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New Approach to Knowledge Transfer Environment Development

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Abstract

Contemporary teaching, research and process innovation is directly connected with most up-to-date information, solutions and testing opportunities. In process analysis, improvement or re-organization for production planning, supply chain engineering, production or transport logistics, knowledge-driven innovation derives from best opportunities of testing and simulations. In the era of information technology, the computer-based simulations are tools of teaching and planning. The cooperation of both academia and businesses are at the same time valuing the opportunity of hands-on practicing and visualizations, prototyping processes and having physical demonstrations of planned processes. The current research focuses on combining digital and hands-on approach towards interdisciplinary business-case-solutions in development of modern knowledge transfer organization for students delivering solutions of process simulations in Logistics and Supply Chain Engineering, Production Planning or Factory Development. The renewed environment providing input for knowledge-based supply process development and production planning is the Innovation Lab of Logistics and Supply Chain at Tallinn University of Technology.

Keywords: prototyping; hands-on-learning; simulation; innovation; interdicsiplinary; higher education; engineering; logistics; supply chain engineering

1. Introduction

The transfer of scientific and technological know-how into valuable economic activity has become a high priority. Universities and other higher education institutions are important sources of new scientific knowledge. Industry can gain access to this knowledge or resources by developing formal and informal links with higher education

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institutions [1]-[2]. Therefore, the development of higher education links with private sector is assumed to encourage innovation and production [3].

The form of linkages between individual firms and higher education institutes might include [4]:

- the transfer of people including founding members of firms, key personnel and staff into employment in firms;
- the transfer of knowledge;
- contract or sponsoring research in the university by researchers and students;
- contract development, design, analysis, testing, evaluation etc;
- access to university facilities;
- less formal interchange with academics which may lead to the important change of information.

Today, there is a growing recognition in the business community about the importance of managing knowledge as a critical source for competitive advantage [5]. Researchers in the field of sustainable competitive advantage have discovered that knowledge, which includes what the organization knows, how it uses what it knows and how fast it can know something new is the only thing that offers an organization a competitive edge [6]. Knowledge is the thermonuclear competitive weapon of our time; knowledge and its management are more valuable and more powerful than natural resources, big factories, or fat bankrolls [7].

According to knowledge chain model [20] competitiveness can be achieved only via learning projection. Education in universities especially on Master's level has been changing rapidly in recent years. An entrepreneurship or business-related case-solving component is placed in the majority of curricula and students are expected to be able to not only have innovative ideas, but also to develop them to start-ups and prototypes. Therefore the success in university programs is not measured by the courses taught but on the ability of the students to be successful and skillful in transforming the knowledge into products or applicable solutions.

The development and application of contemporary teaching and analysis methods, such as computer-based simulations and visualization software, have been introduced in curricula of logistics, production planning and supply chain engineering to support the aim of knowledge-driven competitiveness development. The digital approach has therefore often pulled the attention away from the physical testing and simulating in the process mapping fields where prototyping is regularly not the method and drawing as the first hands-on method cannot be considered sufficient.

Researchers from Aalto University analyzed the best practices from Stanford University, Massachusetts Institute of Technology (MIT) and Royal Institute of Technology (KTH), before they reached the concept of Future Lab of Product Design, combining engineering with business administration and design [8]. The concept was scaled up and as a result Aalto Design Factory was established in Finland as the pioneering academic factory. The concept has been transferred successfully further to Shanghai (Aalto-Tongji Design Factory) and Melbourne (Swinburne Design Factory).

Aalto Design Factory with its roots in engineering and industrial design is currently facilitating experimentation of design-based approaches to learning providing some insights in to the practical arrangement of supporting the development of these skills in conjunction with disciplinary expertise **Error! Reference source not found.**. Such modern factories as innovative university labs and testing facilities for students are open 24 hours from platforms for students to gather together, exchange thoughts and develop ideas into prototypes.

Living Labs are innovation infrastructures where software companies and research organizations collaborate with lead users to design and develop new products and services. Living labs are open innovation infrastructures shared by several stakeholders. Companies considering developing a living lab will find little guidance and no concurrence on best practices, for managing it or integrating it with existing innovation programs. A reference model is required to provide living lab managers and practitioners the tools to create and evolve a living lab following a continuous improvement and evolution approach [11] and [12]. The stakeholders involved in a living lab include companies of the software industry, communities of end-users, computer science research organizations and public administrations supporting innovation policies. ISO/IEC 15504 provides a useful framework for creating such a model. This reference model is composed of a formalized structure for organizing processes and effective practices for software

development and service provision activities; it is used in IT companies to guide continuous process improvement initiatives for providing better products and services. The process categories are summarized as innovation initiatives management; organizational management; technical development; deployment; and monitoring and evaluation. However, in many cases, living lab participants and managers do not have a user innovation culture or the required competences and it is very difficult for them to start participating and managing this kind of user innovation infrastructure [13].

Computers cannot be excelled with human capability in calculations, process visualization or preciseness, simplified or even rough physical floor plans and mechanical movements can improve the understanding of the state of art, the mapping of bottlenecks and lead to better results in process planning. Process simulations in Logistics, Supply Chain Engineering and Production Planning are a challenge as regularly the amount of data and its preciseness allows no approximate solutions but only accurate calculations. Nevertheless – in the interdisciplinary business-cases solved and projects made as consultations to the industry, hands-on showroom is the method promoted to be used in parallel with digital solutions at the Tallinn University of Technology (TUT). Developed lab concept combining hands-on physical prototyping, teaching and research allows different Faculties as Mechanical Engineering, Civil Engineering, ICT and School of Economics and Business Administration to perform interdisciplinary research and testing, providing a platform for game and simulation tools development as well as serve as a simulation and demo-center for students and visitors overall.

2. Concept of innovation laboratory in Tallinn

In the National Strategy for Higher Education 2011-2015, The Estonian Ministry of Education and Science has stressed the role of higher education in supporting the Estonian economic development and innovation [13]. The Strategic Plan of TUT years 2011-2015 states that the teaching methods, environment and tools in education shall be the most up-to-date and that the by year 2020 it will be an active partner of cooperation networks of entrepreneurship clusters and public institutions.

Following the strategy, innovation environment and business-academia cooperation projects have been an emerging activity of the university and its faculties, coordinated and administered supportively also by the Business and Innovation Centre Mektory (Fig. 1). The name Mektory is an acronym from a slogan Modern Estonian Knowledge Transfer Organization for You! In preparation of the concept researchers from Aalto Design Factory shared their knowledge; however novel concept become wider, including also areas important to Estonia as logistics, ICT, e-services, supply chain management.

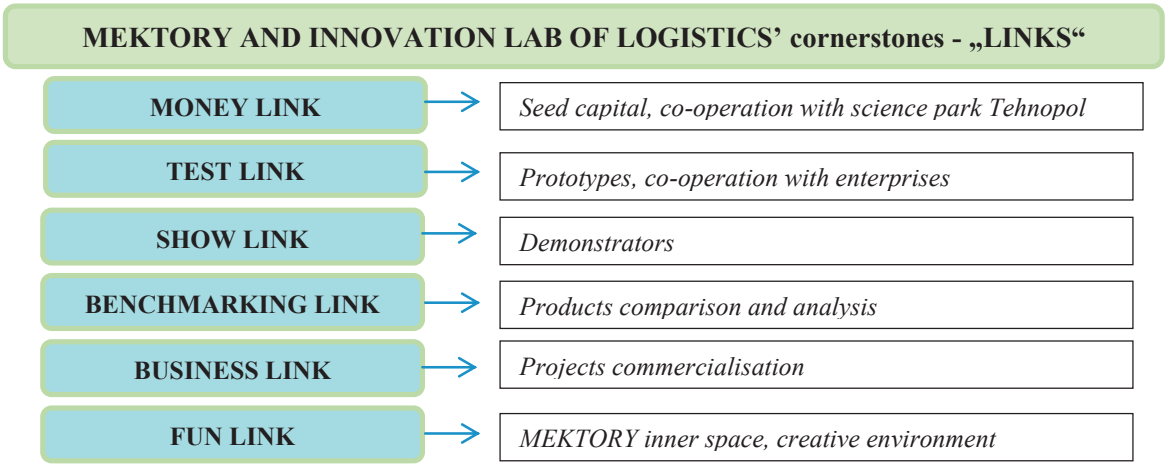

Fig. 1. Mektory conceptual cornerstones.

In February 2012 with the establishment of Department of Logistics and Transport at the TUT, a new era in cooperation between the industry, public sector and academia emerged. The department was called into being by the university and by different interest groups and stakeholders together, among the latter the logistics cluster enterprises and the organization connecting the purchasing and supply chain engineers in Estonia. The establishment of a specific department derived from the need of a better education in the field to guarantee the supply of specialists to the industry, but also allow the academia to support businesses and the public sector in development strategies through knowledge-sharing for solving bottlenecks via thorough analysis, expertise and up-to-date modeling. The interdisciplinary teaching and innovation was expected to emerge from the new initiative in the field of logistics and supply chain engineering.

The first steps in showing the early results with business contact network established almost the day the department was inaugurated, using hands-on games as well as simulation programs in teaching curricula and course assignments provided a platform for the department and its partners to open a one-of-a-kind laboratory – the Innovation Lab of Logistics and Supply Chain, novel in Tallinn as well as in many places of the world.

All this new approach that supports knowledge transfer is the basis for long-term economic sustainability. This is how also the Mektory Centre and the Innovation Lab of Logistics and Supply Chain Engineering is planned to work –allowing students and researchers to work with problem-solving, start-ups, prototyping and networking with partners to have an environment with opportunities and supportive facilities. The space of 4500 m^2 with 20 labs representing all fields of the university gives the chance of experiencing the opportunity of blending research achievements of different the disciplines and transferring the knowledge not only between the businesses and academia, but also between different research fields and economic sectors.

2.1. The innovation lab of logistics and supply chain engineering in Tallinn

The innovation Lab for Logistics and Supply Chain Engineering in Tallinn University of Technology is in other words a process Simulation and Demo Centre for multimodal logistics, transport systems, supply chain engineering and production process. The lab has been established into the newest entity of the University - the Business and Innovation Centre Mektory [15].

The lab has three main sections copying the structure of the department of Logistics and Transport:

a) logistics;

b) transport planning, and

c) supply chain engineering.

All of those are interlinked and interdisciplinary. The lab benefits from participation of researchers and professors, PhD as well as Master or Bachelor students from disciplines needed to solve a case: logistics, ICT, mechatronics, power industry, or business processes will be combined in running a case at the lab. The financial input for creating and developing the lab has come from the university, European Union funded projects, but mostly from the partner companies.

The labs flexibility allows it to be a classroom as well as simulation and testing place for finding solutions to industry's bottlenecks. The lab environment together with focused project management provides structured support to the industry starting from trainings or seminars, case study analysis within a teaching course, management of a thesis project or evolving a large-scale interdisciplinary research project. The specialty of the lab allows the companies and the public sector as clients to be involved in the problem solution process getting access to workshops and methods, if it is their interest.

The lab, being a creative innovation hands-on learning center, demo-space and contemporary digital showroom, also serves as a promotion place for prospective students and possible clients - creating a better understanding of the comprehensiveness logistics, production and supply chain planning and engineering, transport management.

The contents of the lab are divided as follows:

1) Seminar and workshop space with modular build-up;

2) demonstrators and installations;
3) product samples and demo kits of solutions in the field;
4) modular LEGO™ sets and board games;
5) computer-based simulation games, simulation and work programs used in the field;
6) video installations and screen shows via video screens and tablets;
7) up-to-date set-up of video screens, data projector and tablets

Seminar room with modular build-up allows to re-arrange the room according to the shape needed during workshops, games and planning process.

Maquettes and installations allow the visitors and students grasp the basics of transportation logistics, port management and rail and air cargo as well as freight distribution, urban transport management systems and traffic control measurements, Smart City and intelligent transport systems and automated production/supply/warehousing process and monitoring systems.

Product samples and demo kits allow the partners of the laboratory as well as the students to present prototypes and product samples used in the field to raise awareness of students and researchers about the options available in the field. For example, the prototypes developed within the University and the inter-linked companies are presented and their suitability for the case solution can be assessed and tested in the Lab.

Variety of LEGO™ sets allows to simulate and to plan production logistics and automated factory development, supports planning process of on-site measurements or monitoring (i.e. specify points and positions of measurement technology). Board games for teaching lean production and supply chain management as well as planning logistics chains and transport links are an important part of the teaching equipment.

Computer-based simulation games, simulation programs and work programs used in the field compile one the most important part of contemporary teaching of logistics and supply chain engineering. In transport planning, the route planning and map, GIS and positioning solutions are presented and used in study process. Programs developed by other universities and research institutions allow the students to meet with tools important for their field already while studying and allow the university to solve cases that were not possible to be solved due to lack of programs;

Video screens and solutions - four wall-mounted wide-screens TV-s and a data projector - allow computer- or tablet-managed simulation of a port management office, transport control center or production manager's office. The method allows either creation of an environment for the case study or presentation of case data, real-life scenes and the solutions' options on screens. Tablets allow the visual support to the demonstrators and the lab explaining and presenting the content of the lab as well as present a looping sequence of videos of real-life clips from the field (compiled specially for the lab and collected via partners).

Contemporary IT solutions support the attitude of up-to-date university for creating trust in novel and contemporary solutions. Short-distance digital projector taking less space and reducing the feeling of a meeting- or a classroom, wireless broadcasting technologies for screening parallel data flows on the multiple LED-TV video-walls (set up via wireless modules and Apple TV solutions), chip and tag-based security and equipment monitoring/borrowing system are just a few examples of the solutions already created or in process of being installed (not just bought) for the lab.

The lab is in conclusion most of all a study and innovation environment allowing the installations, programs and IT-solutions as well as the mini-library to be supportive to the research groups working with problem-solving, case analysis or prototype models.

2.2. Benchmarking options for the lab

The concept of the lab as well as the whole Business and Innovation Centre Mektory lab cluster at TUT is looking towards similar comprehensive centers in Scandinavia, Europe and world. In planning process, the mapping and analysis of other similar Innovation centers and universities was performed. For development and setting up the lab, the installations and lab contents, games and models, the literature and available descriptions were screened.

As the focus is interdisciplinary and combination of all the three main lines of the department (logistics, transport planning and supply chain engineering), both logistics demo-centers, transport simulation installations and supply chain laboratories have been screened and benchmarked for the transfer of best practices. There is hardly any laboratory in the world acting as a part of university and involving all three dimensions and such a large variety of activities, therefore a combination of best practices and innovation for the type of lab were combined.

The following universities and laboratories were nevertheless the most outstanding regarding the teaching methods and innovative teaching equipment in the fields of logistics and transport planning, production and supply chain engineering.

- The closest to similar examples is at Aalto University - the Design Factory at Aalto University (Finland) [16].
- For teaching, simulation games are used, several universities have developed special board or computer based games for teaching process. The most referred in the region are the supply chain games developed by MIT (USA), by Chalmers University of Technology in partnership with Revere (Sweden) as well as University of Padova (Italy).
- In logistics, the main actors and developers are Institute of Shipping Economics and Logistics in Bremen (Germany) in partnership with University of Bremen and Fraunhofer (Hamburg, Germany).
- While analyzing the best practices in teaching supply chain and production planning, the wide use of LEGO™ bricks and systems was confirmed to be used. Kühne Logistics University (Hamburg, Germany) [17], Keio University (Japan), Ohio State University (USA) use LEGO™ for simulating production process and assembling lines, the elements of human factor in the process [18].
- Chalmers University of Technology (Sweden), A.J. Palumbo School of Business, and Duquesne University (USA) are using LEGO™ for simulating supply chains (ordering-and-filling-the-orders process throughout the supply chain from producer to end user). The elements of measurement and analysis are the speed, quality, preciseness of the production process.
- Chalmers University of Technology also uses LEGO™ for extensive LEAN production teaching process allowing the students to improve the simplified production process step-by-step during a day-long lasting game.
- In Széchenyi István University (Györ, Hungary) LEGO™ in addition to production simulation, LEGO™ is used for simulating storage activities via unloading cargo from vehicles, transferring it to storage sections and working out storage principles and priorities simulate order picking and loading the cars.

The process of screening and timing the transfer and installation of best examples and games to Tallinn University of Technology has been launched; the first stages will be completed during year 2013 and the further stages during years 2014 and later.

3. Hands-on learning and simulation as tools of knowledge transfer

According to the concept of hands-on learning in supply chain engineering, the most known are the process simulations using LEGO™ or similar modular pieces and special board games (mainly used in teaching LEAN production.

Hands-on in factory management and production planning may seem often simplified when using play-sets known most for being suitable for kids. Still, the easy use of allowing re-allocation, the variety of sets and pieces as well as the options of products already available has made LEGO™ probably the most know, but also the most-used tool of hands-on simulations.

The European Innovation Academy session in Tallinn 2013 used 50 mega-sets of Lego Education for business model and business process prototyping during the three-week start-up trainings.

Széchenyi István University (Györ, Hungary) can be brought as one of the interesting examples of the Eastern Europe using hands-on or learning-by-doing method with the help of LEGO™ in teaching and simulation process, of which Bajor and Bodis (2011) bring an expert overview in their research for “Quality 2011” conference [19]. Adding RFID tags and tracking of process would allow real-time coordination of material flows and individually

tracked items, such as merge-in-transit; providing an effective link between physical reality and information systems, such as improved inventory count and goods receipt transactions; and improved logistics management metrics and analyses. If RFID technology is used for tracking, it also enables the automation of operational supply chain processes and creates possibilities of providing information to support managerial processes [20].

3.1. Case Study: Lego Lean Game

Providing the students a large number of games for teaching and simulating *lean* concept and process improvement or teaching value chain mapping can be a budget challenge to several universities and teaching units. Games with instructions costing often several (tens of) thousands of euros, training courses with travel another 5000.

As an alternative to buying a large number of such games for the variety and playing several games developed by another university, the students of TUT produce games themselves as well as work out the instructions for other students to play.

A LEAN game was developed throughout the course "Technology-based Entrepreneurship and Innovation II" within the MSc program of Industrial Engineering and Management at the Faculty of Mechanical Engineering in spring semester 2013. The game aimed at completing Formula 1 cars (LEGO^{TM} products available) at a limited time on four workstations, whereas the production process, bottlenecks are observed and stages timed. After the first round, process improvements could be made. The competitive game was successfully played as test game during the Museum Night in May 2013 and the further-developed version demonstrated of the robotics fair Robotex in November 2013.

The team of students within the course together with the supervisors tested the idea of such a LEGO^{TM} LEAN GAME and Lean Lab on the national business model competition "Mektory business model competition 2013" and were awarded with the 4th place. The competition was co-arranged by Swedbank, TUT, Tehnopol and SilberAuto. The game will be the sample and the pilot project example at the Innovation Lab of Logistics and Supply Chain at the TUT.

Developing a game also serves as a study method both for the methods of the field of study as well as entrepreneurship and product development and this will be continued to be the part of curricula in the Master Studies.

3.2. Case Study: Learning through helping - Logistics Helps

Student course project „Learning through helping - Logistics Helps" is also one example of new innovative learning process. During the spring semester of 2013 students of Logistics were divided in 6 teams with weekly assignments during 16 weeks. Their first task was to identify a country and an institution that needs aid, and produce arguments why that specific country and institution needs help.

The next steps in learning process were to make contact with the institution, specify the items that they are lacking, gather the items from local high-schools, store them, pack them, get delivery funding, and finally ship them to the location chosen. Teams received grades after there was proof of real shipment having reached the institution. During this process the students learned about logistics but also about foreign countries, helping other, marketing, negotiating, working as a team, and as a result gathering valuable experience in succeeding as a future employee.

Using this case study it was possible to observe how students act and feel different carrying out simulations or projects on the paper and projects that have a real life measure. The difference of motivation and enthusiasm was very obvious. Real deliveries were received and joy was brought to institutions in Cambodia, India, Guatemala, Mali, Philippines and Kenya. The chance of helping and learning was fondly accepted by students and the amount of knowledge received to be more skilled in the future was obvious. After this experiment the faculty came to the understanding that similar projects will be permanently integrated into the curricula.

4. Discussion

To achieve this new methods of hands-on method teaching have been adopted and also universities are providing new support systems and support infrastructure for the students. The Innovation Lab of Logistics and Supply Chain aims to be the process innovation and incubation center. The environment is supportive for development of solutions in the area of logistics, transport planning as well as manufacturing process. RFID tags and tracking methods are just one example of the topics that is the field-to-test and to be analysed together with the students via hands-on learning process in partnership with businesses in the field.

Looking at the benchmarking objects for transport planning and supply chain/production process simulation has been made additionally to plan the development activities for years 2014 and onwards. The examples of other universities and research/demo-centers can be transferred, but in many cases, have to be improved in order to fit the local needs.

It is understandable, that in current stage where the knowledge-transfer between the industry and the academia in Estonia is well-developed in several fields (space industry, ICT both technology and soft-ware-wise), it is not yet that developed in fields related to logistics, shipping, transport or production nor warehousing or supply planning. It is therefore not possible to adapt all international models of business-academia cooperation in Tallinn in full speed. At the same time, the teaching methods for hands-on learning used in wide range of universities in the world can be applied; in Estonian case, even more rapidly already together and in close link with the data and cases from the industry. The programs and the IT-solutions developed in different research centers, universities or even companies can be implemented as both academia and the businesses are in Estonian case software and IT-friendly. Those conditions allow Innovation Lab of Logistics and Supply Chain Engineering at the TUT to become one of the leading laboratories and knowledge transfer hubs in the field.

5. Conclusion

The transfer of scientific and technological know-how between the industry and the academia is seen vital for the innovation, business success and economic development of a country or a region. It is only in recent years that clear steps have been taken to strengthen the connections between companies and the universities.

The models of knowledge transfer and the best practices of establishing special centres or innovation laboratories is a trend in its beginning. For problem-solving, prototyping or process improvement case study, an environment in the shape of a Aalto Design Factory or Living Labs have been established. Since 2013, there is such a centre at Tallinn University of Technology, a four-floor Business and Innovation Centre Mektory structuring the connections and knowledge-transfer between businesses and academia.

At the Tallinn University of Technology, the logistics, transport planning and supply chain engineering discipline got its speeding from the establishing of the Department of Logistics and Transport and is gaining strength via the founding of the Innovation Lab of Logistics and Supply Chain. Higher education in the field lacked the involvement of businesses and hands-on learning methods.

With the launch of Business and Innovation Centre Mektory, the cooperation between private sector and the university became more visible and the ground for interdisciplinary research projects in the field of logistics and supply chain engineering became more supportive. With the application of framework of business cooperation standards, student involvement as well as motivation systems, the new Mektory building to be opened as the space for performing the tests and incubation, the aim of reaching a contemporary, competitive and innovation-supporting situation is step by step reached. The businesses, both small- and large-scale, will be approached by the university providing the structured approach to the knowledge transfer as an alternative to business sector's own intra-sector innovation. The university will be having a period of proving its concept to be the working one, still yet, the researches and experience shows that enterprises often make their preference to the university service rather than another private consultancy in process analysis or prototyping.

Before planning and establishing novel environment serving as centre of innovation and knowledge transfer was elaborated methodology for integrating different areas as logistics (service), engineering, ICT, business. The concept

of multidisciplinary centre involving corresponding labs serving as knowledge transfer hubs has been proven through case studies.

The process of launching the Lab – simulation and demo-center as well as interactive space for knowledge-driven research and innovation is happening during the publishing of this paper, the activities and application of comprehensive hands-on teaching methods and knowledge transfer is expected to gain more speed in 2014.

Introducing hands-on learning methods via laboratories for logistics, transport, ICT, production or planning process simulation in Tallinn allows the innovations be more comprehensive and the expected novel supply chain solutions for the private as well as public sector in Estonia and in the region.

The most sustainable and prospective way of guaranteeing continuous research development and the transfer of knowledge starts from micro- or medium-size projects and relatively small student projects, as shown in case studies in the current paper. The methods shall support the Estonian economic development, regional scientific and entrepreneurial environment as well as the European Union aspirations towards the most innovative and competitive Economic Area in the world. It will only be the continuous benchmarking and explanatory work as well as expected results that will allow the progress to be achieved.

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