# Competencies for Paradigm Shift "Survival"

Mats Daniels, Åsa Cajander,
Anna Eckerdal, Mats Lind, Aletta
Nylén
Uppsala University
Uppsala, Sweden

Tony Clear
Auckland University of Technology
Auckland, New Zealand

Roger McDermott
Robert Gordon University
Aberdeen, UK

*Abstract*—How can we prepare our students so they can cope with a working life characterized by frequent paradigm shifts? Adaptation to evolving circumstances and continual management of change are critical features for success in industrial and commercial organisations. In the normal course of events, most changes are evolutionary, with small, incremental improvements being made to theoretical understanding or practical application. Occasionally, however, changes occur of such magnitude that they do not just alter current operational practice but require a thorough reappraisal of the underlying assumptions on which that practice is based. In short, they require a review of the dominant way of thinking, or paradigm. These are "paradigm shifts" in the Kuhnian sense - changes in the "constellation of concepts, values, perceptions and practices shared by a community, which forms a particular vision of reality that is the basis of the way a community organises itself" - and their arrival signifies a period both of creative opportunity and cultural tension and disruption.

The rapid development in the IT area brings a series of shifts, in underlying theories, technology and work practices, that can sometimes be regarded as paradigm shifts. It is important that CS and IT education prepares students for coping with such transitions in their future careers, that students develop the competencies needed. To understand what these competencies are, it is important to investigate characteristics among employees that have flourished in earlier paradigm shifts and not least to build knowledge on how to develop learning environments where such competencies and personal characteristics can be achieved.

This paper is about setting the stage for an action research project aimed at enhancing education with regard to being able to deal with paradigm shifts in the IT industry.

*Keywords—paradigm shift; action research; competencies; capabilities; learning environments; adaptability*

## I. INTRODUCTION

Adaptation to evolving circumstances and continual management of change are critical features for success in industrial and commercial organisations. In the normal course of events, most changes are evolutionary, with small, incremental improvements being made to theoretical understanding or practical application. Occasionally, however, changes occur of such magnitude that they do not just alter current operational practice but require a thorough reappraisal of the underlying assumptions on which that practice is based. In short, they require a review of the dominant way of thinking, or paradigm. These are "paradigm shifts" in the Kuhnian sense [1] - changes in the "constellation of concepts, values, perceptions and practices shared by a community, which forms

a particular vision of reality that is the basis of the way a community organises itself" [2] - and their arrival signifies a period both of creative opportunity and cultural tension and disruption.

We will use the concept of "paradigm shift" in this sense, i.e. one that signals a need for changing fundamental assumptions about working practices, where previous knowledge and skill sets lose significant amounts of value or, in extreme cases, are made completely irrelevant. It might be argued that this term is being applied too loosely when used to describe the case where IT development puts severe strains on industry and education. However, we argue that the concept of a paradigm shift is appropriate to capture a situation where some of the more technology specific knowledge and techniques that students learn at universities are often already outdated when they obtain their first job, and where employees might find their current skill set to no longer be a valuable asset when new technology is introduced.

Examples of what we see as paradigm shifts in the IT Industry brought on by technological advances are the advent of the Internet and the World Wide Web [3], the introduction of the PC [4], open source [3, 5], and the emergence of new programming paradigms such as object-oriented programming [6] and concurrent programming [7]. Other recent technological advances that have this potential are the development of cloud computing infrastructure and smart devices like mobile telephones and app technologies. That the IT industry has been through a number of these dramatic changes in a short period of time should not be seen as a reason to view this as something less than paradigm shift, or to not take the consequences seriously. The fact that IT companies need to pursue new trends or be quickly overtaken by rivals can be illustrated by examples such as Facit [8] and Nokia.

One potential strategy for coping with such change within a commercial environment is to replace experts in the old paradigm with those who more fully grasp the implications of the new one. However, this would lead to other problems such as critical loss of domain knowledge. Even though new employees may have expert knowledge concerning the new technology, they may lack an understanding of the application domain and tacit knowledge of how the company works. This is due to an increased need to understand the environment in which the IT-system is to be used in addition to knowledge of the latest technology. We will consider this deeper integration into a company as a non-technologically driven paradigm shift. An example of a non-technologically driven paradigm shift is

radically increased demand to be able to interact in a wider context, e.g. internationally, across disciplines, and with society at large. From a business perspective, therefore, when paradigm shifts occur, it is of vital importance to maintain some degree of continuity in the core area and have individual employees who can quickly learn and adjust to new situations with new technology or due to changes in work practices.

'Learning to learn' is a competence likely to be important in coping with paradigm shifts. This is also supported by research indicating that competence development will largely be met through employees' own efforts. This is illustrated in a study that indicates that only 10-20% of learning in companies takes place in an organized manner [9]. Other research studies of learning in workplaces have been carried out by e.g. Mittendorf et al. [10], Xiao et al. [11] and James-Gordon and Bal [12]. Much of this research has focused on how companies and organisations can create the conditions for learning [13], which is relevant for the individual's ability to cope with paradigm shifts. We have however not found any work specialising on which competencies for such adaptability are required of the individual.

The purpose of this paper is to set the stage for an action research project aimed at enhancing education with regard to being able to deal with paradigm shifts in the IT industry. The research questions underlying the work presented in this paper are:

*How should a study be designed to investigate what competencies and characteristics an individual IT professional needs in order to cope with paradigm shifts?*

and

*How can educational settings be constructed to better prepare individuals for a working life with frequently occurring paradigm shifts?*

The paper starts by discussing the relevance of the research questions from different perspectives. There are three research areas of special importance in performing the action research project we propose, 1) Competencies, 2) Personality, and 3) Learning environments. Before addressing these areas, the impact paradigm shifts have on society will be presented. The paper will be concluded with a suggested study design and some conclusions.

## II.    IMPACT ON SOCIETY

The IT sector represents a significant part of any modern society. For instance, a country such as Sweden has historically built much of its welfare on high technology industry where IT has emerged as a major actor in the last few decades. On the Swedish IT & Telecom Day 2013, organised by the trade and employers' organisation, IT & Telecom Industries, competence (expert) provision was voted to be the industry's key question [14]. There are, therefore, good reasons for studying paradigm shifts in the IT industry, since successful strategies for surviving and taking advantage of these changes are vital. Previous research has pointed to the fact that paradigm shifts might be problematic even for experienced professionals [15, 16].

Previous research indicates that there exist unspoken requirements that individual employees in the IT industry manage to keep abreast of technological developments and, when necessary, learn new technologies [16]. This is visible in different codes of ethics for professional engineers, e.g., IEEEs [17], saying that members agree to maintain and improve their technical competence. This applies to all employees, including recent graduates. Employees who do not manage to cope with knowledge paradigm shifts will find themselves outpaced by younger or more flexible colleagues. From the company's perspective, rapid turnover in the workforce will mean a loss of general competences and knowledge of the company. It is thus vital for IT companies that their employees can cope with knowledge paradigm shifts.

Due to rapid technological developments, certain technical aspects of a university education might be already outdated at graduation and, consequently, it is necessary for individual professionals to be able to learn new technologies and cope with constant changes in their working lives. Indirectly this means that universities must provide IT students with the competencies needed to cope with such knowledge paradigm shifts. Given this, we suggest that there is an urgent need to investigate the nature of these individual competencies and how educational settings, at universities, in the industry, and individually composed, can provide individuals with appropriate learning experiences in order to develop them. Indirectly this is for the good of a society where IT companies can continue to develop and successfully compete internationally, and adaptable individuals continue to thrive in the face of technology changes.

## III.    THE COMPETENCIES ASPECT

There is an increased attention to competencies other than purely technical, e.g. as seen in [18, 19, 20]. There is still confusion about what constitutes a competence and the Definition and Selection of Competencies (DeSeCo) project [18] is an effort to aid in understanding competencies in general and place them in the European context. A competence in the DeSoCo project is viewed as knowledge and the ability to deal with complex situations in particular contexts. They further state that what they define as a key competence must:

- Contribute to valued outcomes for societies and individuals;

- Help individuals meet important demands in a wide variety of contexts;

- Be important not just for specialists but for all individuals.

The key competencies belong to three broad categories: being able to use tools for interacting with the environment, being able to engage with others in heterogeneous groups, and being able to take responsibility for one's own life in a broad social context and act autonomously.    Important in all categories is the ability to think and act reflectively.

We have in earlier research addressed the competencies aspect in the learning environment area [21, 22], where for instance we have pointed out that there is a gap between what

degree programs are supposed to develop in terms of competencies and what is actually covered in the course units comprising the program. There are several reasons for why this is the case, e.g. competencies are seen as being assimilated during education and they are not considered as measurable, and this paper addresses the issue of faculty not realizing what competencies are, why they are important, nor how to help students develop these competencies. That is, the research study we propose is intended to provide understanding and evidence regarding competencies considered crucial to flourish in a fast changing environment. This critical importance provides a motivation to truly reform course units to have learning objectives that includes development of competencies. Such a study would also provide a base for understanding the nature of these competencies, which is a precursor for creating a learning environment in which to develop them.

We will use a model of competence based on work by Graham et. al [23] and developed by us [24] in which we view a competence as being composed by knowledge, attitude, and skill. This is a model that has been useful in understanding different aspects of what is seen as a competence. There is also an aspect of this model that a person should show all three aspects in order to be seen as having the particular competence. This model also fits well with the idea of communities of practice [25], where each of these aspects can be used to explain why someone moves towards the center of a community whereas others remain on the outer as peripheral members.

## IV. THE PERSONALITY ASPECT

We have earlier addressed the personality aspect in the learning environment area [26], where we point out research stating that perseverance is a strong predictor for academic success [19], e.g. a study showed that conscientiousness and intelligence were equally strong indicators for academic success in higher education and that they were independent of each other [20]. There is no doubt that an individual's personality also is a factor when it comes to coping with paradigm shifts. There are strong reasons therefore to take personality into account when studying how individuals cope, partly to get a more holistic view and partly as an indicator of what to address in creating learning environments aiming for preparing students better for coping with paradigm shifts.

There are many issues to consider if personality aspects should be studied, e.g. which instrument to use when finding out more about the personality of persons. The Five-Factor model [27] is the basis of some of the most commonly used instruments. The name derives from capturing the behaviour as belonging to five more or less independent general personality characteristics; Extraversion, Neuroticism, Openness to experience, Agreeableness, and Conscientiousness. These are defined as subsuming more low-level characteristics, e.g. being strong in conscientiousness is associated with self-efficacy, organisation, cautiousness, self-discipline, and persistence. Another aspect to consider is how to capture the personality shown in the work situation in question and also that personality also changes over time, e.g. as a person gets older it is common to mature and in that process score higher in emotional stability (lower in neuroticism), agreeableness, and

conscientiousness [28]. That personalities can change is a reason to consider how that could be integrated into education. There is also work that suggests that it would be more interesting to look at personality types and characteristics at a finer granularity [29], e.g. academic tenacity [30] and Grit [31] in the academic success case.

A study by the Department of Education in the US points out that grit, tenacity, and perseverance are critical factors for succeeding in the workplace in the future [32]. Another study states that conscientiousness is central to the intra-personal competency, which is identified as being highly important for life in general as well as in the work place [33].

## V. THE LEARNING ENVIRONMENT ASPECT

An essential outcome of an action research project such as the one we outline below is that identification of competencies and characteristics will provide important insights for creating educational settings that better prepare individuals for coping with paradigm shifts (as well as ordinary development). A better understanding of which competences and characteristics are important for individual success in a paradigm shift, will form a basis from which recommendations can be drawn for setting up and improving learning environments that help individuals develop in that direction.

There is a gap between what the industry needs both short term and what we are supposed to prepare our students for long term and there is also a gap between what is stated as general learning outcomes from degree programs and the learning outcomes of individual course units. We argue that these gaps are partly due to faculty and education developers not having a vocabulary to express competencies and personal characteristics in terms of education, which also leads to students not being familiar with these concepts nor motivated to take them seriously if addressed in a course unit. Breaking up a degree program into a set of rather small course units also undermines development of perseverance as such.

In [34] we reason about development of competencies in terms of a model based on Stahl's model of collaborative knowledge-building. We will here give a short summary. Stahl's theory draws on organizational learning [35] and communities of practice [24] and is attempting to:

> "... understand learning as a social process incorporating multiple distinguishable phases that constitute a cycle of personal and social knowledge-building. The cyclical character of this process allows increasingly complex questions to be posed on the basis of more and more sophisticated understanding". [36]

We intended the model to be used to help build a foundation to describe how development of competence is related to a social context. A key element in Stahl's model is social knowledge construction where discussion and analysis leads to formation of a shared communal perspective. This

crucially depends on individuals being capable of clearly articulating views and insights. Lack of clarity or completeness as well as issues with not valuing what each other contributes will lead to limited analysis and rigour of the subject matter. Such deficiencies hinder creation of shared understandings of the subject and thus leadg to difficulties for collaborative knowledge-building. Artefacts created under poor conditions will have limited usefulness and will thus be hard to use to build group identity. The cycle described in figure 1 relies on a high quality of reflection and perceptions of value.
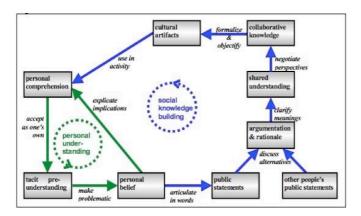


Fig. 1. Stahl's Model of Collaborative Knowledge-Building (from [36], p. 3).

The basic idea in Stahl's model, see figure 1, is that tacit pre-understanding is the foundation of personal knowledge [37] and that this leads to individual and collective understanding which shape how we perceive the world. Sometimes elements of these understandings conflict with experience [38]. Dealing with this conflict is part of the process in this model that eventually leads to new tacit understanding, from where new understanding and learning can start [36]. For us, an interesting aspect of this model, apart from describing a learning process, is that it captures interaction between an individual and others, including use of artefacts.

Of particular interest is the key role a shared language plays. This fits well with our ambition to identify and describe competencies and personal characteristics useful in paradigm shifts in order to integrate them in a learning environment. This is also consistent with the model of competence where it is seen as consisting of knowledge, attitude, and skill. Competencies are mostly applied in interaction with others, which makes this model particularly useful as a base to develop learning environments suitable for development of these competencies.

We see this model as a means to create a common understanding of how to design learning environments which include development of competencies and personality traits among the students that will better equip them to manage in an environment with continual paradigm shifts.

## VI. PROPOSED ACTION RESEARCH PROJECT

The authors of this paper have positive experiences from Action research [39, 40] and suggest that a study should be based on this methodology. This is especially true for the aspect of setting up suitable learning environments. We propose to precede the first action research cycle with a gathering of information phase. The intention of this first phase would be to conduct a fuller literature study, including establishing a definition of what we mean by paradigm shift, competence, and personality in this context. We propose that this literature survey should influence how to carry out the investigations regarding a selected set of employees. Potentially useful methods to gather information are semi-structured interviews and questionnaires/instruments based on these interviews. The topics to cover in the interviews, and later in the questionnaires/instruments, will be decided based on an initial study of potentially interesting areas regarding a person's ability to cope with a paradigm change.

The selected employees should be those that are regarded as having coped well with at least one paradigm shift. Care should also be taken with regard to selection of companies and organisations to study and we suggest that this could be influenced by first identifying which paradigm shifts to look for. Choosing a set of paradigm shifts to look for will help identifying relevant workplaces to study and also provide a basis for comparison. We believe that large companies will, at least in the initial stages, be the ones most relevant to study, but still suggest that also smaller companies should be approached in order to capture a potentially different set of needs. We further propose that the large companies and organisations should be approached through their human resource division as these will be helpful in identifying relevant employees to interview and also, subsequently, to distribute questionnaires/instruments. They are also the ones most likely to understand the concepts of competence and personality. We also advise to collaborate with relevant employer's organisations, e.g. Almega [14], in order to both identify companies and find appropriate contact persons within relevant companies.

The stage of conducting semi-structured interviews and sending out questionnaires would be among the early stages in the first action research cycle along with identifying the focus to use. The middle stages of the first cycle should be to evaluate the interviews and questionnaire responses followed by identifying the general findings. We further suggest that each research cycle should be concluded with a workshop when all researchers, and other potentially relevant persons, discuss the findings and plan for the upcoming cycle. Then, in subsequent years, we intend to refine the research question based on the findings in the previous action research cycle and repeat these investigations in the industry.

This could be seen as an action research study of its own, but we propose that this industry study will be extended, starting from the second cycle, by identifying actions leading to the development of learning environments. The reason to

wait until the second cycle would be that information about competencies and personality gathered from the workplace will be available at that time. We propose that this new "thread" should be based on the Stahl model and a model of what a competence is that is based on our previous work on competencies [24]. This is a model where a competence is seen as being composed of three interrelated parts, i.e. knowledge, attitude, and skill. This will allow the capturing of different aspects of what a competence is and to form a clearer understanding of how a competence can be developed in an educational setting. Issues to study in this "thread" should include studies on how the identified competencies can be addressed in education. The intention of the full action research cycle would be to both identify relevant competencies and develop recommendations on how they can be developed in different educational settings, e.g. at universities, companies, and for individuals, and in different formats, e.g. traditional courses, training events, and distance courses (including Massive Open Online Courses - MOOCs). This setting can continue with several new cycles, where we believe that the identifying part will diminish over the cycles and the educational aspects take over.

The intended goal with this proposal is to raise awareness of the value of the competencies and personality traits that are identified as important in coping with a paradigm shift and especially to promote an understanding that these competencies and personality traits can be developed.

## VII. CONCLUSIONS

We have identified coping with paradigm shifts as an area where further research would be highly valuable and outlined a study design aimed at addressing this area. This paper and other earlier work by the authors provides a first base for engaging in such research. It is also our firm opinion that conducting a study of the type we outline would be beneficial for education developers and teaching staff for achieving broader learning objectives.

Another benefit should be to gain a better understanding regarding paradigm shifts in the workplace, which could be costly if not fully disastrous for a company or organisation. Results from this study are intended to reach the workplace faster than the traditional route of educating new students how to better cope.

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