verbal models and metaphors, is not very popular among biologists like Wilson, who maintain that an understanding of social life should not be based on what he considers ideological readings of society (Marx, Freud, etc) but should rather build on observations of other aspects of the biosphere, such as birds, bees, ants etc. In his view, an understanding of human behavior is thus only proper if it is explained through (Darwinian) evolution, using natural science as a basis for social science. Complex Adaptive Systems (CAS) is a more recent development of GST that has been particularly useful in developing computer models for investigating all sorts of systems that can be seen to behave in this particular biological sort of way (Axelrod & Cohen, 2002).

While biologists and social scientists have been using systems theory for building philosophical framework and trying to explain the world through systems, the practical impact of systems thinking is most clearly seen in engineering in general and computer science in particular. Quality management, which consists of producing flowcharts and collecting measurements along work processes within the organization, is similar to software engineering, or may be seen as an extension of software engineering in its attempt to manage the organization as if were a computer program. Systems thinking is a standard way for quality management personnel to understand organizations (Taylor, 1911; Deming, 1994).

Finally, at the same time as structuralism evolved in France by inspiration from linguistics (Saussure, Jakobson) and mathematics (Bourbaki), Eilhart & Mac Lane (1946) developed an alternative perspective on mathematical structuralism to the one developed by Bourbaki. Rather than using set theory as the foundation for mathematics, Category Theory starts with functions (mappings, arrows, processes, algorithms) and builds a different and more dynamic perspective on mathematical foundations. Building on the philosophy of Husserl, the goal of mathematics becomes to investigate structures (invariants of isomorphisms), not proofs or calculations. Category Theory as a foundation for mathematics has also become popular in computer science and software.
It is my belief that this hermeneutical mathematical theory can be equally useful in quality systems engineering.

2. Psychology
The “control theory model” from the theory of work motivation that I presented in figure 2 fits with the language of cybernetics and mathematical control theory, i.e. systems theory.

Using “what gets measured gets done” as a hypothesis, whenever I observe data that appears contradictory to this, all possible explanations are relevant and interesting. Although there are those who combine systems thinking with phenomenology (Checkland, 1981) or critical social theory (Ulrich, 1983; Flood & Jackson, 1991), the kind of insights that I search are not necessarily of a systems nature. However, if I should be able to see how such findings should fit with systems theory in general or control theory in particular, this will make the research more consistent.

Trying to understand how people respond to feedback, and how feedback can be designed in order to achieve more impact, can be seen as answer to the question of how to make people follow standards, as is the case in my research. In addition to this question, I am also interested in the psychology of designing and interpreting standards in a general context of the psychology of quality management standards (Brunsson et al, 2000).

3. Technology
As information and control can be seen as two sides of the same coin (Beniger, 1986), quality management systems can be seen as a special class of information systems that are expected to comply with standards such as ISO 9001:2000.

An efficient way of making people follow standards may be through “inscribing” standards into technology (Latour). On the other hand, as quality control personnel seldom have impact on technology decisions, it may be difficult to design quality improvement interventions that consist of hardwiring parts of the quality management system into the work processes. Nevertheless, when auditing and investigating a particular quality management system or a part of such a system, it may be interesting to compare and contrast quality control that is embedded in the technology and quality control that has to be managed regardless of technology.

I have not yet done a literature review of relevant literature on automating quality control beyond some of the discussion of how to collect metrics (Sommerville, 2001) and some random papers.

Empirical research strategy
The research is funded by the Norwegian Tax Administration (NTAX), and I work as a researcher at NTAX dealing with practical problems related to quality management of the IT function.
When the PhD research proposal was written and accepted (March 9th, 2006), the general idea was to compare and contrast quality management ideas and experiences from NTAX with those of other organizations. However, the emergent empirical research strategy has primarily consisted of reflecting on the quality management work I did with assistance of colleges at NTAX between 2000 and 2005. While I try to continue collecting and analyzing data from NTAX (which has been rather difficult due to NTAX reorganizations and internal politics), there is still much empirical data from the past that could be analyzed further, given the right sort of questions and theoretical framework.

In the figure below, I present my design for the empirical part of the research. To produce insights on the research questions described above, I have found “design science” to be a rational approach, designing interventions (based on the principle “what gets measured gets done”) and then try to extract insights based on the success or failure of such designs.

Figure 4: Design science cycle

The model above is a slight modification of a general description of the design cycle (Krick, “Introduction to engineering and engineering design”, 1969, p. 160) with dotted arrows added to illustrate how Design Science can be done as an embedded part of the cycle.

To explain the diagram in with respect to what has been written so far, the formulation of model during “engineering design” (top arrow in figure 4) corresponds with figure 1 and solving the model corresponds with figure 2. Implementation and monitoring (arrows at right hand side and at bottom of figure 4) correspond to doing action research within the organization (doing audits against the QMS), which is the expected to result in observations that can be analyzed and discussed against current theory and produce new knowledge.
Current Status

Research activities to date

I have completed 42.5 ETCS credits of courses and seminars, including the 30 ETCS compulsory credits defined by the courses listed in the PhD research contract. I have written eight papers so far. Six of them have been published and registered in the FRIDA research database in use at UiO. If the ECIS paper gets accepted for the conference, I will then have three publications at level 1 in FRIDA.

I presented and defended my “upgrade document” on June 21st, 2007. Feedback I got on the document will be used for defining a “kappa” to be written from scratch. My current plan is to have a mock defense by the end of the year, and then submit the thesis.

Although I am continuously analyzing documents and conducting interviews, the PhD research consists mainly of making sense out of what I have done previously as a practitioner at DNMI (1992-1999) and NTAX (1999-2005).

RQ1: How to focus measurement interventions in a complex organization?
In the most recent paper that has been accepted for publication in the Systemist Journal, I described how to design quality management systems as complex adaptive systems through an illustration of how I adapted an A.I. approach (similar to Genetic Algorithms) at DNMI, and how I used the same idea at NTAX. The approach was initially successful but then failed. I have been extracting what I consider to be key learning in terms of design principles based on this particular failure.

In this particular paper, I used Kevin Kelly’s version of CAS, as that was sufficient for analyzing and explaining the case, but I would now like to write another paper that goes more deeply into how the design strategy could be interpreted as a Genetic Algorithm (Holland, 1998), thus giving a more prescriptive and algorithmic set of instructions on how to design QMS as CAS.

RQ2: How to select, interpret and design quality standards for making control theory interventions work?
In the paper submitted to ECIS-17, I describe how lack of proper measurements and “organizational hypocrisy” (Brunson, 1989) causes an organization to “socially construct” a quality management system and enroll a large network of internal and external actors to believe the system is working perfectly when it, in fact, is not working at all. In order to liberate the organization from this prison of irrationality, I focus on Flood’s work on aligning critical theory with total quality management, describe a way of running the “liberation algorithm” and describe how this partially worked.

In an award-winning paper to IRIS-31, I described how I have used Participatory Design as a strategy for designing quality management systems, having the users themselves design the standards and measurement devices, while the role of quality management was reduced to giving feedback on people following their own standards, using the “what gets measured gets done” principle. This approach worked in nine out of ten cases. When
investigating this final case, it was revealed how people (managers and others) produced explanations that did not fit with the empirical facts. The most likely total explanation seemed like “organizational hypocrisy”.

In a paper published in the Systemist Journal, titled “designing quality management with minimal management commitment”, I pointed out that it is possible to “fake” management commitment in order to make people follow standards, but when management actually get involved there is a risk that they might destroy the quality management system as they are the only ones with the authority to do so. Contrary to conventional wisdom, that says it is impossible to design QMS without management commitment, I suggest an alternative approach of getting minimal commitment and otherwise strategically avoid management involvement unless they are seriously committed to quality.

RQ3: How to design feedback structures in a way that will have impact and create improvement?
My suggestion is to play the politics of the organization. In knowledge management (KM) it is sometimes described as a challenge that people will not share information because of relationship between knowledge and power, and people (managers in particular) will not act in ways that reduce their power. This observation can be used in a reverse way as a part of quality management design. Nobody cares about whether work comply with standards, but they care about others knowing whether they comply or not. Benchmarking results horizontally among teams doing similar work and informal the boss’s boss vertically can cause sufficient tension for improvement starting to happen. I have written about this as part of papers to IRIS-29, IRIS-31, Systemist Journal and ECIS-17. It might be a good idea to write a journal paper that is even more focused on the idea and discusses it in more detail with reference to KM literature and TQM literature.

RQ: How can we improve our current understanding of the way the intervention principle “what gets measured gets done” can be used in designing quality management systems?
The most important paper so far is the IRIS paper “what gets measured gets done”. All theory (technology, psychology, systems theory) should in principle evolve from analysis and discussion of cases where “what gets measured gets done” does not work.

A major problem so far is that I have not consciously positioned myself in any debate or discourse so far. Perhaps further reading of journal papers or discussing with the right people might help me discover that I am part of a discourse, but so far I have been more concerned with understanding than in presenting findings in a context where they have meaning.

**Future research plans**
Here are my current ideas summarized as outlines for conferences and journal papers.

RQ1: How to focus control theory interventions in a complex organization?
Paper #1: Developing quality management design strategies as genetic algorithms
I have not yet fully described how the standard tool of Pareto analysis in quality control can be used for designing a genetic algorithm (GA) for evolving the population of quality problems to be solved and as such function as a “bootstrapping algorithm” for quality management. Such a paper needs to be written as the method itself will be a driving force in selecting future quality improvement research topics and future research (for PhD and beyond).
- Conference target: UKSS
- Journal target: Systemist

Paper #2: Game theory as a way of conceptualizing critical theory as a basis for TQM
I plan to write about the auditing process from a game theory perspective. I already have some empirical material on this as I used game theory concepts in developing and describing procedures on how to control external auditors (circa 2003-2004) when working as an operational quality manager. While most quality management literature I have studied seems to assume that the rational approach of quality management (statistical methods etc) is applied in a context of enlightenment of mutual understanding, my experience is that conflict is the name of the game. Game theory, as a formal approach for modeling and analyzing conflict, was useful for conceptualizing situation when I was working operationally with quality management, and it also seems fit with my current use of CAS as a theory for designing QMS.
- Conference target: QMOD
- Journal target: The TQM Journal

RQ2: How to select, interpret and design quality standards for making control theory interventions work?

Paper #3: Building sustainable quality circles
A quality circle is an informal forum where workers come to discuss how to solve problems, share knowledge and improve the organization. I did one experiment at DNMI, and two experiments at NTAX; one unsuccessful and one successful. In yet another experiment, trying to improve attendance of meetings at NTAX, I used stopwatch statistics. I tried a similar approach at UiO, with interesting results. Based on all these experiments, I believe the way to build a quality circle (how to make people want to come) can be best understood if we interpret the meeting as a way of reading a common “text” and trying to help each other trying to understand the “text”.
- Conference target: IRIS

Paper #4: Quality control through participatory design
All information systems are control systems, some would argue (e.g. Beniger, 1987). My general approach towards designing such systems is to have to workers themselves design standards they want to be measured against, thus making the control process more like a democratic coordination process. I would like to see my research as research in Participatory Design (PD) in the way I want to improve user involvement and democracy at work, with the aim of the research being to find faults and improve the PD methods I and others like me are using.
Conference target: IRIS

Paper #5: Using statistical quality control as a way of testing hypotheses about processes in action research and design research

Trying to understand the writings of Shewhart (1939) and Deming (1986), doing quality control is very similar to doing experimental research. Shewhart points out that the industrial process of specification, production and inspection is very similar to the scientific process of designing an experiment (including hypothesis), doing the experiment and testing the hypothesis. In his view (Shewhart, 1939, p. 150), “it is shown that the nature of the problem of judging whether a state of statistical control exists is essentially one of testing the hypothesis that assignable causes have been eliminated”. This points to a possible input for a very interesting debate in quality control research concerning whether the SPC diagram can be seen as a test of hypothesis (or sequence of tests) [as seems to be indicated by Shewhart above] or whether it is an instrument of prediction and has absolutely nothing to do with hypothesis testing (as argued by Deming). The debate seems to have started in the 1950s (e.g. Deming’s 1953 paper on “enumerative and analytic studies”) and is still a part of current debate. The problem is of significant importance to my research, I would say, as my research design is inspired by Shewhart’s comments about the similarities between mass production and experimental research. My interpretation of Shewhart’s statement is that null hypothesis and alternative hypothesis should be seen as follows:

H0: \( X(t) = Y \)
H1: \( X(t) = Y + \omega(t) \)

The meaning of the null hypothesis is that the stochastic process \( X(t) \) is a stationary process where the random variable \( Y \) typically has a normal distribution. This statement corresponds to what is often described as the process being in a state of statistical control (“stable”). The deterministic process \( \omega(t) \) in the alternative hypothesis represents noise in the shape of “assignable causes”, i.e. special problems in the production process that can be found and eliminated.

Based on Deming’s comments on “tinkering” with processes and his “funnel experiments”, it seems reasonable to assume that a process is in a state of statistical control unless there is reason to believe abnormal variation is created by “assignable causes” (special causes) that can be tracked down and eliminated. Deming (1994, p. 184) uses the terminology of process outcome of Type I and Type II in a similar way to how Error I and Error II is used in conventional parameter hypothesis testing.

Even if we agree with Namilov (1981) that scientific theories are nothing but metaphors, I find it difficult to see how we could build such metaphors without some sort of hypothetico- deductive method, such as conventional statistical hypothesis testing or (in the case above) hypothesis testing based on the pragmatic rules on how to use the SPC diagram for detecting “out of control” patterns. Strangely, I have not found anything to support my argument above yet, as this seems to like a very natural way of generalization from parameter testing to model testing, but perhaps I have not searched.
may be due to lack of sufficient literature research, the idea of testing models rather than parameters seems to me to be the way to make sense out of quality control as research, something that would fit nicely with ideas from design research (testing for faults in design as input for building design theory) and a way of making action research more “scientific” in terms of not only building “local theory” (Nielsen & Svensson, 2006).

Anyway, the idea of using the SPC logic for testing hypotheses about processes is a method I have been using as a quality practitioner since (at least) 2004, it is vital to the way I have been thinking as a practitioner, and I would like to discuss it with fellow researchers as a method for building theory.

- **Journal target:** Journal of quality technology

**Paper #6: What gets measured gets done**
As I won the “best paper award” for my IRIS-31 paper, I have spoken with one of the editors for the Scandinavian Journal of Information Systems (SJIS), and I hope to rewrite the paper and have it published there. The reason I have not turned this paper into a journal paper yet is that it has already won an award, something that could make it useful as a thesis paper in itself, even though it is far from perfect, while I try to spend more resources on problems and papers that go into other aspects of the thesis. If I wait and collect more data, I might improve the paper as a part of how I work on improving the software process that is the source of the writing. Although I have been collecting data from this process since 2000, the process is now broken down due to reorganizations and bureaucratic challenges in the organization. I have been negotiating for getting access to data again since May 2008, but so far unsuccessfully. Hopefully I will eventually gain access and can then include this interrupt as a part of the action research narrative.

- **Journal target:** Scandinavian Journal of Information Systems

**Paper #7: Control theory of motivation to work**
The way I have formulated this status report, the “default research question” in quality improvement research is the question on how to motivate workers (software engineers) to follow quality standards. Although this problem can be read between the lines in all my papers, I have not yet written a paper specifically dealing with the problem through the context of “control theory of motivation” as developed in industrial and organizational psychology. This is an important paper to write that is likely to inform and motivate further research.

- **Conference target:** IRIS

**RQ3: How to design feedback structures in a way that will have impact and create improvement?**

**Paper #8: Knowledge management and quality improvement**
I believe the way to make quality improvement work is through managing knowledge of compliance with standards. Doing quality audits is a knowledge production process, presenting the results is a knowledge sharing process, and I believe the relationship between knowledge and power in an organization is a key element for understanding how to design quality management systems that work.
Conference target: IRIS

Paper #9: Category theory and quality management
The aim of category theory is to identify and compare mathematical structures. This theory has become popular in computer science, and my gut feeling is that this is the proper way to do quality improvement research as well. I would like to investigate the theory and write a paper about how it can be used for producing insights about quality management.

Conference target: IRIS

Paper #10: Quality management through inscription of behavior
In my experience, quality management works better if the controls are inscribed in technology, like how a computer program will not run if there are compilation errors. Although it may be difficult for quality control personnel to contribute to how controls can be inscribed in technology, the issue is still interesting, and I would like to rethink some of my own cases and perhaps interview others to find out how quality management systems can be made invisible and perhaps more efficient when they are inscribed in the technology that are parts of the tools and the process that workers (e.g. software engineers) follow on a day to day basis.

Conference target: IRIS

Areas to be discussed

Issues/concerns related to your research
I believe the most critical point at the moment is to elaborate the GA-approach for quality planning, as this method should also be used for how to prioritize among the other papers I plan to write. My goal is to submit this paper for the QMOD conference (deadline: March 1\textsuperscript{st}, 2009), and then turn the conference paper into a journal paper to be submitted to The TQM Journal.

The issues/concerns I would like to discuss at the 16\textsuperscript{th} PhD Days Workshop depend on how this paper develops.

Issues/concerns related to the progress of your work or PhD in general
According to the contract between UiO and NTAX, my PhD thesis should be submitted by the end of 2009. However, I feel I have spent most of the time so far on figuring out how to formulate the quality management process as a research process. Now that I am beginning to understand how to design TQM as research, based on research paradigms that are consistent with the IS world of research, I feel more like I am beginning my PhD research than finalizing it. I am highly uncertain of whether I should apply for extending my three year research with an additional year (to get some interesting results and make academic contributions) or whether I should think about my thesis as the starting point of an academic career and plan to make my scientific contributions after the defense.