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Information Systems for Organizational Agility: Action Research on Resource Scheduling at the Universidad de Chile

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Organizations need to exhibit characteristics of agility to stay ahead of their competitors and to survive in dynamic environments. One major concern for organizations is how to implement Information Systems (ISs) to enhance their agility. Organizations tend to spend too many resources to change their entire IS instead of only the components that cause problems without exactly knowing whether it enables or suppress organizational agility. To address these shortcomings and practical issues, we provide a framework to assess organizational agility and to diagnose a problem related to IS. By applying this prototype of the *Agility Framework*, we were able to diagnose a problem that the department of Management Control and Information Systems at the Universidad de Chile had and planned actions for them to improve its organizational agility with a course scheduling system, eClasSkeduler. This action research, which took more than 25-month for the first cycle, further develops the *Agility Framework*, which not only provides a way to link IS with organizational functions but also illustrates how to use it to diagnose a situation and plan actions for improving organizational agility through an information system.

Keywords : Organizational agility, Information Systems, E-scheduling, Action Research

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Ⅰ. Introduction

Organizations are made up of resources (assets) and processes (capabilities) [Leonard-Barton, 1992; Winter, 1987] that need to be adjusted constantly as fast as possible to survive in competitive environments [Volberda, 1996]. The challenge is to have the right resources and processes for present and future market conditions [Tushman and O'Reilly-III, 1996; Tushman and O'Reilly-III, 1997]. Moreover, an organization needs to be agile in how it acquires and keeps its resources up to date as well as in how to operate structures and processes that allow it to react to changes. The abilities to anticipate change, to marshal resources, and to react successfully to unanticipated events are how an agile organization will differentiate itself in the marketplace and build competitive advantages [Ashrafi *et al*., 2005].

Information Systems (ISs) have been identified as an important factor that shapes organizational abilities, including agility, by speeding up communications and, in particular, processing and analyzing data [Boudreau and Robey, 1996; Robey *et al*., 2002]. Although much research has revealed how a particular technology contributes in improving a specific function such as information retrieval and knowledge management [e.g., Phillips-Wren and Forgionne, 2006], an IS is assumed to be "a stable, settled artifact that can be passed from hand to hand and used as is, by anyone, anytime, and anywhere" without observing what or how each element is used [Orlikowski and Iacono, 2001], which is key to analyzing and explaining how an IS can enable or limit organizational capabilities.

We see ISs as one of the pillars supporting an organization and generating competitive advantages, instead of an independent and reactive object [Morris and McManus, 2002]. An organization consists of many elements that depend on the performance of each other and on the capabilities that arrange the elements. In this view, ISs are one element that affects tangible and intangible parts of the organization [Latour, 1987; Orlikowski, 2007]. Thus, inappropriate ISs can impact the overall performance of an organization. If we assume an IS is a black box, the diagnosis for a rigid organization might be "you have a problem with your IS," but if we consider the components of IS and evaluate the impact of each component on the overall agility, we may be able to provide a more precise diagnosis.

In financial and operational perspectives, it is too costly to change the whole IS whenever there is a problem. The replacement of the whole IS is not necessary for all problems. If an organization can diagnose an exact problem related to its IS, agility can be improved with minimum effort, cost, and risk [Verstraete, 2004]. Organizations can use this concept not only for problem solving but also for prevention. Beyond embracing changes, agility is about aggressively creating changes-creating new markets, new business processes, and new organization structures [Goldman *et al*., 1994]. As Truex *et al*. [1999] point out that the continuous improvement of an IS is significant for organizational capability, organizations should examine their IS continuously to find weaknesses and improve organizational agility. Then the question is how to find and diagnose a problem relevant to ISs in the context of organizational agility.

This paper provides a way to link ISs to organizational agility through the action research method.

A conflicting situation that the Department of Management Control and Information Systems (DMCIS) at the Universidad de Chile faced was analyzed and diagnosed, actions were planned to develop and implement eClasSkeduler, a course scheduling application for its main business unit, and the organizational agility before and after the implementation was evaluated by applying the *Agility Framework*. This research contributes in identifying how ISs are related organizational functions and structures, which has been a shortcoming in IS and organizational studies [Orlikowski and Iacono, 2001, Zammuto *et al*., 2007], and illustrating a way to relate ISs with organizational functions. Furthermore, we demonstrated how researchers could apply the theoretical framework to assist organizations in gaining their organizational agility through the improvement of IS capabilities.

First, we propose a theoretical framework based on literature to reveal the relationship between as IS and organization. This framework breaks down the components of the IS in relation to organizational agility by showing how each IS component contributes to enhancing or suppressing organizational agility. Second, we introduce the method of action research, including evaluation criteria and data collection. Third, we explain the background of the case before performing the action research. Fourth, we apply the proposed framework to this case through the action research cycle. Fifth, we conclude with the theoretical and practical implications of this study and directions of future research.

Ⅱ. Literature Review

Although Orlikowski and Iacono [2001] encourage researchers to focus on studying Information Technology (IT) artifacts by proposing five views to conceptualize IT: 1) the tool view, 2) the proxy view, 3) the ensemble view, 4) the computational view, and 5) the nominal view, there are few studies [e.g., Doherty *et al*., 2006; Limayem *et al*., 2006] that systematically analyze ISs within an organizational context. Among the five views, the *Ensemble view* suggests one way to examine how the components of the IS are related to organizational functions, structure, and performance because it is a perspective that considers technology as one of the elements within an organization performing socio-economic activities. There are other elements such as human resources, policies and organizational structure that are intertwined with technology in forming an organization and performing its activities. Although the proposed framework can be applied to find a relationship between these elements and organizational agility, we focus on the IS element in this paper, because ISs can be significant barriers for organizations to be agile if they are not properly assessed [Seo and La Paz, 2008].

The concern about the lack of understanding of information systems has been shared in the field of organizational studies. Zammuto *et al*. [2007] indicate that research on organizational forms and functions has not considered or incorporated IT, even though IT has been indispensable for organizations since the 1990s. Zammuto *et al*. propose five ways to conceptualize the relationship between IT and organizations: 1) visualizing entire work processes, 2) real-time/flexible product and service innovation, 3) virtual collaboration, 4) mass collaboration, and 5) simulation/synthetic reality. In agreement with Orlikowski and Iacono [2001],

Zammuto *et al*. [2007] strongly encourage researchers to understand and analyze the intersection of technology and organizational features and to simultaneously unveil the relationship between IT and organization.

To understand and analyze an IS within the context of an organization, we base our perspective on the *Ensemble view* of Orlikowski and Iacono [2001] and a suggestion of Zammuto *et al*. [2007]: *real-time/flexible product and service innovation*. We believe that the *Ensemble view* is the most appropriate perspective to understand the relationship between the organization and the IS and to analyze the influence of the IS on organizational functions, structure, and performance, as it recognizes the intertwined relationship between the organization and the IS. The reason we take the suggestion of *real-time/flexible product and service innovation* is that a particular way of thinking emphasizes the organizational ability to create or align IS components in a new and innovative way, which is one of most significant organizational capabilities to survive in highly competitive markets. As a part of the organization, the ISs can positively help the organization to be agile or negatively suppress its agility [Seo and La Paz, 2008].

2.1 Agility

Meyer [2001] emphasizes that today's organizations need to "make decisions fast, change direction nimbly, and figure out when to enter and exit markets." Ashrafi *et al*. [2005] recognize that "operational agility is a catalyst to enforce quality, cost effectiveness, and delivery, thereby meeting organizational objectives." By the same token, a rigid company cannot satisfy its customer's desires for value, quality, responsiveness and support when providing goods and services.

Ashrafi *et al*. [2005] synthesize the concepts of absorptive capacity and dynamic capabilities in a framework for implementing agility through knowledge management systems, claiming a cause-effect relationship between knowledge management and organizational agility. The absorptive capacity, coined by Cohen and Levinthal [1990], is defined as "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends." Eisenhardt and Martin [2000] assert that dynamic capabilities are "processes that integrate, reconfigure, gain, and release resources to match and even create market change" and that those processes can be understood as "organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve, and die."

In the context of agile manufacturing, agility refers to "the nimbleness of a company to quickly assemble its technology, employees, and management via a communication and information infrastructure in a deliberate, effective, and coordinated response to changing customer demands in a market environment of continuous and unanticipated change" [Amos, 1998]. This encompasses the concept of resources and the ability to manage or assemble these resources. In addition, the importance of the information infrastructure is clearly brought out in this definition.

In summary, these studies agree on the significance of organizational agility and contribute in developing various theories further in the field of organizational agility. However, it is not clear how to assess organizational agility in

term of related to IS. For this reason, this paper proposes a framework to be systematically applicable in analyzing organizational agility related to IS.

Ⅲ. Conceptual Framework of Organizational Agility

We extend Haeckel's [1999] adaptive enterprise framework to propose the *Agility Framework*, because Haeckel's framework emphasizes on the information processing ability of businesses. Haeckel assumes that an enterprise's ability to adapt depends on how it processes information [Haeckel, 1999]. Successful firms have something in common-they are good at quickly transforming apparent noise into meaning. Such explicit interest in firms' information processing ability is well aligned with the research interest of dissecting and imposing IS components onto the map of organizational agility.

Haeckel suggests that businesses need to migrate from the Industrial Age make-and-sell model to a sense-and-respond model to become an adaptive enterprise in this environment of discontinuous and unpredictable change. Haeckel [1999] defines sense-and-respond as a type of organizational behavior based on a collection of capabilities and assets managed as a purposeful adaptive system.

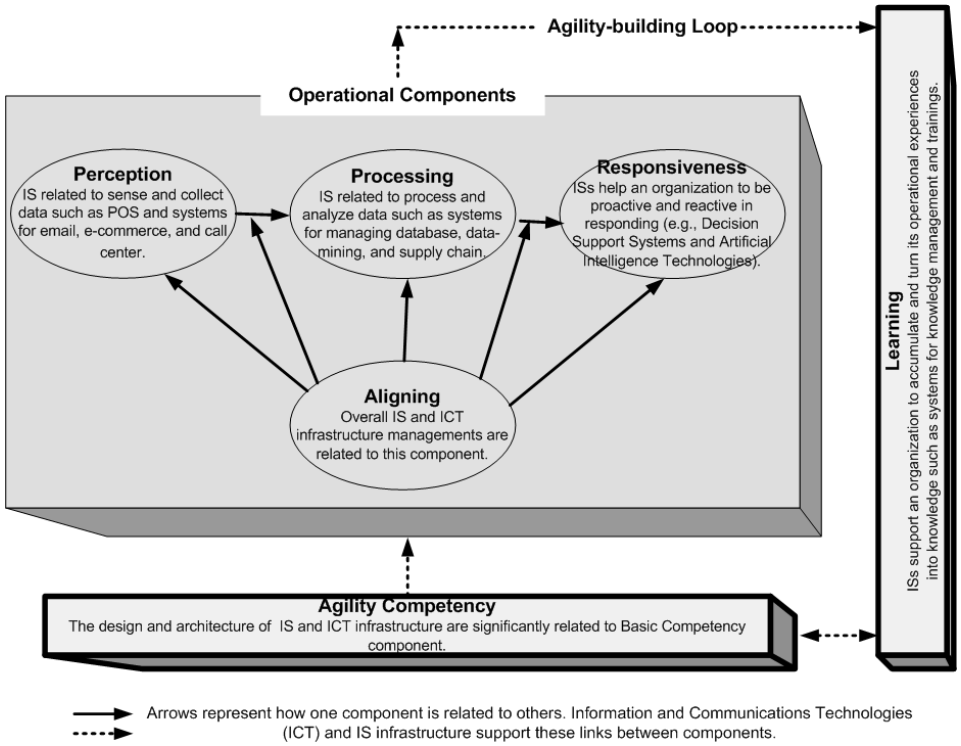
One of the underlying assumptions about adaptive enterprises is that they are social systems. A unique property of social systems is that individuals can and do make decisions within the system and about the system [Haeckel, 1999]. Therefore, Haeckel emphasizes intentionality and purposefulness with regard to complexity and adaptiveness as essential properties of an organization. This perspective supports our view for an open-ended outcome of organizational agility that can be enhanced or suppressed by ISs.

Haeckel proposes a circular and continuous process model for adaptive organizational entities [Haeckel, 1999]. He argues that every adaptive system survives by making sense out of its environment and responding with an appropriate action. The process model has four phases. Adaptive organizations 1) sense changes in their environment and internal states; 2) interpret these changes in the context of their experience, aims, and capabilities; 3) decide how to respond; and, finally, 4) act on their decisions.

In this paper, we adapt and expand Haeckel's adaptive enterprise framework to build our model for relationships between organizational agility and IS components. We focus on the process model of adaptive loops.

Our proposed model for organizational agility describes two types of components – ***operational components*** and ***agility-building loop components***. The operational components that are based on the adaption of Haeckel's adaptive enterprise framework deliver organizational business processes daily, and the agility-building loop components that are expanded parts hold up the operational components (see <Figure 1>).

The operational components consist of *perception, processing, responsiveness*, and *aligning*. The *perception* component is matched with the "sense" element in Haeckel's model. The *processing* component is related to the "interpret" element, as an organization needs to process raw data into meaningful information and knowledge to interpret environments. The "decide" and "act" elements of Haeckel's model are merged into the



<Figure 1> Agility Framework

responsiveness components because ISs do not make organizational decisions and act accordingly, but they do help and support human beings in deciding through analyzing a great amount of collected data and in acting through delivering appropriate information and knowledge to right people in a timely manner. In addition to these three components, *aligning* is added as a part of operational components. Reconfiguration of resources upon market changes is significant for organizations [Eisenhardt and Martin, 2000]. ISs should be aligned or realigned to allow organizations to perceive, process and respond to their dynamic environments [Mirchandani and Lederer, 2012].

The agility-building loop components – *learning and agility competency* – hold up and support the operational components. These components are not shown in Haeckel's Sensing-Interpreting-Deciding-Acting (SIDA) model, but it is significant to recognize and analyze these components as a backbone enabler/disabler for the operational components to create, advance, react and learn from change [Conboy, 2009], even though the agility-building loop components do not directly act in an organization's daily operations.

(1) ***Perception***: an organization must be able to detect signals, whether they come from internal or external environments [Chonko and Jones, 2005]. This refers to the ability to sense or detect changes in the environment and requires a good understanding of environments, the identification of signal sources and their characteristics.

(2) ***Processing***: this is one of the strengths of ISs [Ashrafi *et al*., 2005]. It refers to the ability to filter, evaluate and manage incoming signals to generate adequate responses and recognize patterns in signals [Gunasekaran, 1998].

(3) ***Responsiveness***: it is necessary for the organization to adequately respond to information, both proactively and reactively [Archer, 1999; Breu *et al*., 2002; Sharifi and Zhang, 1999] and is defined as the ability to quickly formulate an appropriate response after perceiving and processing signals [Archer, 1999; Sharifi and Zhang, 1999]. Arrows connect these three components to represent a sequence and relationships. An organization perceives signals and then processes and responds [Ashrafi *et al*., 2005; Haeckel, 1999].

(4) ***Aligning***: this represents the ability to re-evaluate and align perception, processing, and responding resources and capabilities according to environmental changes. The organization may need to realign its current processes, resources, goals and even objectives when the change is radical according to the new information. Such an adjustment must be time-sensitive [Coronado, 2003] and fast with new directions [Sambamurthy *et al*., 2003]. Aligning involves not only the activities of three components (perception, processing, and responsiveness) but also information flows between them, as it is important to coordinate these three components to maximize their efficiency and effectiveness in appropriate information flows while minimizing time and resource consumption. Therefore, arrows go from aligning to perception, processing, responsiveness and the connections between them for the relationships among aligning, perception, processing, and responsiveness.

The agility-building loop components in the proposed framework include organizational learning and agility competency, which support the operational components. Organizational learning theory states that organizational cognitive capability is to learn through past experiences and current business activities, recognizing surroundings and adapting accordingly [Argyris and Schon, 1996; Robey and Sales, 1994; Robey *et al*., 2002]. An organization learns through the activities of four operational components, and this learning eventually influences the agility competency [Argyris and Schon, 1996; Ashrafi *et al*., 2005]. This competency also affects organizational learning, as the learning ability depends on its existing know-how, experiences and capabilities for agility, and there is thus a mutually influential relationship between learning and agility competency (Argyris and Schon, 1996).

(5) ***Learning***: this is an important process in organizations [Argote, 1999; Brown and Duguid 1991; Cohen and Levinthal, 1990]. An organization learns and improves its competencies through processing four operational components. This refers to the ability to create knowledge based on experience, allowing the organization to continuously improve and be better suited to deal with changing environments. A company that is adept at learning will also internalize technologies, tools, abilities, and procedures from third parties [DeVor *et al*., 1997]. This learned knowledge finally becomes a part of the agility competency.

(6) ***Agility Competency***: this implies organizational fundamental agility capabilities to support organizational perception, processing, responding, aligning/re-aligning, and learning from experience [Chonko and Jones, 2005]. Competencies

comprehend expertise in the industry and the processes or know-how in performing internal tasks and collaborative tasks with third parties [Sharifi and Zhang, 1999]. There is a two-way connection between agility competency and learning, as it is a mutually influential relationship. Agility competency affects the activities of four operational components, which is represented with a unidirectional vector from agility competency to the group of operational components. At the same time, the activities that the operational components perform influence learning. This is represented by an arrow going from the group of operational components to learning. This loop is the *agility-building loop* in <Figure 1>. These arrows show the relationships among learning, agility competency, and the group of operational components.

Importantly, the activities of these components must be harmonized as a whole to form a sound system [Truex *et al*., 2000]. As Haeckel [1999] and Truex *et al*. [1999] emphasize continuous organizational improvement, the proposed framework highlights the cyclical process of an organization for agility.

Ⅳ. Methods

4.1 Action research

With the purpose of illustrating how to dissect, diagnose, and improve ISs in the context of organizational agility through the use of the *Agility Framework*, this study adopted a conventional action research method instead of its variants (e.g., an action research design [Sein *et al*., 2011]). As indicated by Baskerville and Wood-Harper [1996, p. 235], the action research is "a post-positivist social scientific research method, ideally suited to the study of technology in its human context." Taking this view, we use action research as an interventional mechanism to explore the applicability of the *Agility Framework* in assisting an organization to achieve its organizational agility in a real-world setting.

First, to understand how a manual course scheduling system [Foulds and Johnson, 2000; Hinkin and Thompson, 2002] became a barrier for the organizational agility of the Department of Management Control and Information Systems (DMCIS), a longitudinal observation with an in-depth analysis was necessary. However, action research went beyond the analysis of observation [Baskerville and Myers, 2004]. It was an interventional process to solve a problem [Azhar *et al*., 2010]. As the investigators, we were responsible for this research and were actively involved in solving the organizational problem of being rigid, partly by the use of the manual scheduling system.

Among the variety of action research [e.g., Braa *et al*., 2004; Martensson and Lee, 2004; Sein *et al*., 2011], we took one of most widely used methods, the canonical action research of Susman and Evered [1978], because this method provides a standardized, rigorous, and collaborative approach with five phases (listed below) [Lindgren *et al*., 2004] so that we can adopt and apply the *Agility Framework* in a proper manner.

1. Diagnosing Phase: understand and analyze the situation to identify problems.
2. Action Planning Phase: specify actions to solve the identified problems or to improve the situation.
3. Action Taking Phase: Implement the speci-

fied actions.
4. Evaluating Phase: Assess the situation impacted by the actions.
5. Specifying Learning Phase: Due to the nature of cyclical process, the documentation of learning outcomes is essential for the next cycle of action research.

4.2 Evaluation Criteria

To be consistent and more reliable, we follow the evaluation criteria of Davison *et al*. [2004] that are specifically developed for canonical action research. The five principles of the evaluation criteria are as follows:

1. ***The principle of researcher-client agreement*** : It is important for researchers and practitioners to agree on their roles as cooperators, especially for the role of researchers, as researchers usually come from outside an organization to intervene in its activities. The roles of the researchers for this study are listed below.

   Role of the researchers: The roles of the researchers in this project were critical. We were actively involved in each action research phase. First, we recognized the rising problem for the DMCIS when the environment changed. Second, we formulated and applied the *Agility Framework* to diagnose the situation. Third, we planned actions (e.g., making criteria to buy or develop a scheduling system) for the DMCIS to take. Fourth, one of us participated in developing a scheduling system, and others monitored how planned actions were taken. In this way, we were more than just observers; as action researchers, we were involved in taking actions. However, we were able to hold a neutral position to assess the whole procedure because not all of the researchers were directly involved in taking actions. This provided us with a space to evaluate the actions with a rational, unbiased and objective perspective. Fifth, we evaluated how the implemented actions impacted the organizational agility. Sixth, we identified lessons from this project and suggested a direction for future action research cycles to improve the organizational agility of the DMCIS further.
2. ***The principle of the cyclical process model*** : The cyclical process of the five phases is essential for the canonical action research to continuously improve the situation. The research process is described below.

   Research process: To identify the role of IS in the context of organizations, we have developed the *Agility Framework* based on the literature review as shown. We were searching for a case to apply the framework so that we could illustrate the applicability of the framework. Although we encountered difficulties in persuading companies to participate in our study, we found a perfect case to apply the framework. We witnessed that the DMCIS was losing its agility in scheduling courses. As an innovative education provider, this was tarnishing its reputation.

   To address this situation, we decided to follow a cyclical action research approach suggested by Susman and Evered [1978]. Recognizing the problem (losing the organizational agility in scheduling courses), we

first applied the *Agility Framework* to diagnose the situation from November 2007 to March 2008. Second, actions were planned based on the diagnosis in April 2008. Third, the actions were taken accordingly from May 2008 through December 2008. Fourth, we again applied the *Agility Framework* to evaluate the results of the actions by comparing the organizational agility before and after the implementation of actions from January 2009 to July 2009. Fifth, we assessed what we learned from this cycle and identified more parts to improve for the next cycle during August 2009 to January 2010. This first cycle took more than 25 months. Through this process, we confirmed the applicability of the Agility *Framework*, as we found that the evaluation of our interventions positively impacted the improvement of the organizational agility of the DMCIS. A summary of this action research project is presented in <Table 1>.

3. ***The principle of theory***: The theoretical framework is critical in the action research [McKay and Marshall, 2001]. It enables researchers to focus on the research as well as solve a practical problem. It also helps the researchers relate the finding in extending literature. The proposed *Agility Framework* is developed based on this principle.
4. ***The principle of change through action***: The expectation of action research is improving the organizational situation. Following this principle, the change in the organizational agility of the DMCIS will be shown through the action research cycle described later.
5. ***The principle of learning through reflection***: The most important activity in action research is defining learning outcomes [Lau, 1997]. It is significant for practitioners and researchers to transfer findings into contributions in both practice and research [Iversen *et al.*, 2004]. In the academic perspective, this paper will show how IS plays a role in the context of organizational agility and how to utilize an IS as an enabler in gaining organizational agility. From a practical perspective, it will illustrate the improvement of the agility of the DMCIS through action research.

4.3 Data Collection and Reflection

Data were continuously collected by observing the manual scheduling system for weeks, by having workshops with administrators and instructors, and by interviewing students at the diagnosing and action planning phases. During the action taking phase, all interventions and actions were documented. For the evaluation and specifying learning phases, the data from interviews and the performances of the manual and the electronic scheduling systems were collected.

Ⅴ. The Situation Faced by the DMCIS

The Department of Management Control and Information Systems (DMCIS) is one of the departments in the Faculty of Business and Economics (FBE) at Universidad de Chile. In the period between 2003 and 2008, the DMCIS increased student enrollments from 200 to almost 2,000 in Executive Education programs.

The principal mission of the Executive Education Unit (EEU) is to develop teaching materials

(regarding economics, information technologies, business, and management control) and educate managers and professionals from industrial and public sectors.

> "EEU is a strategic unit for DMCIS because it brings an important portion of income for the department and positions us as significant educators and researchers in the domestic market" (interview with the head of the DMCIS).

Every year, the EEU offers more than 50 courses. The numbers of students and courses have increased significantly from less than 500 students to more than 1,500 students in 2009. This sudden environmental change increased the pressure on the DMCIS to organize the schedule better in terms of the efficient use of facilities and the effective allocation of instructors because a person manually planned the scheduling. This manual system eventually made this business unit at the Universidad de Chile a rigid organization in managing information, resources, and facilities for the EEU programs.

It is important to mention that the EEU has offered "closed" courses for companies since 2005. The "closed" courses are exclusive programs designed and customized for particular organizations upon request. Companies can require closed courses anytime, affecting the initial schedule of the given academic year and forcing the DMCIS to reschedule facilities and instructors several times during this period.

Ⅵ. Applying Action Research

<Table 1> Summarizes the action research cycles conducted.

6.1 Phase 1: Diagnosing (losing organizational agility due to environmental changes)

Until the early 2000s, there were small numbers of courses and students in executive education programs, so the manual scheduling of instructors and facilities worked properly. However, as the programs prospered so quickly, the DMCIS faced a complex and challenging situation, as demonstrated by several complaints from students and instructors about inefficient service in 2007.

> "Instructors are unhappy because the current scheduling method has assigned them to more than one course in different programs and classrooms at the same time" (interview with the coordinator of operation).

They perceived the service quality to be extremely poor because of the frequent changes and problems related to the scheduling and timetabling of ongoing courses and classrooms. Common problems reported were as follows: assigning a classroom with smaller capacity than the actual number of students or too large and expensive classrooms for courses with the small number of students, assigning an instructor for two courses at the same time, changing classrooms frequently without proper notice, and assigning computer labs to the wrong classes. The ad-hoc solutions for the problems were either unfeasible or extremely expensive. For example, to solve the conflict of two courses assigned to the same classroom at the same time, the DMCIS had to reschedule one course, implying that the DMCIS must compensate students who could

<Table 1> Action Research Cycle

Phase 1. Diagnosing (November 2007~March 2008)
The demand of courses and the enrollment increased. As a result, the manual system did not work properly. **Data sources:** • Countless complaining letters and emails • Ten formal workshops with instructors and administrators • Many informal interviews with students **Data analysis:** • The data from complaints and interviews were discussed and analyzed. Consequently, the manual system was reviewed to determine whether it could handle the environmental changes (Increases in demands of courses and enrollments). • The *Agility Framework* was applied to analyze the agility/rigidness of DMCIS to respond to environmental changes.
Phase 2. Action Planning (April 2008)
We concluded that the manual system was no longer appropriate. We thus formulated conditions that a suitable scheduling system should handle. The resulting criteria were that the system should minimize conflicts in schedule, minimize costs, maximize the use of school facilities, and schedule in a timely manner. • Plan A – Based on the criteria, the DMCIS and we would look for a potential scheduling system to buy at a feasible price. • Plan B – If an automated system was not found at a reasonable price, the DMCIS and we would develop the scheduling system that could meet the criteria.
Phase 3. Action Taking (May 2008~December 2008)
Taking Plan A, we could not find a scheduling system with a reasonable price. Therefore, Plan B was followed.
Phase 4. Evaluation (January 2009~July 2009)
The scheduling system was developed and implemented. To evaluate the organizational agility of the department, we reapplied the *Agility Framework.* **Data sources**: • Interviewing people (e.g., students, instructors, and administrators). • Collecting and analyzing data such as the total time to schedule, the number of clashed classes for the same classrooms, the number of mismatches between the number of students and the size of a classroom). **Data analysis**: • Analyzing which component in the Agility Framework improved, based on the comparison of data before and after the scheduling system.
Phase 5. Specifying Learning (August 2009~January 2010)
Our interventions positively influenced the organizational agility of the DMCIS. The *Agility Framework* was useful and effective during diagnosing and evaluation phases. **Anticipated consequences**: • Improvements in the processing, responsive, and aligning components according to the • *Agility Framework.* • Consequently, the DMCIS would enhance its agility capabilities. **Unanticipated consequences**: • Changes in the *Agility Framework.* • Significant cost savings for the DMCIS.

not attend the rescheduled class.

> "Our students usually miss the first classes because the last minute changes do not help them to find the corresponding classrooms" (interview with the coordinator of the operation).

To face these problems, the DMCIS realized that it should gain organizational agility to deal with the situation. The DMCIS assessed its organizational agility with the *Agility framework* in March 2008 and concluded as below.

1) Perception: To schedule courses in the EEU, a person manually collected data on the number of courses to be offered, the number of students for each course, time slots and available instructors through e-mails, phone calls, and internal memoranda. These procedures took on average one week, were unstructured and caused data inconsistencies.

2) Processing: The same person who collected data also processed them to schedule courses and resources. This person built and used a large matrix to describe courses in size, time slots, and the availabilities of instructors and facilities. The schedule was drawn up manually through matching an available instructor with a classroom for each course without considering costs and the effective usage of facilities. If a problem (e.g., assigning the same classroom for two courses at the same time) was detected or a change was required, the matrix had to be adjusted with new data. This procedure took about two weeks and was repeated every time a change was required.

3) Responding: Responding to changes presented several difficulties due to the manual processing. The major problem was mismatching among time slots, classrooms, the number of enrolled students, and instructors. One way to respond this problem was that the DMCIS leased conference rooms from nearby hotels, which resulted in logistic issues of transporting students and instructors. This ad-hoc solution was extremely expensive and deteriorated service quality. Consequently, it damaged the university's image.

4) Aligning: Due to the fact that the DMCIS responded the issues in ad-hoc manner, the alignment of resources was also ad-hoc. The repetition of these situations (e.g., the cancellation of a class and the mismatch between a classroom capacity and the number of enrolled students) would keep requiring the inefficient aligning of organizational resources.

5) Learning: Historically, the responsibility for solving problems (learning) resided in the person producing the scheduling matrix. However, the experience was not systematically accumulated or analyzed by the person, as this person was also responsible for many other tasks during the entire academic year.

6) Agility competency: The agility competency in scheduling courses was primitive, as it relied on one person. Through the operational routines based on the manual system, the DMCIS was unable to learn and build its agility competency.

Consequently, the DMCIS as an organization did not have any agile capability to cope with the changing environment. In fact, it did not

strategically plan or optimize the use of facilities to deliver a high quality service in coordination of courses with minimal costs.

6.2 Phase 2: Action Planning (buying or developing a scheduling information system)

After the diagnosis, the DMCIS recognized that it did not have enough capabilities for all six components in the dynamic environment, particularly, responding to the increase in student enrollment. Ideally, the DMCIS could gain capabilities in all components at once. We thus planned a course of action. Plan A – To expedite the improvement of the organizational agility of the DMCIS, we advised the DMCIS to determine possible software applications to purchase.

Plan B – When Plan A was not feasible, we suggested that the DMCIS develop the necessary software with one of us so that we could intervene from the designing stage of the software development. In this case, we would prioritize the components from the *Agility Framework* to develop the software because considering the limited resources that the DMCIS had. As shown in the diagnosing phase, the processing component directly impacted the allocation of classrooms and instructors. Although better *perception* could lead to better *processing*, it was more urgent for the DMCIS to improve its processing capability even with the given perception so that it could respond quickly and properly to frequent changes.

6.3 Phase 3: Action Taking (developing the scheduling system)

When the DMCIS and one of the researchers assessed the possibility to buy a scheduling application, there was no software application to solve the particular business problem that the EEU had at a reasonable price. Therefore, we recommended that the DMCIS pursued Plan B – developing its own information system to handle the situation. Consequently, it started to develop and implement an automated computational system, eClasSkeduler, to gain more effective and efficient processing and responding capabilities in scheduling courses.

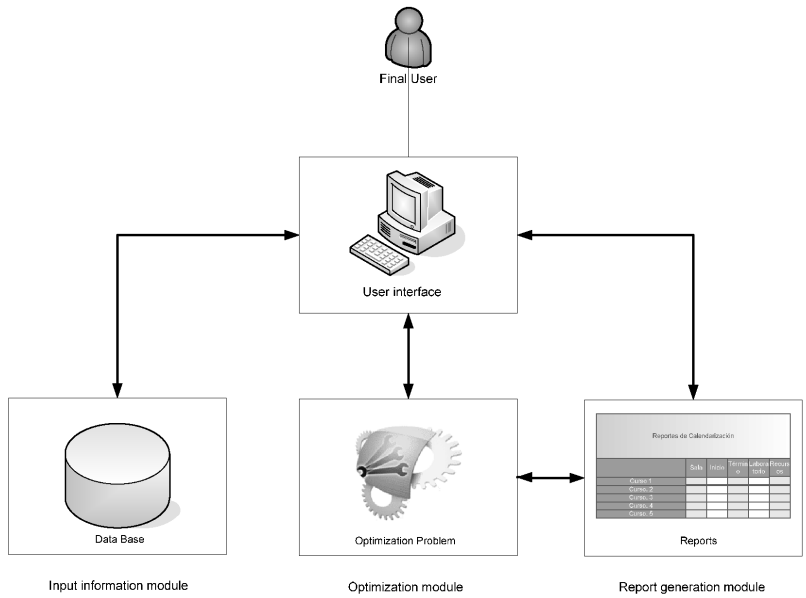
The eClasSkeduler system is a decision support system based on mathematical models that follow the classification provided by Liang *et al*. [2008]. The eClasSkeduler tries to find an optimal solution within a series of constraints (e.g., number of classrooms, instructors, courses, and enrolled students) and objectives (e.g., minimizing the leasing costs of external classrooms and computer labs, matching the nominal capacity of a classroom and the number of students in a course, and avoiding the allocation of two courses to one classroom at the same time).

The eClasSkeduler architecture consists of four main modules, which are represented in <Figure 2>. The user interface module is used as a control mechanism of the system. From this module, the information entered into the system is transformed according to the requirements and format. Through this interface, the user can define and weight each objective pursued by the DMCIS.

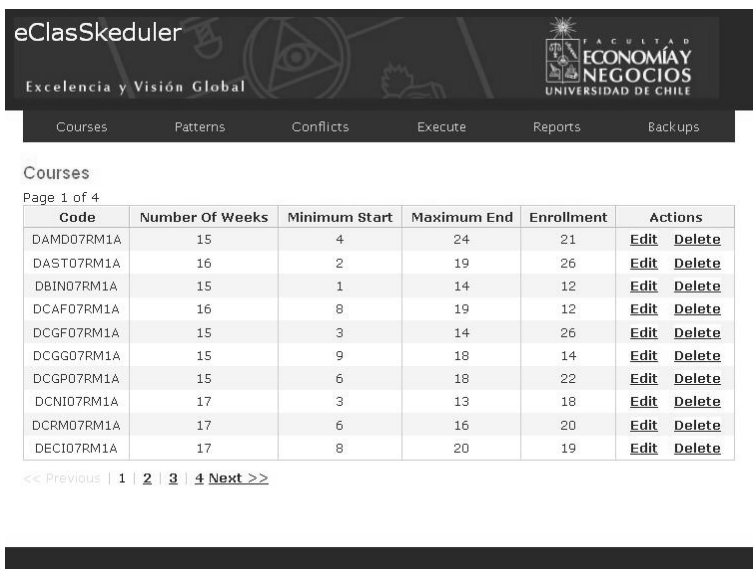
The input information module is a database that stores all the information regarding the availabilities of courses, classrooms, and instructors. Each course is defined by the duration in weeks, the earliest and latest feasible weeks to start, and the estimated number of enrolled students. <Figure 3> shows one view of the interface used

to edit the course information (e.g. duration of a course and number of enrolled students) from the database.

The optimization module is the central processing component to execute necessary equations for solution instances. It runs all input variables and constraints to provide the most effective and efficient solution in achieving the objectives.



<Figure 2> Modular Description of eClasSkeduler



<Figure 3> Interface to Edit Courses

Finally, the reports generation module summarizes and organizes information in several types of reports after receiving them from the optimization module. The generated reports include the assigned classroom, the instructor, the time, the day, and extra information for each course.

6.4 Phase 4: Evaluation (gaining organizational agility with eClasSkeduler)

With a manual scheduling system, it took on average two weeks to process the data. The DMCIS took sequential steps to generate a timetable: 1) the collection of data such as the courses offered, the availability of classrooms, and the number of enrolled students took about a week; 2) the scheduling matrix construction and reports generation took two weeks; and 3) the validation and adjustment of the proposed schedule with academic directors took another week.

After developing eClasSkeduler, the construction of a scheduling matrix and reports takes only 30 minutes. Reducing the data processing time is extremely important as it makes possible to process data multiple times when the DMCIS confronts unforeseen requirements (e.g., sudden requests from companies about closed courses) before the schedule is released. The processing improvement also decreases the time for the validation and adjustment, as the DMCIS can run eClasSkeduler many times a day upon directors' requests. The eClasSkeduler not only allows the quick generation of a solution but also analyzes multiple scenarios and compares them while weighing the constraints and objectives differently. Through the improvement of the *processing* component, the DMCIS is also able to enhance the *responding* component by responding faster and more flexibly, even though the *perception* component has not yet improved.

The improvement in the *processing* component also reduces the total operating cost of the EEU. In particular, it reduces the cost of leasing classrooms outside the university. This illustrates that the improvement of the *processing* component enhances the *aligning* function through increasing the efficiency in matching classrooms, courses, and instructors without mismatching, which again leads to the improvement of the *responding* component.

The cascading effect of improvements on *processing, aligning* and *responding* were measured using five dimensions: a) leasing costs of the DMCIS classrooms, b) unused capacity, c) conflicting schedule of resources, d) the number of external conference rooms, and e) the number of external computer labs. When the actions were completed in December 2008, the DMCIS already finalized the scheduling for 2009. However, we were able to convince the DMCIS to reschedule courses for 2009 with eClasSkeduler. In this way, we evaluated not only the situations before and after actions but also the actual impact of the actions. We ran eClasSkeduler with data from 2008 and the same data that were used for scheduling course for 2009. <Table 2> illustrates the visible measurements by the five dimensions.

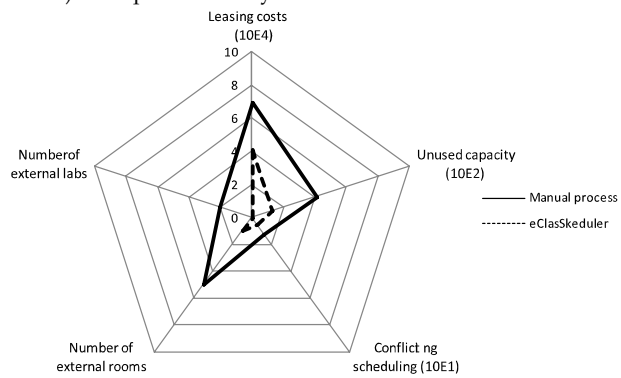
<Figure 4> shows the improvement on each dimension and the accumulated impact by eClasSkeduler as a Decision Support System (DSS) in 2008 (part a) and in 2009 (part b).

Each axis in the radial chart represents one dimension. The accumulated impact is determined by calculating the area that arises by

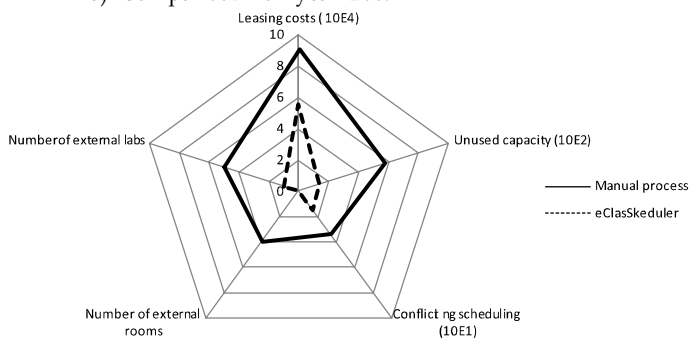
<Table 2> Evaluation of Actions with Measurable Results

	2008	2009
Leasing costs of classrooms	41% reduction – from 34.7 to 20.5 million pesos.	39% reduction – from 45.1 to 27.7 million pesos.
Unused capacity of classrooms	61% reduction	74% reduction
Conflicting schedule of resources	From 12 to 5 courses	From 34 to 15 courses
Number of external conference rooms rented	From 5 to 1 room	From 4 to 0 rooms
Number of external computer labs rented	From 2 to 0 rooms	From 5 to 1 room

a) Comparison for year 2008



b) Comparison for year 2009



<Figure 4> Manual versus eClasSkeduler Solutions

linking all dimensions (the polyhedron). The larger area inside the polyhedron indicates greater cost incurred. The area of the manual system is 9.6 times larger than the eClasSkeduler system for the year 2008 and 9.8 times larger than that for the year 2009. This shows the visible impact of eClasSkeduler.

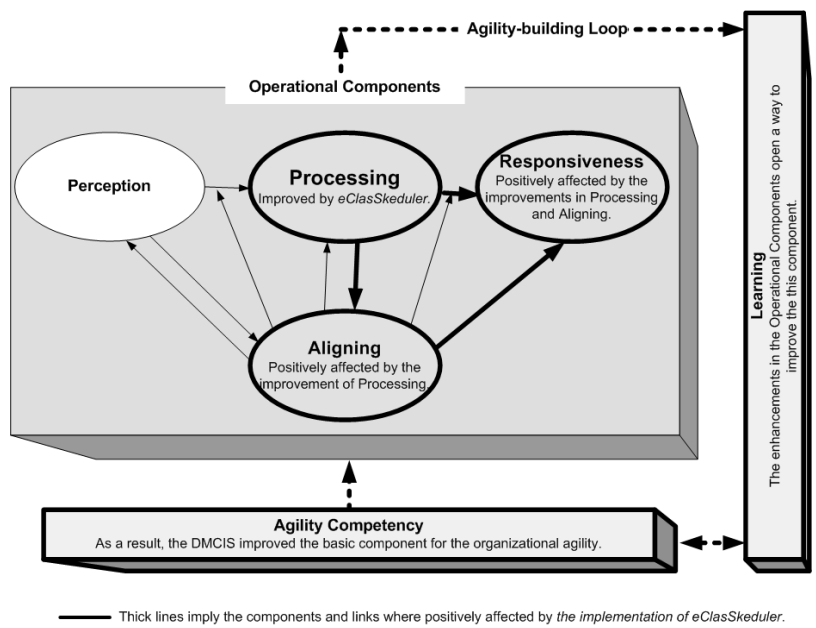
6.5 Phase 5: Specifying Learning (modifying the agility framework and lessons for future action cycles)

As we assessed that the intervening actions were appropriate and brought positive results, we also learned lessons. First, in the proposed

framework (<Figure 1>), the arrows from the component of *aligning* to the three components (*perception, processing and responsiveness*) and the links between them are unidirectional. However, during the action research, we realized that the *processing* component presents a bi-directional relationship with *aligning* <Figure 5> because organizational processing can influence aligning capability. For instance, the processing improvement allowed the DMCIS to align its resources more efficiently and effectively. Second, as mentioned in Phase 4, with the measurable improvements in the efficient use of the facilities, the DMCIS saved a significant deal of costs. These are unanticipated consequences. We believe that this bi-directional relationship between *perception* and *aligning* components will be true if the *perception* component is improved by ISs.

The anticipated consequences are described below. Although the DMCIS could not develop an IS in a way that increases capabilities for all organizational agility components at once, the researchers responsible for this study with the collaboration of the Head of Department and the director of the EEU selected the most urgent issue to gain attainable agility capabilities. With the framework, we were able to analyze the situation of the DMCIS more precisely and choose the most urgent component to improve. The eClasSkeduler has improved the processing capability of the DMCIS drastically. Accordingly, it has impacted the responding and aligning capabilities (see <Figure 5>). All these effects improved the organizational agility of the DMCIS. The Agility Framework is used not only to diagnose the situation and prioritize components to improve at the beginning but also to evaluate the consequences of implementing eClasSkeduler.

The *perception* component has been identified as the next enabler of agility to improve in the



<Figure 5> Improvement of Agility Capability of the DMCIS after Implementing eClasSkeduler

next cycle of action research. The DMCIS still manually collects data for its perception, which takes approximately one week. This indicates that the DMCIS spends approximately one week and 30 minutes on generating an initial schedule even with eClasSkeduler. If the DMCIS develops on-line registration for students, instructors and companies and links eClasSkeduler with databases describing courses and requirements (e.g., available instructors and classrooms), the DMCIS will increase efficiency in collecting data by automating or decentralizing the process, which will eventually enhance its perception capability further.

As this implementation is recent, it will require time to develop other information systems and to train people to adequately use the system, interpret scheduling reports, and compare them. However, with eClasSkeduler, the DMCIS has made great progress in achieving organizational agility. First, it does not depend on one person any more. Second, it can systematically keep all data instead of depending on papers and one person's memory, which opens a way to build ***learning*** capability (see <Figure 5>). One plan we suggest for the DMCIS is storing all data that go through eClasSkeduler to build a knowledge management system. From this system, the DMCIS can mine data and develop simulation tools to forecast future demands so that it can reformulate its curricula and train employees. All of these activities will become part of its learning capability because in this way, the knowledge will not be drained away but will be captured, formalized, and accumulated. This learning will feed in building its organizational ***agility competency*** to support its operational components. Once this virtuous cycle is placed, the DMCIS will be able to build its agility further as it passes through each ***Agility-building loop***.

Ⅶ. Discussion and Research Results

The eClasSkeduler system, even as a recently implemented application, enables important improvements in organizational agility, primarily in some of the operational components described in the *Agility Framework* – Processing, Responsiveness, and Aligning. As mentioned above, the evaluation after the eClasSkeduler implementation reveals the areas that need further improvement, such as *perception and learning*, to gain more organizational agility. Developing the eClasSkeduler application works as a 'quick win' in the sense that it has greatly impacted the organizational response-time, operational efficiency, and service quality of the DMCIS. The successful development and implementation of this initial project, according to the evaluation using the *Agility Framework*, will lead to other projects as identified in *Phase 5 Specifying Learning* for the following action research cycles. Suggested projects concern constructing new IS to be connected with eClasSkeduler so that the integrated systems can improve *perception* and *learning* competencies as well. The components of *learning* and *agility competency* are considered to be more challenging to improve, as human actors should be involved in these processes. For example, people must eventually learn, make a decision, and take actions, even though the systems help them to collect and analyze data and information.

The in-house development of the application produced positive results and showed great po-

tential; however, it also revealed some challenges. The positive results include enhancing quality service, customer satisfaction, cost efficiency, decision support, organizational learning, and agility. The remaining challenges are to further understand and analyze the business model of the DMCIS to detect manually running areas that can be replaced by ISs to improve organizational agility. From an operational perspective, there is still a shortfall in the number of users trained to load data, to periodically run the application, and to interpret the reports. Having only one trained user will soon lead to problems; for example, it may delay responding and aligning resources. There are also technical challenges in developing more software modules and smoothly linking them together. It is easier to operate one independent system than to orchestrate multiple systems as one. Therefore, the development and implementation procedures demand well-planned schedules, tests, and managements, which leads to further action research. Another issue in the future can be about people's dependence on technology. If systems are developed and implemented too well, people will depend on the systems too much and lose their creativity and ability in facing and solving problems. To avoid this situation, the DMCIS can use the *Agility Framework* to constantly evaluate its agility in response to changing environments. Due to the nature of action research, we also expect that more action research will help elaborate the *Agility Framework* from an academic perspective.

Ⅷ. Conclusion

As action research requires the balance between academic and practical demands [Lindgren *et al*., 2004], the theoretical framework and findings should be related to literature. Simultaneously, the formulation of research questions and findings must be related to practitioners' problem-solving processes. Following this requirement over a 25-month research period, we developed and applied the *Agility Framework* to link the components of an IS to organizational agility. The study has a number of theoretical and practical contributions.

On the theoretical front, this study contributes to the efforts in the fields of IS and organizational studies by expanding the existing theory to propose the framework that is applicable in analyzing organizational agility and to provide a way to relate an IS to organizational agility. As mentioned above, organizational behavior needs to be linked with ISs as much as ISs need to be analyzed within an organizational context. The *Agility framework* dissects and maps IS components to organizational capabilities, providing insights into how each component operates and is related with others.

In particular, we illustrate how eClasSkeduler as a Decision Support System (DSS) can improve organizational agility by replacing the manual system in the *progressing* component. One characteristic of a DSS is that it optimizes an objective given constraints and conditions. This characteristic is significant for organizations seeking to be agile because it is directly related to the responsiveness of organizations. This research demonstrates how researchers can help organizations to dissect and link ISs (in this case, the Decision Support System) to organizational functions in improving agility.

On the practical front, the *Agility Framework* can be very useful to managers and practi-

tioners in a number of ways. Organizations can use this framework to assess their current IS status and diagnose agility enablers or drivers and barriers in ISs to improve agility as shown in the eClasSkeduler case. We used the framework to diagnose agility status of the DMCIS and to take actions in improving its processing capability. Therefore, we supported the DMCIS in developing and implementing eClasSkeduler as an appropriate solution to its particular problem. Consequently, the DMCIS as an organization has achieved immediate and visible gains, as shown in the previous sections. More importantly, it has become more agile to environmental changes and has also provided a foundation for further improving its agility.

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