Agility in a Small Software Firm: A Sense-and-Respond Analysis

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Abstract
Small software firms are vulnerable to environmental uncertainty. While agile methods and other technologies offer suggestions to address this challenge, we know little about how these firms combine project and firm level capabilities to effectively respond to changes in their environment. On this backdrop, we examine data from a small Danish software firm, TeachTech Inc., through the lens of Haeckel’s sense-and-respond approach. Our analysis suggests that 1) the firm has appropriate sense-and-respond cycles in place, but improving the modularity of processes and the flexibility of human resources could increase its ability to respond faster and more effectively; 2) the firm focuses on specific business goals, but these are not clearly explicated and expressed as governing values to empower employees to respond quickly and in a coordinated fashion; 3) there are complex and demanding challenges related to dynamically reassigning commitments between employees and the supporting mechanisms are insufficient; and 4) some of the most impeding restrictions are leveraged by a useful modularized product portfolio. We conclude the article with a discussion of the implications of these findings for theory and practice.
I. Introduction

Developing successful software in uncertain environments is challenging. Small software firms typically have organic structures suggesting they are sufficiently responsive and flexible to face this challenge. However, they also often rely on niche markets and they are therefore particularly vulnerable to environmental changes. Moreover, due to limited resources, adaptations will likely impact the present allocation (Richardson and Wangenheim, 2007), (Mathiassen and Vainio, 2007). Hence, despite their typical organic structure, managing small software firms successfully in uncertain environments requires capabilities that may be hard to identify and allocate.

Agile software development (www.agilemanifesto.org.) has received a lot of attention since the late 90s and claims to help software firms respond successfully and quickly to change (Cohn, 2006). Many of the current software agility ideas and approaches apply to resource strategies in small software firms (Cockburn and Highsmith, 2001; Boehm & Turner, 2003). Our current knowledge of software agility is, however, mostly limited to the project level to help developers respond more quickly to customer needs, often overlooking the need to bring agility up to an organizational level (Lyytinen & Rose, 2006). This limitation is particular problematic for small software firms (Azar et al., 2007). They need to mobilize resources across the firm and coordinate short-term responses to individual customers with coordinated attempts to maintain a strong market position. Combining knowledge about organizational agility with an interest in small software firms, we therefore focus on how increased agility can be achieved by combining project and firm level capabilities. The research question we are exploring is: How can small software firms combine project and firm level capabilities to successfully navigate in uncertain environments?

To this end, we use the Sense-and-Respond framework developed by Stephan Haeckel (Haeckel, 1995) and the extension of this framework for small software firms suggested by (Mathiassen and Vainio, 2007) as analytic lenses. In terms of research method, the paper is based on a single case study of a small Danish software firm, TeachTech Inc., with approx. 50 employees. Focusing on a specific project and its interactions with the organization, we collected data over a period of one year. The case study followed a qualitative approach with interviews of key persons from the organization and the entire project team. Reviews of
project documents were conducted on site as well as assessments of the different development approaches applied.

In the following, we present the theoretical background both related to software development in uncertain environments and to the principles for sense-and-respond organization suggested by Haeckel. After having elaborated on the adopted research approach, we use the sense-and-respond framework to analyze the empirical data material from TeachTech Inc. Finally, we explicate the insights from the analysis and briefly discuss their implications.

II. Theoretical Background

A. Software Project Agility

In software development, we try to grasp concreteness out of interpretation and perception, thus making uncertainty an aspect which should not be taken lightly. Galbraith defines uncertainty as the amount of information required during task performance relative to the amount of information already processed by the organization (Galbraith, 1973). Changes occur due to instability in any of the task aspects, but their impact is amplified by the associated uncertainty. The consequence of uncertainty caused Brooks to state that software development always will be hard (Brooks, 1987). From these boundary conditions we will review knowledge on software and uncertainty, and the different suggestions for either reducing uncertainty or at least being able to adapt to it.

In (Mathiassen and Stage, 1992) we find a balanced approach to address uncertainty and complexity. This challenge exists independent of the size of both projects and firms. But what situation specific parameters and challenges apply to software projects in small software firms? From (Kelly and Cullerton, 1999) we find that projects in small firms typically involve every team member in most aspects of the process, whereas larger firms typically have a more well defined role delegation. Other small firm characteristics include being responsive, having a flat organic structure, simple coordination mechanisms, an entrepreneur culture, and a niche market position (Daft, 2004).

There has recently been intense focus on handling changes, instability, and uncertainty in software projects. The focus has been streamlined into agile software development practices and values. In (Cockburn and Highsmith, 2001) agility is distilled to ultimately centring on
creating and responding to change. Multiple sources (Larman, 2006), (Fowler, 2005), (www.agilemanifesto.org), describe agility as both welcoming, embracing, and responding to change. Key agile practices are: collocation, close customer collaboration, short iterations with focus on prioritized business value, people orientation, simple design, and refactoring. These practices seek to minimize uncertainty by frequently updating the information held by the involved actors.

Even though there are several approaches to being agile (Abrahamsson et al., 2003), some common characteristics are identified by (Qumer and Henderson-Sellers, 2006). In (Boehn and Turner, 2003) and (Vinekar et al., 2006) we find advice seeking a path relative to the organizational context. The agile ideas are typically adopted by, or related to, the situation of smaller firms as their organic structure and coordination mechanisms fit the agile values rather naturally (Boehm, 2002). As pointed out by (Abrahamsson et al., 2003), most agile approaches target specific situations and utilize only a subset of available disciplines. In (Turk et al., 2002), eleven agile assumptions are investigated and their potential limitations are identified. These considerations are in concordance with (Mathiassen and Vainio, 2007) who reason that identification of mechanisms which strengthen the interaction between project and firm level capabilities are necessary to create sturdy agile software development firms.

B. Small Firm Challenges

Organizational structure plays a crucial role in the effectiveness of value creation. Mintzberg provides an initial understanding of coordination patterns, but also of the unavoidable change every firm experience over time (Mintzberg, 1983). Managing information and knowledge in a changing environment becomes vital to ensuring the continued existence of the firm. Dissonance between structure and knowledge management strategies affects both the process and the output. A knowledge management strategy will influence the different areas in software development; relying on codification to strengthen formal procedures, whereas the less standardized approach taken in personalization supports a more innovative setting necessary to produce creative solutions (Mathiassen and Pourkomeylian, 2003).

Learning is a key factor in knowledge management. (Demarco and Lister, 1999) point to the key question of where, not how learning is achieved. Their research indicates that the
most important learning often happens around middle management. Unfortunately, middle management is typically very limited or nonexistent in small firms as they mostly are organized either as simple structures or adhocracies (Mintzberg, 1983). Due to the size, market situation, and firm context, small firm culture resembles a development culture from (Iivari and Huisman, 2007). Learning is also closely coupled with innovation capabilities, and (Dybå, 2000) discusses how small firms should focus on exploration to improve its competitiveness, a point also elaborated in (Lyytinen & Rose, 2006).

Wernefelt discusses the importance of resource awareness in firms and how their administration deeply influences the firm’s growth and market position (Wernefelt, 1984). A resource can be thought of as either a strength or weakness; but resources are never static and require continuous evaluation. (Teece et al., 1997) define dynamic capabilities as an organization's ability to integrate, build, and reconfigure both internal and external competences to address rapidly changing environments. The coupling between organizational knowledge and dynamic capabilities is further investigated in (Prieto and Easterby-Smith, 2006). In the context of small firms, special characteristics for dynamic capabilities emerge; they become more fluid and simple, further requiring the firm to emphasize continuous knowledge creation and flexible production cycles (Eisenhardt and Martin, 2000). This imposes several management challenges to a small firm, as the organic structure and simple coordination mechanisms (Daft, 2004) require considerable information processing and high degree of accountability between employees (Haeckel, 2003). Finally, in (Strigel, 2007) and (Lumsden, 2007) we find a discussion on small firms targeting specific markets and to what extent they may be hindered by their size.

C. A Sense-and-Respond Approach

Stephan Haeckel’s sense-and-respond framework (Haeckel, 2004), (Haeckel, 2003), (Haeckel, 1999), (Haeckel, 1995) addresses many of the considerations related to organizational agility. In (Overby et al, 2006), a similar framework is devised emphasizing the importance of information technology. (Haeckel, 1995) notes that it has become increasingly difficult for organizations to manage and coordinate the behaviour of empowered units, which is exactly some of the key values touted by software agility proponents. Haeckel points to increasing decentralization and the importance of swiftness as
a problem for any organization of a certain size. Both internal and external synergy becomes increasingly important, as organizational structure generally becomes more fluid.

Two common traits are recognizable for firms capable of surviving in turbulent environments; they are capable of responding to both anticipated and unexpected changes in proper ways and due time; and they adapt faster than their opponents. Haeckel’s sense and response framework makes the following assumptions about adaptive firms:

1. **Strategy**: should be based on creating and developing mechanisms that enable responses to change rather than on planning specific goal oriented actions.
2. **Structure**: should consist of dynamic networks of modular collaborative capabilities rather than static hierarchies of tasks and responsibilities.
3. **Governance**: should be achieved through coordination based on shared values and information rather than dedicated command and control activities.

A firm’s response-ability depends on the fitness of its sense-and-respond cycles depicted in Figure 1 (Haeckel, 1999). This cyclic behaviour illustrates the ongoing interaction between a firm and its environment. After sensing changes in relevant environments, interpretation takes place based on many individual variables. Interpretation builds the groundwork for decision making which leads to actions. Thus a sense-and-respond firm continuously iterates through several of these cycles, sensing change and responding to it.

![Figure 1](image)

So, how do organizations enable and coordinate actions in a coherent and effective manner? Haeckel proposes to adopt systemic management on the firm level through four principles for an adaptive enterprise:
Processes that learn; this principle adopts the cycle described from Figure 1 on every level in the firm. Learning involves every aspect of the firm’s activities and processes.

Value based governance; sound governance principles enable coordination across sense-and-respond cycles by letting the employees independently identify what needs to be done, and how to do it.

Dynamic personal accountabilities; all processes have two dimensions: accountability and procedure. When accountabilities are defined, we know who owes what to whom and by when. Procedure, in contrast, informs us about what needs to be done to what and with what. In order to obtain dynamic allocation, firms must ensure that commitments between both employees and customers are easily created and recreated.

Modular processes and products; as a firm moves from pure make-and-sell to sense-and-respond, its processes and products must be transformed to be easily customized for different situations at the same price as the cost of deploying make-and-sell products.

Haeckel’s framework applies to most generic situations and firms. But (Mathiassen and Vainio, 2007) offer five principles derived from Haeckel and specifically aimed at small software firms. These are:

Cultivate external relationships; as small software firms have limited resources, their limited abilities can be leveraged by cultivating external relationships.

Distribute sense-and-respond cycles; engaging more people in its sense-and-respond cycles increases a small firm’s capability to quickly sense-and-respond to changes. This requires both flexibility and a systematic approach on all levels.

Ensure firm-level coordination; without proper coordination and integration of distributed sense-and-respond cycles and the cultivation of external relationships, these activities are wasted. So to ensure coordination, both management and employees must be aware of the overall purpose of the firm, the culture and governing principles.

Leverage component-based architectures; high quality and appropriate modularization of architectures further leverage the limited resources in a small software firm. But without
proper dynamic capabilities to adjust and use the strength of component-based architectures, the advantage is lost.

*Balance standardization and customization:* because it is difficult to develop a market oriented strategy from standardized components alone, continuous attention to balance standardization and customization of the firm’s product portfolio is needed.

These general and specific principles form the theoretical foundation for this article and will be the lenses through which we study the case. Haeckel’s framework constitutes a generic framing for investigating the survival skills of firms, and the extension devised by Mathiassen & Vainio promotes its applicability as an analytical tool for small software firms.

### III. Research Method

A. Case presentation

Our argument is based on a case study of *TeachTech Inc.*, a small software firm in Denmark. *TeachTech Inc.* is in a transition period as it seeks to standardize its processes and structure both due to growth in market share, product complexity, and organizational size. *TeachTech Inc.* generates income from several sources; retail of third party applications, pedagogical applications and solutions developed by *TeachTech Inc.*, and from support services.

B. Case study structure

We designed the case study following the advice given in (Yin, 1994) with primary focus on a specific project within *TeachTech Inc.* aiming to release the next version of a key product, WriteHelp. The case study spanned 12 months and consisted of qualitative interviews with the managing director, the development department director, the project leader, and project team members. Data were collected using interviews based on an interview guide following advice from (Kvale, 1997). The interviews were recorded, summarized and approved by each individual participant. Furthermore, project status meetings were observed during the last half of the case study, and project documents and tools were reviewed on site. Interactions between the external environment and the firm
were investigated by reviewing customer newsletters published by the case study organization.

C. Research data approach

Data were primarily analysed through the sense-and-respond framework extension proposed in (Mathiassen and Vainio, 2007). With this as an offset, we analyzed TeachTech Inc.’s capabilities. This involved the firm level and the project level as we focused on the WriteHelp project. For each principle, we noted interactions between the firm level and the WriteHelp project. In addition, the data analysis followed the strategies found in (Yin, 1994) emphasizing the research question defined earlier. The perspectives we applied are summarized in Table 1.

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Perspectives</th>
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</thead>
<tbody>
<tr>
<td>Sense-and-Respond principles for small software firms</td>
<td></td>
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<td>Sense-and-Respond cycles</td>
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<td>Adaptive Enterprise Principles</td>
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**Table 1: Data analysis perspectives**

In the analysis, we looked at the case data from the five principles identified by (Mathiassen and Vainio, 2007) while at the same time relating them to Haeckel’s general principles. To that end, we applied the mapping between Mathiassen & Vainio’s principles and Haeckel’s summarized in Table 2:

<table>
<thead>
<tr>
<th>Mathiassen &amp; Vainio</th>
<th>Haeckel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribute Sense-and-Respond cycles</td>
<td>Processes that learn</td>
</tr>
<tr>
<td>Cultivate external relationships</td>
<td>Processes that learn</td>
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<tr>
<td>Ensure firm-level coordination</td>
<td>Value based governance</td>
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<tr>
<td>Leverage component based architecture</td>
<td>Personal dynamic accountabilities</td>
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<tr>
<td>Balance standardization and customization</td>
<td>Modular processes and products</td>
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</tbody>
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**Table 2: Relation between Specific and General Principles**
We validated our data by having them reviewed by each participant, approving quotations and references. Applying a soft systems exploration (Checkland and Scholes, 1999; Frederiksen and Mathiassen 2005) of the problem domain helped us understand the case context better. Application of the theoretical framework was ratified by the participation of one the framework authors in this article.

IV. Research Context

Our case study revolves around TeachTech Inc., a small firm with approx. 50 employees, 12 of whom work in the development department. Originally a municipal company, the firm was privatized in the early 90s and is today owned by the managing director. The firm was originally both a development and sales organization, but outsourced development in the mid-90s. After a couple of years it was apparent that this model did not work out, so management decided to reinstate a development department. Software development now plays an increasingly important role within the firm, as profit share from in-house products grows. Recently this lead to a recognized need to standardize business and development processes, one of the first steps on this journey being introduction of a project model built upon the Unified Process. The firm is managed by two groups; the Strategy Group which consists of regional directors, and the Coordination Group where selected employees with management responsibilities take part. The Strategy Group meets on a monthly basis to conceive new business ideas and steers the firm’s strategic goals. The Coordination Group functions as the daily operational resource and project coordinator.

TeachTech Inc. specialises in producing educational and learning software for public schools and other educational institutions. A subset of the products also targets other markets as they are categorized as helping utility applications for dyslexics. The market is typically serviced through licenses running over several years in product packages containing a fixed number of products. Several competing organizations exist, but during the last couple of years TeachTech Inc. seems to accelerate away from these, both in product and market share dimensions.

Our case study observed the WriteHelp project which seeks to produce the next release of WriteHelp. The project team consists of nine members, four of these are developers. This product is a corner stone in TeachTech Inc.’s portfolio, and one of the few products regarded as a utility application. WriteHelp is a writing aid providing users with context-based and
phonetic word suggestions. The application is closely integrated with the residing Windows platform.

V. Sense-and-Respond Principle Analysis

We use the five principles identified by (Mathiassen and Vainio, 2007) to analyse TeachTech Inc. from both a firm and a project level, looking at how the two levels interact.

Distribute Sense-and-Respond cycles

Firm level

Business development cycle

To keep business healthy, management has deployed several activities and initiatives to sense customer needs and market trends. Through the consultancy department, both sales and pedagogical consultants participate in gathering information to the Strategy Group. The initiative to start new product development and in other ways strengthen the competitive position is then taken by the Strategy Group. Other improvement steps may include strengthening network connections or introducing existing products to new markets. Overall, this sense-and-respond cycle is crucial as it ensures organizational coherence by actions which may affect all departments and the overall market position. The high level of participation strengthens the cycle and makes it more resilient, but as the governing principles are primarily implicitly defined this may also cause uncertainty in different parts of the process.

Product management cycle

The life cycle of a product from TeachTech Inc. involves many sense-and-respond characteristics, which enable continued customer satisfaction and portfolio consistency. When a product has been released to customers, it becomes associated with a product specialist who takes overall responsibility for sensing feedback, problems, and opinions related to the product. This feedback is gathered through focus group information, customer support, reported bugs, and surveys. By ensuring a high number of feedback interfaces, TeachTech Inc. continues to emphasize a highly distributed sense-and-respond cycle approach. The information is interpreted based on criticality, impact, and scope. The product specialist decides what action should be taken, but does not carry them out individually.
Generally, TeachTech Inc. delegates responsibility to each product specialist, which may present a risk as the level of dynamic personal accountabilities are not correspondingly high.

**Human resource cycle**

Managing projects, products, people and resources in TeachTech Inc. require skills and sensitivity, not only because there are many business domains to consider, but also because of the diversity in the employees’ professional background. The primary actor in this cycle is the Coordination Group, supplemented by product specialists and project leaders. Sensing is done through feedback mechanisms from project leaders, who regularly report back in written form, and from the product specialists on an ad-hoc basis. The ability to interpret these signals rests on combined skills of the group members. This structure facilitates that decisions are made where the relevant information is available. Decision making must take several aspects into account; individual project and product priority, time schedule, personal qualifications, and project leader competencies. It also needs to be in accordance with the strategic goals set by the Strategy Group. The decision making process primarily impacts personnel and project issues as reallocation of resources causes ripple effects throughout the firm. Overcoming these dependencies is difficult as the number of projects and products outnumber the number of developers.

**Project level**

**Requirements cycle**

There are three sources of requirements for the WriteHelp application; customer requests, competitive features, and third party application compatibility issues. Product requirements are gathered from the different customer groups associated with TeachTech Inc., plus focus and test groups. As the WriteHelp project builds upon previous releases, requirements are also gathered from feedback on the existing release. The product specialist senses and evaluates similar competing programs and interprets whether or not these pose recognizable business threats on future releases. Sensing customer requirements concerning third party applications impacts the project, and couples it closely to the technology cycle, which we review shortly. In the WriteHelp project, one person covers the roles as product specialist and pedagogical consultant and this person is therefore the primary responsible for interpreting sensed information. If there are technical issues to be considered, interpretation and evaluation of the issue will be delegated to a developer. Decisional power is typically
shared, but pedagogical and sales consultants claim the right to press decisions through, although it is rarely enforced. Due to the domain experience most developers have gained, they have created governance principles to guide their choices during implementation with quality assurance playing a coordinating role. The sense-and-respond cycle spans most of the project life cycle, as implementation occurs throughout the project. Although the ongoing sensing keeps the project in sync with external changes, it also introduces continuous change to requirements slowing project momentum down.

Technology cycle

As the WriteHelp application integrates with several other applications and the operating system, technology is an important element to observe through the project as these external factors are uncontrollable. Project team members with technological responsibilities each monitor the platforms and tools they are involved with and sense changes. Their expertise enables them to interpret the impact a technological change could have on WriteHelps modules. Depending on the impact’s severity, action is either taken by the individual developer or by the group. If the change influences future possibilities of the product, the decision is passed onto the product specialist and the Strategy Group. Again, there is a lack of dynamic personal accountabilities, as developers are locked into certain positions by being responsible for specific technical areas.

Process cycle

The Write Help project is one of a few pilot projects in TeachTech Inc. ’s path to process standardization. WriteHelp’s project leader holds primary responsibility for sensing task and overall project progress. This requires involvement from all team members since there is very little overlap in task assignments; each team member therefore holds some level of feedback responsibility to the project leader. As the project is still underway, it is difficult to state the complete impact of the process standardization model; but one developer expressed the following about the present situation:

“The project does not run faster now we have a dedicated project leader, but it seems to be better administrated and we know who to address when we have problems. ”

This indicates that the introduction of a formal project leader has improved the level of accountabilities and procedures in the firm, but not that it has become more dynamic. As
sensing is distributed in the project group, so is interpretation of information. During project status meetings held once or twice a month, each member evaluates status and risks in cooperation with the project leader. Proper action is taken by the project group if deemed necessary; these actions primarily address critical chain issues or implementation situations. Feature issues, especially high priority, are delegated to the Strategy Group. This loop provides milestone and status feedback on a regular basis to the Coordination Group.

**Firm-Project level interactions**

Interactions between the two levels primarily happen with the WriteHelp application as the interface. Especially through the prioritized feature set, the Strategic Group several times caused confusion and frustration over compatibility issues related to an open source application suite. Actions are mostly initiated from the firm level toward the project level based on feature and application decision. But feedback from the project level may cause reconsideration at the firm level.

The developers tend to feel there are two organizations within the firm, the development department with its technical culture, and most of the remaining organization with its more pedagogical, humanistic culture. Organizational culture mix is a product of the combination of developers, sales people, pedagogical consultants, and former teachers. All team members express satisfaction with their current group and have to some extent overcome the cultural barriers, and mutual understanding and respect are high. Team members appear focused on the importance of structuring the project in a synergizing way as pointed out by a team member:

“In our project, we are very aware of the importance of processes, and also to invent processes when there is none available which fits our situation. The organization wants processes; they just are not as defined and concrete as we need them.”

The initiators of process improvement, favour letting the project model emerge from different parts of the firm to avoid the sense of having the model enforced top-down. This indicates a reliance on governance principles, which may be very differently perceived by the different organizational parts.

* Cultivate External Relationships

**Firm level**
The most important relationships to *TeachTech Inc.* are the customers, partner firms, and regional offices. Even though several government bodies may impose a high degree of market change risk, influencing high level market forces is difficult. This is countered by establishing good customer relationships. Cultivation of customer relationships is accomplished through several means and learning cycles. *TeachTech Inc.* provides customers with a wide range of product solutions and services. These services include; personal networking opportunities, application courses, and a broad set of tools and support options. This approach leverages the limited resources in *TeachTech Inc.*, as they transform customer relationships from being just a supplier, to being a partner in education. The close customer contact and high market penetration motivates partner firms, whose products are sold by *TeachTech Inc.*, to deepen their engagement with the firm. Regional departments and partner firms are cultivated by involving them in activities within the firm. Through product diversification, *TeachTech Inc.* provides their regional departments with strong tools for market penetration. The high degree of external interactions and the closeness of relationships, enable learning both in *TeachTech Inc.* but also at its partners.

**Project level**

The WriteHelp project team has several external learning interfaces, mainly through sales and the pedagogical consultant. Their purpose is partly to provide updated information about the customers they serve and the required application functionality. Some of the project members participate in communication with regional departments, as WriteHelp is going to be released in several markets shortly in different versions. Therefore developers participate in technical cooperation issues related to the application architecture. Although the external application contacts can introduce the project to unfiltered noise, they also couple development closely to the actual sources of information, something that should strengthen the project group’s position and arguments with both the Strategy and the Coordination Group.

**Firm-Project level interactions**

Contact with external relationships has been distributed throughout *TeachTech Inc.*, ensuring that people with proper competences handle information and learning. Because contact affects relationships, it is important to ensure that this happens to a satisfactory degree and according to firm strategies. This requires both well-functioning sense-and-respond cycles and governance rules. Integration with an open sourced application suite also
caused concerns in the Strategy Group on how such a move would be interpreted by existing third party application providers. Because many customers use the retail applications offered by third party firms, TeachTech Inc. must find a balanced approach between maintaining independence and flexibility in their own product portfolio and projects. Partner firms thus become both an enabler and a potential barrier to TeachTech Inc.

Ensure firm-level coordination

Firm level

TeachTech Inc.’s reason for being, although not explicitly defined, is well recognized by its employees: TeachTech Inc. produces high quality IT-based solutions that supports users with reading and writing problems and enhances their learning capabilities. The sharing of this vision reveals itself through the awareness and pride project team members have in their product, as stated by TeachTech Inc.’s managing director:

“It is very costly to hire new people, especially in the development department. The process of learning to understand the communication which takes place between our consultancy and development department is very important, but takes time. That is why it is crucial that employees feel they are contributing to something important.”

On a more detailed level, there are no explicit governance values that can help employees make decisions. However, the different types of professionalism in TeachTech Inc., e.g. pedagogic, IT, and sales, create a comprehensive basis for making judgments and decisions about solutions and emerging problems. As many important issues in TeachTech Inc. span several professions, it is important to constantly coordinate decisions across groups. This coordination takes place through ad-hoc discussions and is supported by having key people represented in the Coordination Group.

Dynamic personal accountability, i.e. the capability to dynamically assign and reassign individuals throughout the firm, is quite important because TeachTech Inc. supports more than 20 different IT-based solutions based on a group of approximately ten developers. There are different degrees of dynamics related to each solution, but it is basically a very complex and demanding challenge to assign and reassign developers to both maintenance tasks and development projects. Today, this challenge is mainly addressed by having each developer at a given point in time assigned to several tasks and more than one project. Resources are then re-allocated, not by reassigning people, but mainly by modifying the
percentage of time each person spends on different tasks. The extensive multitasking that results from this set-up causes some frustration amongst employees:

“I would like to have fewer tasks than I in reality have. Just being able to concentrate on a single task at a time would complete them sooner. I am flexible, but the situation is not optimal.”

**Project level**

Coordination within the WriteHelp project is the prime responsibility of the project leader. Several tools and mechanisms are deployed to achieve this. Physical coordination takes place through status meetings and one-on-one’s between group members. Coordination through Information Technology utilizes email, a bug reporting system, and an internal project information web specifying personal accountabilities. The codification of knowledge, which these tools offer, does to some extent provide a better foundation for increased dynamic accountabilities. As mentioned earlier, there is very limited responsibility overlap and sharing, effectively tying individual team members tightly to their expertise domain.

**Firm-Project level interactions**

Management acknowledges the risks tied to the high level of personalized knowledge and expertise present in the WriteHelp project group. It is therefore a management goal to move towards a project and work structure which is less dependent on individuals, although this will require major shifts in how both implicit and explicit knowledge is handled. The establishment of formal project leaders marked a decision to relieve the development manager from much of his monitoring and control tasks.

**Leverage component-based architectures**

**Firm level**

The license model obligates *TeachTech Inc.* to release a number of new products or versions annually, but *TeachTech Inc.* has maintained flexibility to reconfigure the annual combination of products provided by the primary license agreement. Several other license agreements are offered by *TeachTech Inc.*, with some shared dependencies. Modularization of products thus allows *TeachTech Inc.* to provide better market coverage. Business function
modularization is high as every department in TeachTech Inc. plays a separate role in providing customers with solutions.

**Project level**

Increasing product complexity from added features and third party compatibility requirements, make a component based architecture a necessity. This was already dealt with in the previous release of WriteHelp, but continues to require consideration and resources. As an example, WriteHelp’s project leader devised a new test strategy. Previously testing was performed primarily during the final phases of the project, but by request from both testers and developers, the project leader constructed an iterative test plan which both relieved the test department, but also ensured better test case construction and leveraged resources in several departments and projects. Conceptual quality assurance was previously done by an internal consultant group, but this group was dissolved as it mainly generated overlap and duplicate communication channels. The unfortunate result was that the project team became uncertain of who had actual quality assurance responsibility. Accountabilities suffered, at least for a transition period, and project team members automatically started picking up the pieces they could best relate to. Overall, however, the increased focus on process seemed to leverage the growing size of compatibility tasks and issues.

**Firm-Project level interactions**

The success of WriteHelp motivates management to explore several new markets. But this decision may also have been one of the reasons why the WriteHelp project had to postpone its deadline as it drained an already heavily loaded project team. In this case, firm-level leverage had an adverse effect on the WriteHelp project, which then found the necessary flexibility in the process to move tasks around as suitable. Organizational learning processes became especially clear during the structuring of the new test strategy, where WriteHelp’s pilot project status on the new project model provided improvement input to the entire firm.

**Balance standardization and customization**

**Firm level**

Customization is market based, but a subset of the product portfolio is localized and is not easily customized. The remaining products are customized to the individual market
segments. *TeachTech Inc.* takes a proactive approach towards its customers through established learning processes, identifying different market segments and their specific needs. Even though products are not always customized, customer solutions are flexible as *TeachTech Inc.* offers a broad range of opportunities via its modular product portfolio. Over the last couple of years, the percentage of *TeachTech Inc.*’s annual turnover generated from their own products has doubled, now covering 40% of the total. So even though retail of third party products still amounts to a considerable portion, the relative income from in-house products are much higher, showing *TeachTech Inc.*’s evolution from being mainly a sales firm to being more development oriented. But without clear governance principles, the almost equal division between sales and development orientation may cause confusion and an unclear market position.

**Project level**

As WriteHelp has existed for several years in previous releases, the decision to diversify the products for each regional market, has forced the project team to take several architectural heritage aspects into consideration during the life cycle. Unfortunately, the lack of dynamic personal accountabilities drained the project for resources as only the existing project team was capable of adapting the product. But the addition of an external developer with a professional background in linguistics, although initially difficult to get up to pace, has reduced the workload on other key developers and ongoing work to modularize WriteHelp’s architecture and component dependencies will leverage future challenges and requests.

**Firm-Project level interactions**

*TeachTech Inc.* has secured its position on the market, but continues to sense and interpret competitive movements and other market influencing trends. The strategic balance between standardization and customization done on a customer segment basis, appears reasonable considering the size of *TeachTech Inc.* and its limited resources. Several departments can operate relatively independent of typical competitive conditions due to the license agreement model. This is probably one of reasons why personnel turnover is very low, even though neither pay nor extra benefits exceed average levels. Hence firm level modularity enables existing strengths, and coordination secures them.
VI. VI. Discussion

Emerging from the analysis are both strengths and potential problems within TeachTech Inc. As we have observed a single project, some of the following considerations may not apply to other TeachTech Inc. projects. Reviewing the findings based on Haeckel’s four principles yields Table 3.

<table>
<thead>
<tr>
<th>Processes that learn</th>
<th>Value Based Governance</th>
<th>Dynamic Personal Accountabilities</th>
<th>Modular Processes and Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strengths</td>
<td>Weaknesses</td>
<td>Strengths</td>
<td>Weaknesses</td>
</tr>
<tr>
<td>Strong external learning cycles. High distribution of cycles.</td>
<td>Key personnel dependencies. Undefined knowledge management strategies.</td>
<td>Project members are included directly in product learning cycle</td>
<td>Project team has developed a sense of product governance principles.</td>
</tr>
<tr>
<td>Weaknesses</td>
<td></td>
<td>Weaknesses</td>
<td></td>
</tr>
<tr>
<td>Mismatch in values could destabilize the ongoing process improvement. Initiative.</td>
<td>IT is increasingly used to coordinate actions and share knowledge.</td>
<td>When organizational changes occur, uncertainty could have been avoided by clearer principles.</td>
<td>Even though there may be different interpretations, both levels desire the same goal.</td>
</tr>
<tr>
<td>Firm level</td>
<td>Level interactions</td>
<td>Project level</td>
<td></td>
</tr>
<tr>
<td>Strengths</td>
<td></td>
<td>Strengths</td>
<td>Weaknesses</td>
</tr>
<tr>
<td>Strong Reason for Being as all employees view their job as meaningful.</td>
<td>Only implicitly defined, letting culture influence perception.</td>
<td>Project team has developed a sense of product governance principles.</td>
<td>A broad range of IT tools ensure coordination and a degree of knowledge management.</td>
</tr>
<tr>
<td>Weaknesses</td>
<td></td>
<td>Weaknesses</td>
<td></td>
</tr>
<tr>
<td>Cultural still impacts perception and decision making.</td>
<td>Only implicitly defined, letting culture influence perception.</td>
<td>Project team has developed a sense of product governance principles.</td>
<td>The new project model helped define accountabilities.</td>
</tr>
<tr>
<td>Resources are scarce and not dynamic enough.</td>
<td>Resources are scarce and not dynamic enough.</td>
<td>All changes to the project must be handled by a limited set of resources.</td>
<td>High dependence on specific human resources.</td>
</tr>
<tr>
<td>Limited development of products.</td>
<td>Processes are adaptable.</td>
<td>Processes are adaptable.</td>
<td>Modularity ensures value generation in all departments.</td>
</tr>
<tr>
<td>Strengths</td>
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<td>Level interactions</td>
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<tr>
<td>Value Based Governance</td>
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</tr>
<tr>
<td>Strengths</td>
<td></td>
<td>Strengths</td>
<td>Weaknesses</td>
</tr>
<tr>
<td>High modularity of products.</td>
<td>Both Procedures &amp; Accountabilities are established. Solid coordination mechanisms exist.</td>
<td>High modularity of products.</td>
<td>Mismatch between high modularity and limited resources.</td>
</tr>
<tr>
<td>Weaknesses</td>
<td></td>
<td>Weaknesses</td>
<td></td>
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<td>Limited development of products.</td>
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</tr>
</tbody>
</table>

Table 3 Key Findings According to Haeckel’s Principles

The firm has strong learning mechanisms and is capable of sensing changes and responding to them; furthermore it has constructed its product portfolio in a suitable modular way and is undertaking actions to modularize its processes accordingly. Reading through the analysis highlights certain areas as strengths:

- **Customer Relationships; TeachTech Inc.** has extensive and strong capabilities in place to manage customer relations, and has consequently achieved a synergetic position as a partner in learning. They cultivate a network of partnering firms and institutions, and this network serves as an important mechanism to sense changes, interpret them, and discuss and explore possible new directions.

- **Broad Product Portfolio; TeachTech Inc.** has a broad and relatively well structured product portfolio. This makes the firm less vulnerable towards market changes. At the same time, the product portfolio offers customization to meet particular customer needs. Even though the division between being a sales and a development firm still exists, the joined capabilities of these two departments help ensure a strong market position with barriers for competing firms.

- **TeachTech Inc. ‘s implicit Reason for Being;** this is a strength although we assess the governing principles as a possible weakness. The reason for being is presumably one
of the key factors in the high level of job satisfaction most employees express. *TeachTech Inc.*’s culture is strong and shared between its members. The focus is on creating new ways for communication and learning; this strongly motivates members of the firm and helps them focus attention and coordinate efforts.

The two remaining of Haeckel’s principles we identified as being weaker in *TeachTech Inc.*, i.e. is how they manage value based governance and personal dynamic accountabilities:

- **Improvement of Dynamic Personal Accountabilities** may greatly improve the flexibility of the firm. To achieve this requires emphasis on knowledge management to both ensure continued business awareness, but also to improve learning cycles, an important step in building a more dynamic organization. Improvements in dynamic personal accountabilities will leverage the strain imposed by limited resources. Procedures are improved by the ongoing work to standardize the project model, but it is important that accountability is taken equally into consideration.

- **Increased focus on Value Based Governance.** There is a tacit presence of governing principles in *TeachTech Inc.*, and there is a rather clear, although not standardized, governance model. But paying more attention the governing principles could improve the agility of projects and their teams as it supports dynamic personal accountabilities. Because of the cultural differences within *TeachTech Inc.* we recommend that governing principles are made explicit and that every department inherits the firm level principles and customizes them to their specific context while still ensuring overall coherence.

Concerning agile practices and values, *TeachTech Inc.* already exercise some agile traits like requirements prioritization, mutual team adjustment, and estimation. But neither the firm nor the project could probably cope with the transparency and empowerment an all-in agile transformation would impose.

### VII. Conclusion

Our analysis of *TeachTech Inc.*, based on Mathiassen & Vainio’s extension to Haeckel’s principles, identified both strengths and weaknesses in the firm. These can be viewed as enablers and barriers in the firm’s struggle to persist and maintain a market leading position. The analysis was completed by extracting key findings and identifying them according to Haeckel’s four principles.
As we assess our research question on how small software organizations can combine project and firm level capabilities to successfully navigate in uncertain environments it is evident that TeachTech Inc. could utilize the capabilities and resources better on both levels by focusing more on value based governance and dynamic personal accountabilities. Doing so would boost both internal and external relationships, as well as facilitate better exploitation of knowledge. We identified three sense-and-respond cycles on both project and firm levels, all with the potential to be generic across small software firms.

This article has, hence, brought us one step closer to defining a context specific sense-and-respond framework which can be applied to small software firms to gain an understanding of the learning cycles and dynamic capabilities which are so important to ensure a firm’s survival in uncertain environments. The case documented that Mathiassen and Vainio’s principles are helpful as an extension to Haeckel’s framework. While the principles provided ample means to assess and analyse TeachTech Inc., more research is required to further validate and legitimize the expanded sense-and-respond framework.

VIII. Acknowledgements

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