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Achieving sustainable learning through erp based supply chain in vitro laboratory

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Abstract

In order to enable sustainable learning, practical motivation behind every theory in consideration needs to be experienced extensively. The purpose of this study is to enhance sustainable learning on logistics and supply chain management through an in vitro laboratory environment in which real life supply chain structure is simulated over actual physical flows, and also through enterprise resource planning (ERP) systems, and then to measure the level of sustainability achieved. Research is conducted by including a group of students to a hands-on implementation through both physical and computerized applications in this representative business environment. To support the findings, surveys and focus groups are conducted.
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Keywords: Enterprise Resource Planning (ERP); Supply Chain Management; In Vitro Laboratory; Sustainable Learning

1. Introduction

In recent years, great efforts are spend on education to meet the requirements of the real business world. It is increasingly recognized that the value of education is better experienced when it supports real life businesses or reinforces the adoption of students to real business practices. With this in mind, both academicians and practitioners tend to work closely to the actual requirements of businesses, and adapt these into educational scenarios. These efforts bring collaborative relationships into the foreground among company executives and academicians. In this context, many different areas of education have become related to practical settings. The adaptation of enterprise resource planning (ERP) tools to related academic disciplines has aroused within this framework.

Rapidly changing marketplace conditions, coupled with the increasing competition has triggered the survival efforts of many companies. With this aim, companies have started to consider the use of technological advancements to add value to their business processes and increase their market share in this harsh competitive environment.

Implementation of enterprise resource planning (ERP) systems into their business processes are one of their primary consideration within this framework. Momoh et al. (2010) consider ERP systems as the primary solution for integrating various functions and processes through the supply chains to ensure smooth flow of materials, services and information. Although this was a value adding opportunity for most of the companies to improve their business processes, it was also a very challenging task to implement. In order to facilitate this adoption, companies started

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looking for employees experienced and skilled in ERP tasks. This has encouraged the academics to direct their efforts to a more organized curriculum in terms of ERP software tools.

The fundamental concept of ERP has originated from manufacturing systems which mainly focuses on materials resource planning and integrates basic functions of accounting, finance, human resources and marketing in common (Peslak, 2005). Thus, it is considered as an effective tool for not only educating students on information systems, but also enlightening them on business process management concepts. Therefore, ERP tools have been adopted into curriculums to both improve the technical skills of the students and to improve their managerial skills on business process management and change management.

Although the need of real business was for both technically and non-technically skilled employees, most of the education on ERP is concentrated on improving the technical skills. Thus, many engineering and information systems educations have adopted ERP tools into their curriculums. However, in addition, improving non-technical skills such as process management, change management and employee management are also important in terms of critical success factors of such ERP implementations of companies and need serious consideration in ERP education (Mohamed and McLaren, 2009). This has also motivated other programs such as Business, Logistics and Supply Chain Management to incorporate ERP tools into their curriculums.

Aristomenis (2010) highlights the importance of developing new university training methods that enhance the connection between theory and practice. Within this framework and forthcoming need of real business, to add value to Business, Logistics and Supply Chain Management curriculums in terms of improving both technical as well as other managerial "soft skills", this study proposes an innovative approach to education by demonstrating a supply chain in an in vitro laboratory environment, including both physical materials flows and computer applications supported by ERP tools.

This study ensures lifelong learning through continuously developed contemporary scenarios from real business cases, and provides a clear understanding on living business environment and critically experienced issues. Senge (1990, pp.14) states that “for a learning organization, ‘survival learning’ must be combined with ‘generative learning’, learning that enhances our capacity to create”. Sustainability is related with the processes which can be carried out continuously. Indefinitely, learning is the key factor in creating a sustainable world. Besides, Senge et al. (2010) suggests that learning should help today’s innovators see the larger systems of which they are a part and foster collaboration across every imaginable boundary. Furthermore, sustainability is related with realizing latest trends in the market and implementing the latest technologies. Hence, tangible prototypes are critical for this issue.

Thus, the purpose of this study is to enhance sustainable learning on logistics and supply chain management through an in vitro laboratory environment in which real life supply chain structure is simulated over actual physical flows and also through enterprise resource planning (ERP) systems, and then to measure the level of sustainability achieved.

To summarize, the study aims to provide a detailed explanation of the development stages of an ERP based supply chain in vitro laboratory. In addition, the effectiveness of this laboratory on sustainability of learning is measured to provide an understanding on the results achieved.

2. Literature Review

Both practitioners and academicians agree on the idea that, from the business side, training is considered as being one of the most critical success factors to ERP implementation (Esteves et al., 2002; Duplaga and Astani, 2003; Aristomenis, 2004; Peslak, 2005; Marler et al., 2006; Shahin et al., 2010; Aristomenis, 2010; Momoh et al., 2010). The research results and practical experiences show that training not only facilitates technical use of the systems, but also improves the adaptation to use. This is important for the effectiveness of the implementation process as well as the effective utilization of the whole system in businesses. It is clear that a key enabler to improve the employees’ ability to use a software system depends on whether the employees are satisfied with the ease and usefulness of the systems, which can only be achieved through effective background training. Aristomenis (2004) states that, "the perceived degree of complexity of ERP systems will have a negative relationship with implementation success". This complexity, combined with a lack of skills and knowledge, will lead to resistance. At this point, the role of

education in ensuring a comprehensive understanding on the new tasks is critically important for the achievement of the desired position and success.

Therefore, rather than only in specific research fields, ERP has started to be significantly considered important in terms of general educational aspects. The need for technically and managerially skilled graduates in ERP tasks and its significance for future business sustainability have triggered a number of universities to incorporate ERP courses into their curriculums (Jensen et al., 2005). Gupta (2000) argues that the challenges associated with the ERP system implementation in businesses, such as resistance to change, cost / time impact and data accuracy, can be facilitated through an effective and continuous training program starting from the university years. According to many researchers (Bingi et al., 1999; Peslak, 2005; Jensen, 2005), the availability of employees skilled in ERP tasks directly affect the success of ERP implementations and sustainability of ERP driven businesses.

With an aim to reinforce innovative approaches to teaching and learning, Watson et al. (2006) highlights several university curriculums related with enterprise systems from around the world. Leger (2006) presents an innovative method to teaching ERP concepts through a simulation game which matches theory into practice through a "learning by doing" approach. His observations on the application of the game point out the experience of the students on the understanding of the value of process view on the business functions as being the key driver for real integration. "It appears that the pedagogical approach used in the simulation game is more than just a simple hands-on experience with software; it is an opportunity for students to experience what it means to run an integrated enterprise and to experience the benefits of data integration" (p.14).

The importance of ERP education and its contribution to university level students in terms of improving skills and competencies in job market is further emphasized by many researchers such as Watson and Schneider (1999), Selen (2001), Guthrie and Guthrie (2000), Davis and Comeau (2004), Kirkham and Seymour (2005), Klein et al. (2010). ERP systems are considered as important and effective tools for business process education and for experiencing the integration concept to the students with no industrial background. It is nowadays accepted that the familiarity to such software systems can best be achieved through training which starts much earlier than university education years and is conducted with the motivation to improve the acceptance of technological systems by supporting it in the related university curriculums.

Therefore, a number of studies have focused on improving the educational background of information system graduates in terms of ERP skills (Kirkham and Seymour, 2005). However, as ERP systems are adopted to businesses in order to improve business processes and functions, the necessity of the integration of information systems' education into the areas of business process management education is also pointed out by many researchers (Walker and Black, 2000; Davis and Comeau, 2004; Kirkham and Seymour, 2005; Peslak, 2005; Jensen et al., 2005). As the maturity of ERP systems improve, the importance of technical skills will be replaced by more advanced skills which add value in terms of managerial aspects. In order to facilitate ERP adoption and provide effective use of related functions in real businesses, educational aspects in terms of both technical and non-technical perspectives need strong support for curriculums which have a clear focus on the various skills which need to be developed.

This study agrees with Davis and Comeau (2004) that ERP education is not only necessary for information system students, but also needs to be incorporated into Business Schools in order to provide such students with a comprehensive management theory and principles through the improvement of technical skills. The business school students be assured a theoretical knowledge on business processes and business functions through software tools, and develop a better understanding on cross-functional business processes. Thus, this study will demonstrate an improvement in student capabilities through several real life scenarios in the experience of computerized as well as physical tools.

3. Methodology

Sustainability of learning through this tool is mainly provided by the effectiveness of the methodology; getting participants prepared for business life challenges through a simulation in an in vitro laboratory and by experiencing both physical material flows and ERP system counterparts of logistics and supply chain management business flows. The essence of this study is the demonstration of the development of stages of ERP-based supply chain in vitro

laboratory, outlined in detail. To this end, the effectiveness of the ERP based in vitro laboratory on some specific criterion is measured. The measurement approach is outlined and initial findings are also explained.

In a series of articles, Kirkpatrick (1959a, 1959b, 1960a, 1960b) introduced a framework for the evaluation of training and education used in many applications of business, government, military and industrial training. The evaluation process is divided into four segments as follows (Kirkpatrick, 1977): 1- Reaction: How do the participants feel about the program? To what extents are they "satisfied customers?" 2- Learning: To what extent have the trainees learned the information and skills? To what extent have their attitudes changed? 3. Behavior: To what extent has their job behavior changed as a result of the training program? 4. Results: To what extent have results been affected by the training program? This research explores the potential sustainability of learning provided by this tool, and evaluates its effectiveness on specific criterion (reaction, learning, behavior, results).

In this research, sustainability of learning is measured through a comprehensive qualitative analysis. We further support the findings of the qualitative analysis through quantitative analysis. The results are evaluated to provide the explanatory findings regarding the tool. The comments and feedbacks of the participants are also considered as a way of improving the laboratory material for future applications.

At the qualitative analysis stage, the observations on the improvements of participants' skills on managing logistics processes, realizing problems, taking necessary actions, analyzing results, identifying and resolving bottlenecks are explained to identify the sustainability of learning provided by this tool. In addition, the findings of focus group studies are outlined.

At the quantitative analysis stage, a survey is developed to measure reaction, learning and behavior provided. The scale that is used for the survey is compiled from Kirkpatrick (1959a, 1959b, 1960a, 1960b, 1977), Wexley and Baldwin (1986), Campion and Campon (1987), Noe and Schmitt (1986) and the scale for identifying ERP related outcomes is taken from Seethamraju (2008). Such quantitative analysis has the drawback of requiring the repeated implementation of the methodology. Since the cycle is for implementation has to be carried out over a long period, it

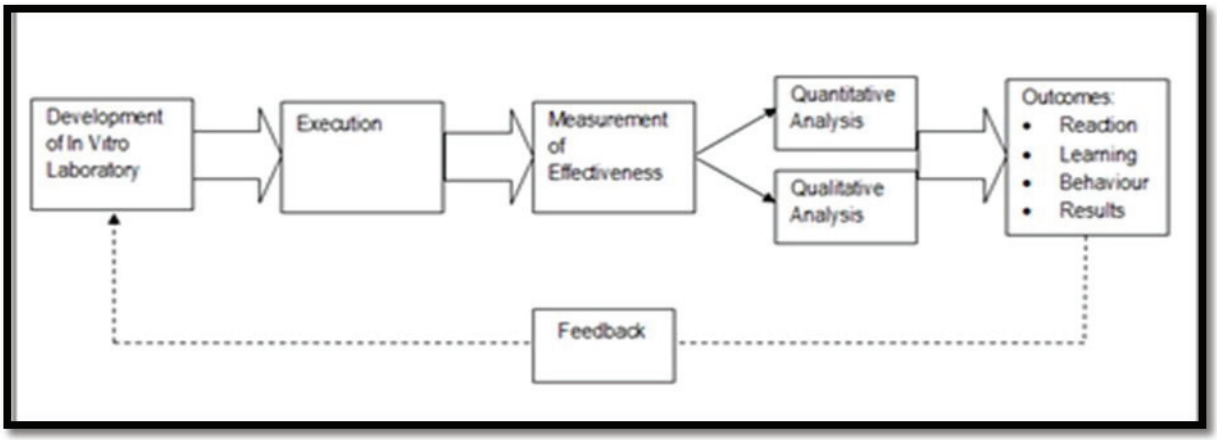

Figure 1. Conceptual Model of the Study

is not possible to perform a quantitative analysis in the course of this research using a large accumulated sample size immediately after the first implementation of the system, or provide a descriptive statistical analysis, due to the time needed to accumulate a sufficient sample size. However, fundamentally, we suggest the integrated use of qualitative and quantitative analysis in the long run towards assessing the sustainability of the system.

The conceptual model of the study in figure 1 shows each phase of the research in general as follows;

The initial run of the model was carried out on undergraduate and graduate level students. The course was applied to two groups of students from different universities over a 14 week period. Thus, it was necessary to use those students specifically as sample groups to conduct the research. Therefore, judgmental sampling is carried out in this research. Both of the universities are located in Izmir, Turkey; Dokuz Eylül University and Izmir University

of Economics. This course was applied at different levels, the graduate level students from the Maritime Faculty, Dokuz Eylül University and undergraduate level students from the department of Logistics Management, Izmir University of Economics. In each ease, 20 students were given a course for one semester, organized within both theoretical and practical framework. Students were involved in hands-on implementation through both physical and computerized applications in this representative business environment. The educational experience of students was supported by several scenarios from real business practices.

4. ERP Based Supply Chain In Vitro Laboratory

4.1. Development of In Vitro Laboratory

4.1.1. Background of the Study

The idea of this study is to develop a supply chain simulation of a two-echelon supply chain structure in an in vitro laboratory environment, which incorporates computerized hands-on implementation as well as physical material flows for the use of Business School students. In this environment, through both physical implementations and ERP applications, it is planned to give Logistics and Supply Chain Management students experience in the roles of the main parties of the business environment including suppliers, customers, operational plants, third parties as well as the main processes towards and among those parties like production planning, materials planning, purchasing, warehouse, production, quality, import, export, and shipment. The laboratory experiences of many ERP focused courses are mostly based on hands-on demonstrations of working business environments through computerized tools. In this study, in order to attract the interest of the students and demonstrate the real atmosphere of a real life working company, the physical environment of the businesses involved in supply chains are also considered, including real material flows over the business processes which also enhances the real feel of the business experience. Therefore, physical material flows are simulated as in real life companies, whereas information systems infrastructure is built parallel to physical material flows. This process is manipulated by contingency events.

The main scenario of the study is developed over the structure of a manual implementation which was originally performed as “Just in Time Production Systems” game. The physical materials used in this game were nuts, washers, bolts and couplers. Two final products, called “4” Yokimabob and 3” Yokimabob” are produced in three different workstations.

A group of 6 people worked together to prepare this environment and make it suitable for course content. The complete demonstration was ready after three months’ work, including regular weekly meetings of three hours.

4.1.2. Scope of the Course

In this course, the two dimensions introduced by Jensen et al. (2005) regarding the conceptual knowledge and system-specific functionalities are both considered. Conceptual knowledge is fundamentally given on business process management through a specific emphasis on supply chain management concepts, with a further contribution on improving system-specific functionalities supported by hands on implementation through both computerized and physically managed business flows. The real idea is that it is considered to be hard to improve managerial skills on ERP systems without a systems approach; that is to say, a supply chain management viewpoint.

Pellerin and Hadaya (2008) developed an innovative approach to improving ERP training experiences of information system students by collaborating with a real life company in order to focus on its business process transformation. In contrast, in this present study, a real life company structure is demonstrated in an in vitro laboratory environment and business process transformation experiences are developed through several real case scenarios. In view of the difficulties of collaborating with a real life company for each individual course, this approach provided a representative access to regular company operations. Several business processes are reviewed and business improvement, decision making, risk taking aspects are all covered, over several different scenarios.

4.1.3. Software System Selection Process

Issues of the lack of resource in such ERP adaptation processes into university curriculums are emphasized by several researchers. Kirkham and Seymour (2005) points out the difficulties of establishing hands-on ERP courses into university curriculums and outlines the ways for overcoming such issues without investing on large resources, especially in developing countries. Guthrie and Guthrie (2000) also provide a guide to outline how to implement hands on approach of ERP courses by matching resources with academic programs and provide examples of three of the leading ERP programs within universities. In addition, other than successfully implementing ERP tools to Logistics and Supply Chain Management curricula, it is also of highest importance to keep it sustainable. Therefore, the continuity of technical support becomes an issue in the long term. Considering all these facts, in this study, special care was taken in the software selection process, as well as the conditions of the potential collaboration between the university members and software consultants.

Among several alternatives, it was agreed to use Netsis Software, produced by a locally owned software company with worldwide business interests, based at the same city as the two universities. The ERP package of the company is flexible and user friendly, and covers all related business processes and functions that is planned to be considered within the course scope.

Having agreed on the software capabilities, it was also very important to ensure that the software consultants will provide continuous technical support whenever required. As the company is a local one, it was easier to come to a mutually beneficial arrangement. Other than contributing to the Logistics and Supply Chain Management curriculum of the universities, it also benefited software owners in terms of familiarizing trainees and potential customers with Netsis ERP through the course material. Furthermore, as the software company was local, the technical support is ensured.

As a result, the adaptation of ERP tools to Logistics and Supply Chain Management curricula was successfully carried out within a limited budget and the resource constraints faced by many universities are all overcome.

4.1.4. Implementation Process

Having defined the scope of the course and selected the software company, the next stage was to enter the related data to the system, identify the necessary processes and make the system work. At this point, the software consultants and academicians worked together, meaning that the academic personnel were trained on related modules and functions during implementation.

In parallel to the work on the technical setups, the laboratory environment was created, with Netsis consultants uploading the system to the existing computers at the universities. The physical tools were already in existence, therefore, it was only necessary to synchronize the physical flow and the computerized system.

Several tests with the academicians were conducted before the course started to ensure that the physical material flow and the computer aided tool were working properly and in synchronization. After three runs, the in vitro laboratory was ready to be used by the students.

4.2. Execution

4.2.1. Course Outline (ERP Based Supply Chain Management)

The course started with an introduction session regarding the aim and scope of the course and related fundamental concepts of Logistics and Supply Chain Management. Following this, a theoretical review on main management information system (MIS) concepts and on the role of ERP tools for Logistics and Supply Chain Management were given to the students. Before passing to the computer sessions, a hands-on run of the whole process with physical material flows in supply chain was performed in the in vitro laboratory. In this run, the process was followed with manual documentation to enable the students to benchmark the difference of managing the supply chains with and without the use of ERP tools at the end of the semester. The process then continued with the hands-on trainings of ERP modules on computer. Having reviewed all the related modules, a complete run with physical material flows through computerized ERP tools was experienced to the students in the in vitro laboratory in

three two-hour sessions. The learning on the course material was supported by a homework task in which students were required to develop their own finished goods and supply chain environment (suppliers, customers, product specifications, lead times, ordering policies, raw materials, prices…etc.) and run their supply chain accordingly.

4.2.2. In Vitro Laboratory Experience

After all modules are reviewed and students are qualified enough to run their own environment, the class is divided into groups with specific tasks such as Planning, Purchasing, Warehouse, Quality, Production, Customer Service, Suppliers and Customers. Each group is given the role of creating a crisis in the related department processes that they manage, such as inaccurate data entry, error in bill of material, late arrival of a raw material, unforeseen price increases…etc. Each party in the supply chain has its own key performance indicators to follow during the experience. They are required to apply those scenarios at the in vitro laboratory to the other groups of students with a complete run through both physical and computerized flows. The whole class is obliged to locate the problem source, manage the crisis, take necessary actions and report their experience. This is to improve the students' skills on managing logistics processes, realizing problems, taking necessary actions, analyzing results, identifying and resolving bottlenecks and to cope with these in the context of a realistic business atmosphere though a hands-on of both physical and computerized ERP tools.

Selen (2001) highlights the importance of a more integrated knowledge framework, emphasizing that "Some organizations engage in single-loop learning, i.e. they learn "know-why" or "know-how" or "know-what", without reexamining the underlying values" (p.106), instead of learning all simultaneously. Accordingly, this experience was important to give the students the responsibility to moderate the whole supply chain, which incorporates several scenarios, all attacking the environment.

A brainstorming session is organized in order to involve other students in the system development phase.

4.3. Measurement of Effectiveness

The fundamental approach of this study is to measure the sustainability of learning through ERP based supply chain in vitro laboratory with both qualitative and quantitative analysis.

The findings of the qualitative analysis are based on the observations of the instructors on the progress of the students through the course semester, as well as on the feedback received through the focus groups formed among all students. Students with different backgrounds are involved in the structured course. Other than undergraduate level students, there were also graduate level students, some of who have previous experience in or are currently working in the industry. This diversity among attendees strengthened the findings of the research.

The progress on the students' capabilities on logistics and supply chain process management were observed for one semester (around 14 weeks). After a brief theoretical review on fundamental concepts, the supply chain simulation is experienced through physical tools and manual documents. Students prepared documents for each process, such as ordering, production, warehousing and quality and ran materials requirement plan (MRP) manually, providing experience of the supply chain process flows without the use of ERP tools.

Having formed the picture of a supply chain and experienced the supply chain environment physically, students are involved in intense computer sessions on ERP modules. At this stage, each ERP module is explained with reference to manual application in a comparative manner. This helped students to understand the role of ERP tools in supply chain process management and to better concretize the concepts.

After each individual ERP module is reviewed in detail, the students are asked to make a complete run of supply chain processes, from the issuance of a customer order to the delivery of the finished goods to the customer, through computerized applications. In this way, students are able to master the processes of the supply chain by themselves.

In order to have a more comprehensive viewpoint on supply chain functions and process management, scenarios in which usual flow was attacked by unexpected events, are experienced to the students which are originally adopted from real life business cases. At this stage, students are required to analyze the situation, understand the problem,

identify bottlenecks, resolve the crisis and manage the business. This is where students start to be excited about putting their own efforts on real problems and taking initiative.

In order to involve the students in real practices better, other than making them the one who have to deal with the crisis, they are required to create the crisis themselves. At this stage, the students are required to develop their own crisis scenarios and apply it to other groups of students. These helped students to outline the potential problems which can occur at particular stages of a supply chain, and how and to whom such crisis can be addressed. This comprehensive run, which is enacted by the students themselves, is experienced in the in vitro laboratory environment. This time, the processes are managed through the use of the ERP tool, and which is also followed by the physical material flows. This enabled the student to comprehend supply chain process integration and visualize real business operations. At this stage, the sustainability on learning is enhanced by the stimulation of different sensations. The visuality of the environment through ERP tools concretized the students' theoretical learning as well.

At the quantitative analysis stage, the survey which is developed in this research is conducted among all students to measure the reaction, learning and behavior provided through this tool. The results of the quantitative analyses are evaluated in order to provide an outline of the descriptive results regarding the tool through statistical analysis. However, in order to summarize a comprehensive set of descriptive results, it is necessary to work with a large accumulated sample size. As such, the analysis requires the course implementation to be carried out repeatedly over a long period of time to achieve an acceptable level of sample size and therefore it is not possible to provide a precise analysis from the survey results conducted in this research, even though the initial findings are outlined through the survey as explanatory feedback.

4.4. Outcomes of the Study

The observations on the students' performance through the whole semester outline the improvement on the students' satisfaction on being able to apply their theoretical learning in practice. They are gratified to be involved in real life business scenarios and take the initiative themselves. The scenarios experienced in the in vitro laboratory reinforced their learning, and considerably enhanced their motivation. They had the opportunity to experience the internal and external interrelations and interactions involved in logistics and supply chain management processes. In addition, the scenarios that they themselves have developed provided experience of the importance of information accuracy in decision making and the importance of integration. Also, their capability in analyzing the reports improved.

In the focus group, students all gave similar feedbacks. They agreed that they learned about ERP tasks well, experienced the entire supply chain integrity and that the practical setting of the course strengthened their theoretical knowledge.

One of the most important feedbacks of the students in the focus groups was that all agreed that their learning is sustainable. The main facts providing the sustainability is listed as the content and flow of the course, scenarios experienced, but more importantly, the role of physical setting in the course. The students explained that ERP tools provided the system viewpoint to be experienced, whereas the physical setting provided visuality, and the combination of the two closed the applications up to reality, hence provided sustainability. The materials flowing in parallel to computerized application provided the atmosphere of a real business, which excited the students and involved them in "flow" (Klein et al., 2010). Theory of "flow" involves a high degree of engagement in tasks considered to be challenging and interesting (Csikszentmihalyi, 1990). Klein et al. describes the practice of being in a flow as follows: "The hour has really flown by because you have been in a state of flow". One of the students stated that, "*This is the best and the most beneficial course I've ever taken. I have got the utmost from this course for real business life competency*". All the students agreed that the physical setting enhanced the sustainability of learning and that the ERP course without the physical materials have not been sustainable to the same extent.

The findings of the observations and the feedback outlined by the focus group are reflected by the students' improved ability to managing supply chain process tasks and on using ERP functions effectively. The in vitro laboratory experience allowed the students to discuss on their own strong and weak sides regarding both technical

and managerial skills. They are involved in the business synergy and learned to work as a team. They experienced the consequences of their decisions in the in vitro environment enabling them to receive quick feedbacks on decision making, which accordingly, expedited their learning.

At the end of the semester, their way of thinking and capability on decision making is considerably improved. The assignments and in class performances of the students provides evidence that they learned to use logistics and supply chain management functions through ERP tools, and gained system point of view, thus, helping the students achieve sustainable improvement on not only their technical skills, but also on their managerial skills.

5. Conclusion and Further Research

The increasing needs for business of both technically as well as managerially skilled employees has triggered the efforts of several universities to adopt innovative approaches to education to ensure effective and sustainable learning. According to Senge (1990, pp.14), "for a learning organization, 'survival learning' must be joined by 'generative learning', learning that enhances our capacity to create". Thus, sustainable learning is reinforced by the extensive experience or the practical motivation behind every theory. Within this framework, using ERP tools in curriculums not only provides a baseline for developing a system perspective, but also facilitates and enhances learning on business tasks.

With this motivation, in this research, an ERP based supply chain in vitro laboratory is developed. The focus of the laboratory was to train the students on different system modules and to show how the cross functional processes are carried out. The study is carried out to enhance sustainable learning on logistics and supply chain management through the in vitro laboratory environment, in which real life supply chain structure is simulated over actual physical flows and also through enterprise resource planning (ERP) systems, and to measure the level of sustainability achieved. The main focus is put on logistics and supply chain management students. The students are given a course for one semester in the in vitro laboratory, where real life supply chain structure is simulated over actual physical flows, and also through enterprise resource planning (ERP) systems. ERP simulation, supported by physical flows, is an effective tool for a better understanding of business processes, as it not only enhances the integration of theoretic knowledge into practice, but also provides a real life company experience with physical material flow management. Thus, this research develops an innovative approach to education and hands-on terminology in education, by demonstrating a supply chain in an in vitro laboratory environment both with physical materials flows and computer applications supported by ERP tools.

In this research, sustainability of learning is measured through a comprehensive qualitative analysis, which is further supported by quantitative analysis to provide the explanatory findings. The observations on the improvements of participants' skills through the course semester are explained, findings of focus group studies are outlined and initial evaluation on survey results are shared.

The results of the analysis revealed that the methodology developed for course provides sustainable learning and the hands-on approach with physical material flows reinforces sustainability of learning. The students' ability to manage supply chain process tasks is improved, and they become capable of using ERP functions effectively. The visuality of the environment through ERP tools helped the students to relate their theoretical learning with practice as well. By the end of the semester, sustainable improvement is achieved on not only the students' technical skills, but also on their managerial skills.

The limitations of the research can be given as the sample size. The implementation of the methodology needs to be conducted repeatedly over a long period of time. The results of the implementations with a large accumulated sample size will provide a more precise descriptive statistical analysis. Within this framework, further research can be conducted on different groups of students, preferably, at different universities.

In addition, this tool is applicable for not only the use of students, but also for academicians, practitioners and software system owners to support learning, system development and business problem solving at different levels. Therefore, further research alternatives can include applying this tool to different profiled groups.

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