Dynamics of organizational learning and continuous improvement in six sigma implementation

Taina Savolainen
Department of Business and Economics, University of Joensuu, Joensuu, Finland, and
Arto Haikonen
Genworth Financial, Helsinki, Finland

Abstract

Purpose – The purpose of this paper is to examine the dynamics of organizational learning and continuous improvement (CI) in the context six sigma implementation in business organizations operating in multicultural environments.

Design/methodology/approach – A specific research question is: does learning mechanisms and continuous improvement practices support each other and how, and what type of learning can be identified in the improvement of business processes. The question is linked to one of the fundamental issues currently discussed in the field of organizational learning: how do organizations get “from here to there”, in other words, what is the dynamics of the processes of learning and how progressive learning is achieved. A case study of a few Finnish companies is made and a procedural implementation model is applied.

Findings – The findings suggest that the learning process is characterized by measurement, detection and correction of errors, and cost reduction. In six sigma implementation, learning is a single-loop type of learning. It is an incremental change process which reminds a technical variant of the learning organization. Continuous improvement occurs through procedural practices (the DMAIC-cycle) which forms a structure for sustaining learning.

Research limitations/implications – In this study, an essential question remains still unanswered: what type of learning is appropriate when organizational performance is enhanced by process improvements in production, delivery processes, etc. and what kind of learning mechanisms are the most supportive to continuous improvement practices. Further research is needed to find out how (if at all) the technical (single-loop) approach develops into social (cultural and political) type of learning enabling sustainable capability development. For researching this a longitudinal case study setting would be required. As this paper has reported on the authors’ first exploration, further research is needed to increase understanding of learning mechanisms that support CI practices. In further studies it is necessary to “dig” in real life practices of six sigma implementation more deeply.

Practical implications – Management should invest in, and allocate resources to staff training in order to promote learning and CI. On the level of operational leadership, the role of the leaders needs to be more clearly defined and leaders should be empowered. Managerial implication is that the development of information systems is a necessity for supporting CI and progressive learning in six sigma implementation.

Originality/value – Explains the dynamics of continuous improvement and learning process. Presents findings from a case study in three Finnish multinational companies. Presents a few key success factors for progressive organizational learning in conclusion.

Keywords Six sigma, Learning organizations, Continuous improvement, Finland

Paper type Research paper
Introduction
Theoretically organizational learning and continuous improvement are both linked to organizational change which is currently one of the most widely discussed and studied organizational phenomenon – in fact, the enigma of the twenty-first century organizations (Struckman and Yammarino, 2003). Organizational learning and continuous improvement have been linked in studies increasingly in the past five years (see, for example, Paton and McCalman, 2003). The implementation of organizational change – the practices of CI – requires supportive structures of organizational learning. This is to say that to improve continuously requires commitment to learning. It is not well known, however, how organizational learning and continuous improvement work dynamically and mutually. For studying the mutual dynamics of these two widely known concepts in the organization theory and quality management fields, the six sigma approach – an improvement methodology for business processes – forms a fertile context for examination.

There are not yet too many scientifically sound reports and case studies of six sigma implementation in real-life. In the dynamic developments of pursuing organizational effectiveness, the six sigma approach is currently gaining more and more ground in high-performance organizations aiming at the highest level of quality (six sigma by definition). Managers allocate resources to the improvement activities they regard as crucial for increasing organizational performance. Six sigma is an improvement method that aims to increase business performance through solid and accurate business focus. The applying of six sigma is progressing in Finnish business life, and this paper reports on a preliminary case study in three companies. Conclusions are made and on how learning and continuous improvement practices support each other, and on the type of learning in the six sigma implementation.

The findings show that in a procedural implementation of six sigma learning mechanisms and continuous improvement practices are intertwined creating mainly a single-loop type of learning. The type reminds a technical variant of the learning organization (Easterby-Smith and Araujo, 1999) which is characterized by measurement and cost reduction. On the basis of the findings, a further research question can still be raised, what type of learning occurs in the implementation of six sigma, and, more importantly perhaps what type of learning is appropriate when organizational performance is enhanced by process improvements in production, etc.

Organizational learning, continuous improvement, and six sigma
Defining and examining the main concepts
Organizational learning. During the last 40 years, that the concept of organizational learning (OL) has existed, a number of approaches and definitions have been produced. In this paper, Huber’s (1991) definition is applied as follows: an entity learns through the processing of information, potential behaviour changes and acquiring knowledge that it recognizes as potentially useful to the organization. Three main views in OL can be identified according to Easterby-Smith and Araujo (1999) the technical, social and cycle views. The technical view is characterized by the effective processing, interpretation of and response to information inside and outside the organization. Argyris and Schön (1978) make distinction between two types of learning – single-loop learning and double-loop learning. The former, which reminds the type of learning the six sigma approach represents, is the detection and correction of errors within a given set of governing variables. Double-loop learning involves changing those variables.
The social view focuses on how people make sense of their experiences at work. Organizational learning is seen as a political process, which is not recognized as important in the technical view. The social view involves also cultural aspects. As the processual change approach has gained ground since the 1980s, the social view in organizational learning has, in turn, emerged and spread more widely in the late 1990s. Moreover, individual vs. organizational learning is one of the main topics of the discussion and research in the field.

An important issue is what form and type of change are associated with learning. Single-loop learning is linked to incremental change, where an organization applies new methods, and finds new ways of action and attempts to get feedback on their consequences in order to be able to make adjustments and adaptations. Double-loop learning is linked to radical change involving major (strategic) changes (Easterby-Smith and Araujo, 1999). Discussion about the learning organization as a whole "entity" is also characterized by the technical and social variants. Cyclical models have been developed as well. The technical orientation examines interventions based on measurement and learning curves. The social orientation focuses on the human side, i.e. the ability of individuals to learn from their experiences, from or with each other in work settings. A number of linear (stage based), hierarchical progress models, and cycle models of the learning organization have been developed. Kolb’s (1984) experiential learning cycle has formed an inspiration for many of the models. Learning is seen as a continuous process. It goes through several stages involving generation of information, the interpretation of information, and development of actions on the basis of interpretations, and iteration between individual and organizational learning.

Six sigma. The six sigma methodology is a structured tool with techniques of quality management, and it can achieve strategic business results through its applications on a project basis (Wang et al., 2004). The process improvement methodology was first developed in the 1980s in Motorola (Breyfogle, 1999). A number of books and articles provide the basic concepts of six sigma (see, for example, Harry and Schroeder, 2000; Hahn et al., 2000). Recently, six sigma has been applied in wider areas of organization, such as human resource management (Wyper and Harrison, 2000). Six sigma is a process improvement methodology that aims to increase business performance through a solid and accurate business focus (Haikonen et al., 2004). It is a systematic approach to achieving continuous process improvements. More specifically, six sigma focuses on eliminating variation by detecting and reducing the sources of variation. Six sigma’s target is to achieve less than 3.4 defects or errors per million opportunities – hence the name. The higher the number of sigmas, the more consistent the process output or the smaller the variation.

Successive and simultaneous improvement projects are selected based on the impact on the bottom-line business performance. The major purpose of the method is to search for opportunities for improvement that have the maximum effect on the bottom-line compared to the net-expenses of the project. Six sigma links customer requirements and process improvements with financial results.

The six sigma methodology incorporates five stages of implementation in process improvement. The stages are called the DMAIC-cycle of define-measure-analyze-improve-control. These steps guide the improvement process and help detect root causes of the failures in a single improvement project. It is possible to concentrate on the process failures causing most of the variation and, thus, have the greatest impact
on the existence of output failures. Craig (1993) presents the key steps in six sigma as follows:

1. Defining product characteristics that affect customer satisfaction.
2. Using a failure mode and effect analysis to identify and control parameters to meet customer specifications.
3. Employing a reproducibility and repeatability study to measure the control parameters.
4. Estimating the process capability of the prototypes and thereby being able to correct individual defects immediately.
5. Developing the quality control plan and training material.

The idea of continuous improvement and learning are involved in the implementation of six sigma projects through the DMAIC-cycle. The cycle includes basically searching for improvement opportunities which requires commitment to learning. The increasing need for performance improvement tends to invalidate existing answers in an organization and requires continuous learning (Dixon, 1994). Knowledge is attained through learning; learning generates improvements that can lead to learning and again to further improvements. Organizational learning occurs on a continuous basis. It functions as a dynamic mechanism for improvements. And the organization’s capabilities to learn more quickly are likely to enhance and sustain competitiveness.

Continuous improvement. Continuous improvement (CI) is defined as “an organization-wide process of focused and sustained incremental innovation” (Bessant et al., 1994). According to Bessant and Francis (1999), organizational capability of CI provides dynamic mechanisms for involving the organization in learning processes.

The six sigma methodology is linked to continuous improvement, due to the systematic selection and continuing implementation of improvement projects. Zinkgraf and Snee (1999) present the following key elements in the selection of six sigma projects. First, project selection starts with the clarification of the “Big Picture” using strategic plans and an annual business operations plan. Second, the plant’s productivity baseline needs to be established. Third, the projects need to be prioritized based on customer value, resources required, and schedule. Finally, key projects with leadership support need to be selected. This includes also the checking of accountability. Traditionally process measurements have been made to support financial systems and identify customer needs. The six sigma methodology differs in that it emphasizes the need for measurements that are focused on process improvements. Thus, new measurement systems with associated data collection, analysis, and reporting are needed. The systems need to be linked and integrated at different strategic, managerial, and operational levels in the organization to ensure fact-based decision making in the improvement process.

There are several different managerial and operational roles in the six sigma methodology and its implementation; Executives, Champions, Master Black Belts, Black Belts and Green Belts. Executives are representatives of the senior management who are in charge of the company’s overall strategy. They are usually trained one-to-two days to give an overview about the philosophy.
Champions are vice presidents, superintendents, directors and group managers, who are expected to take a five-day training session about the philosophy and methodology. The champions are leaders who are responsible for leading six sigma projects, i.e., selecting appropriate projects, resourcing them and taking responsibility for other details related in the improvement project management. Black Belts are team leaders who are responsible for measuring, analyzing, improving and controlling key processes that have influence on customer satisfaction and/or productivity growth. A Black Belt is a person who has the potential to have a synergistic expertise between their work area and the six sigma methods and tools. They are supposed participate in extensive four-week education on the methodology. The Black Belts are usually working full-time within six sigma. Master Black Belts are teachers who also review and mentor Black Belts. Selection criteria for Master Black Belts are quantitative skills and the ability to teach and mentor. They take additional one-week training session after working a few years as a Black Belt. Green Belts are six sigma team members who are trained approximately two weeks to understand the philosophy and the use of basic quality tools (Haikonen et al., 2004).

**Linking the main concepts**

Finally, the main concepts discussed above are linked in a framework (Figure 1). Several links can be found between learning, CI, and six sigma. In the context of six sigma, continuous improvement is based on learning. Procedures and practices are mentioned above that facilitate the achievements of major process improvements, and of financial gains. As is prescribed in the six sigma philosophy, it involves structures that enable basic problem finding and solving. Mechanisms that facilitate learning include an idea management system, extensive training, and reward and recognition system. Practices of continuous improvement focus on strategy and strategy deployment with a bottom-up systematic monitoring and measurement system. These practices are prescribed to be important in the six sigma approach. In the implementation of six sigma, continuous improvement and learning are linked through the DMAIC-cycle. The cycle is closely linked to the Deming’s PDCA cycle (see, for example, Deming, 1986) showing a structure for dynamic continuous improvement process through learning.

![Figure 1. Integrating framework of the main concepts](image-url)
The fundamental purpose of the six sigma methodology aims to support the growth and profitability of business enterprises. Continuous improvement of process performance requires effective implementation of systematic quality methods, such as six sigma. Effective use of quality methods requires appropriate organizational learning strategies (see, for example, Hyland et al., 2000; Gieskes and Ten Broeke, 2000; Mitki et al., 1997). In summary, the “integrating” framework in Figure 1 incorporates several learning mechanisms and CI practices illustrating the dynamics between the two, and their links to six sigma implementation.

Case study
Case companies and methodology
Findings in this paper are based on a preliminary case study of three companies operating in Finland. The first case company is one of Nokia’s suppliers, a leading Finnish company implementing six sigma. The second case company is a leading international supplier of housing and environmental technology, and the third case company produces ground up trucks and industrial vehicles in any size and configuration. Data were gathered mainly during the implementation process by researchers and experts who were involved in the training process in the case companies. In addition, company documents available were used, as well as experiences of the experts (“cumulative knowledge”) involved in the process. The cases are reported next one by one. Figure 2 illustrates the procedures of implementation. This is the approach recommended and followed by experts from the University of Technology Lahti Center who were involved in a training process in the case companies.

![Figure 2. Procedural model for implementing six sigma in the start-up phase](image-url)
First case company

This leading Finnish company in implementing the six sigma philosophy aims to establish the six sigma culture in the organization through an extensive employee-training program for the key actors in the implementation process. By the end of 2002 the company has trained almost 50 Black Belts (BB) and Champions (CH). Although the Green Belt training started in 2002, the company is currently lagging clearly behind the goals of the GB training compared to BB and CH training. The company intended to take a “quantum” leap straightforward from no-training to well trained six sigma experts (from low-low box to advanced-fair box presented in Table I).

In total, 16 six sigma projects were carried out during 2001. The outcomes were favorable – in fact, significant financial benefits were attained. However, the start-up phase in using and implementing the six sigma methodology was not smooth and straightforward. One of the most important reasons for this is the nature of production. Production life cycles are so short that there is no time to finish the defined improvement projects of specific manufacturing processes before the manufacturing is finished. Therefore, the case company aims to set-up processes using design for six sigma methodology in order to be able to meet more and more demanding customer requirements and save costs of poor quality. In that respect, the case company reminds many other companies that pursue to implement actively new operational modes. For example, trained Black Belts are often not directly involved in the six sigma implementation after training but are expected to spread “the word” in the company. This is partly a conscious decision.

Second case company

This case company – a leading international supplier of housing and environmental technology – offers a wide selection of systems in the areas of heating and cooling, water and energy supply, indoor air and wastewater management, as well as various utility-pipe solutions to builders and home-owners. Furthermore, the company invests in product and systems development, and due to that are known for many innovative solutions within the industry. The company has production plants in 15 countries, about 5,000 employees, and customers in 100 different countries. Annual net sales amount to 1.1 billion euros in 2002.

<table>
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<tr>
<th>The efficiency of the organization’s development activities</th>
<th>The maturity of the organization’s development activities</th>
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<td>Low</td>
<td>Low (1) Management’s (Champion) and process workers (Greenbelt) training = development of readiness to implement (Case 3)</td>
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<tr>
<td>Fair</td>
<td>(3) Top management’s (Champion) training = setting of the management of the development activities</td>
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Table I. Classification of the maturity and efficiency of the case organizations in development activities
The company aims to proceed from the low-low category (see Table I, box 1) via the advanced-low category (box 2) to the advanced-fair category (box 4) using an extensive Champions and Green Belt training. The company made plans also to train at least one Black Belt in the start-up phase in order to increase organizational awareness of six sigma. A learning process was divided into the following five main aspects: setting-up the goals for development activities, the criteria and methods for decision making, resource allocation for development activities, development of new follow-up and reporting procedures and setting-up a new control system. The start-up phase is still in progress. Despite that, a few preliminary findings from organizational learning can be presented. First, the top-management learned to lead in a more accurate manner due to development of the on-time measurement and reporting systems. This is linked to a decision-making process on an operational level and in development activities which have become more effective so far. This was shown, for example, the selection of a successful pilot project. Second, training for employees (process workers) increased their understanding about the nature and efficiency of systematic development. Furthermore, their capabilities to carry out such projects developed remarkably. Third, the organization’s awareness and understanding of the processes increased also. They are now able to define the capability of their operations in a more precise way. Moreover, they are able to identify new learning opportunities, i.e. to find out development potential better than after the first steps in six sigma implementation.

Third case company

This company provides ground up trucks and industrial vehicles in any size and configuration which have one thing in common – they need axles to run on, and, in a word, axles are the business. The expertise of the company is in knowing how to convert the forces generated by a vehicle into effective work on the ground. And the company pursues providing an optimum solution for every customer’s needs. One of the company’s competitive advantages is that, as a medium-sized flexible company, short lead-times with responsive, top-quality service can be offered. The annual net sales amount to 20 million euros in 2002 with 110 employees.

The company aims to move from the low-low category (box 1) to the low-advanced category (box 2) presented in Table I by an extensive GB training. Plans have been also made to train a few Champions and Black Belts in the start-up phase in order to be able to reach the level of fair-low category (box 3). The company took a more quality standard-oriented approach to six sigma implementation and organizational development. The aims of the company to launch ISO 9001:2000 standard by the end of 2004 and six sigma training is expected to support this goal. Although the company – like the second case company – is at the start-up phase, a few conclusions can be drawn from the approach the company selected in order to enhance competitiveness. Even though the company has trained several people in six sigma both on the management level and on the process specialist level, their ability to carry out single development projects is not on the same level as in the first and second case companies presented above. This relates to the HR development and practices for generating know-how, i.e. organizational learning. Despite a successful pilot project execution, organizational learning did not evidently make such a progress as it did in the two above-mentioned case companies. Thus, when aiming to enhance organizational learning the approach taken was not practical enough. This is not to
say that a quality standard-oriented approach cannot create organizational learning. But implementing the six sigma kind of methodology for pursuing easy gains in the development of business operations may not occur fast and effectively enough. It can be stated, however, that quality standards could be applied after an effective deployment of a systematic implementation of strategic development activities.

Results
A common to all three case companies was that they all pursued progress through piloting six sigma projects. They all succeeded in them by generating roughly 200,000 euros net savings per development project on the average.

A few key steps for a procedural implementation process were identified in the case companies. First, top management education and training to understand the core of six sigma methodology. This was organized by two to three day training and through a pilot development project in a particular case company. Second, definition of the organization’s key processes and their measurement. The key measures are aimed to form an integrated and on-time reporting system that supports managerial decision making. Third, the experts and operators were trained by 10 to 20 day training program and through a number of training-related improvement projects. Fourth, the clarity of the roles of different actors involved in the improvement process; actors may play a crucial role in supporting organizational learning and continuous improvement.

As a result, the three case companies are classified by a two-by-two categorization presented in Table I. The companies are categorized by identifying their progress and proceeding in the sense of learning and development. The “criteria” for categorization are maturity and efficiency to carry out development activities. The two criteria refer to the pace and progress, and quality of development efforts (see also Savolainen, 1997). This categorization is only proportional and each company are placed in one of the “boxes”. The case companies started in the low-low category (box 1) before the training period, and were expected to proceed to the advanced-fair category (box 4) through an extensive training program and through practicing (L-b-D) when carrying out six sigma projects. It should be noticed that certain factors, such as top-management commitment and the level of advancement in organizational process management have an influence on the companies’ maturity and efficiency in implementation, and on making progress in a learning process. In the empirical part of this paper, only training is studied.

When comparing the categorization between the case companies, they can be classified as follows. The first case company can be placed in the box 4. This is based on commitment to implementation throughout the organization and on the significant process capability development. The latter led to significant economical benefits by applying six sigma methodology. It can be argued though that they might have gained similar achievements with minor investments in, for example, training. The second case company can be placed in the box 2. This is because of the development of the company’s efficiency to carry out development activities is on a fairly good level – especially regarding the managerial level. But organizational capability, i.e. know-how, is not yet on the level that would be assessed as being effective enough in a practical application of methodology. The third case company, however, is placed in the box 1. The company’s training efforts were oriented to support the quality standard update into ISO9001:2000. But training did not have an effect on a practical level development. The company has not made any major progress after the pilot project in process.
development and in other operational modes. Yet, this company is moving towards more practical implementation of six sigma. Moreover, two projects were launched recently to achieve process improvements and financial benefits.

The implementation process (see Figure 2, a procedural model) in the case companies seems to be a step-by-step process starting with management training and education first, establishing six sigma “infrastructure” next, in other words, a measurement and reporting system, process management, time table. Then it proceeds with organizing roles and responsibilities, and respective training for different levels and roles. The case study findings suggest that this kind of a “by the book” implementation procedure turns out to create learning and support to continuous improvement. The procedural implementation process seems to catalyze learning and push continuous improvement forward. However, this does not yet mean a double-loop type of learning (Argyris and Schön, 1978) or a social view of the learning organization depicted by Easterby-Smith and Araujo (1999).

Conclusions
Based on the case study findings, six sigma implementation seems to reveal mainly technical, single-loop type of learning. It is a problem-based learning process, an incremental change process starting with problem finding and proceeding to producing solutions. The analytical and step-based implementation methodology of six sigma involves structures and procedures that support continuous improvement. Support is shown, for example, the identification of major reasons in the beginning of the process improvement. This can be seen as a built-in type mechanism for single-loop learning at the operational level which facilitates continuous improvement practices.

On the basis of the findings an essential question remains still unanswered: what type of learning is appropriate when organizational performance is enhanced by process improvements in production, delivery processes, etc. and what kind of learning mechanisms are the most supportive to continuous improvement practices? Further research is needed to find out how (if at all) the technical (single-loop) approach develops into social (cultural and political) type of learning enabling sustainable capability development. For researching this a longitudinal case study setting would be required. As this paper has reported on the authors' first exploration, further research is needed to increase understanding of the six sigma approach as an improvement method with detectable learning mechanisms that support CI practices. For further results it is necessary to “dig” in real life practices of six sigma implementation more deeply.

Managerial implications
Finally, the findings imply that managerial commitment is the foundation for improving continuously and creating sustaining learning. Top management needs to define, promote, and launch the six sigma philosophy in the entire organization. The investments in executive training should be made on a continuing basis to overcome crucial barriers. Creating the six sigma council is also recommended. Organizing and resource allocation are some of the key managerial responsibilities. Management should invest in, and allocate resources to staff training in order to promote learning and CI. On the level of operational leadership, the role of the leaders needs to be more clearly defined and leaders should be empowered. The development of information
systems is initially a managerial responsibility. As the ultimate goal is the best possible utilization of existing information in monitoring and decision making, the development of information systems is a necessity for supporting CI structures and for progressive learning. The organization may enhance learning and support to continuous improvement by organizing a forum for knowledge dissemination where successes and failures are shared. Dissemination is seen as essential by many researchers of learning (Kolb et al., 1984, Senge, 1990, Garvin, 1993, Dixon, 1994, among others). Sharing of knowledge would lead the organization towards collective, social learning and a more advanced level of development activities.

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Further reading


About the authors

Taina Savolainen is Finland’s leading expert in quality management. She is Professor of Management and Leadership at the University of Joensuu, Finland. She has previously held Professorships of Quality Management at the Helsinki University of Technology and the University of Oulu. Taina Savolainen specializes in organizational leadership, change and development issues. Her doctoral thesis was a groundbreaking study in Finland and is of international significance. In recognition of Savolainen’s outstanding doctoral thesis she was nominated for the European Award for Theses on TQM by the European Foundation for Quality Management. Prior to taking up her academic appointments, Taina Savolainen has worked for years as a corporate adviser in the regional business service office of the Finnish Ministry of Trade and Industry. She has been extensively involved in management training for both private and public sector organizations, is CEO of TQM Finland Ltd which specializes in quality management training and consulting, and has spoken on managerial leadership and quality management at seminars and conferences around the world. She is the corresponding author and can be contacted at: taina.savolainen@joensuu.fi

Arto Haikonen (Lic.Sc.Tech) is Nordic Black Belt in Genworth Financial, Scandinavia. He has worked as a Unit Manager and Researcher in the Unit of Quality Systems and Methods in the Helsinki University of Technology, Lahti Center. He has a Licentiate degree in Technology and Master’s degree in statistics. He has also participated in and carried out six sigma Black Belt and Champion training by the American Society for Quality. He has been involved in a number of companies as a consultant and trainer to facilitate companies in implementing six sigma and to carry out single improvement projects.

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