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# A Multidisciplinary Learning Environment in Information Systems Development

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# A Multidisciplinary Learning Environment in Information Systems Development

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**Abstract**

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Developing quality information systems for any field requires both technological expertise and perception of the field, which can be achieved through multidisciplinary teamwork. Laurea University of Applied Sciences' student-centered pedagogical approach, *Learning by Developing*, along with the variety of degree programmes and externally funded research, development and innovation projects that Laurea has, forms a framework with many possibilities for this to be actualized. The various projects can be seen as learning environments that create new skills and competencies for students, teachers, researchers, companies and public organizations alike. The Learning by Developing model develops both academic knowledge and competencies by solving authentic problems in real-life situations.

This study examines one exemplary learning environment where these aims were actualized. Students (n=6) from Business Information Systems, Security Management and Nursing collaborated to foster an authentic environment, where solutions from an international research project, Multi Agency Co-operation In Cross-border Operations (MACICO), were evaluated during Viksu 2014 Camp for Junior Firefighters. This project environment resulted in five theses with different perspectives and objectives. The novelty of this environment was the broad multidisciplinary team of students. Furthermore, similar studies on student collaboration during the authentic demonstration phase of such a project had not been done before.

This explanatory case study aims at answering the question: "How can multidisciplinary studying be understood and described in information systems development?" through analyzing descriptions of student interactions collected iteratively from various data sources. This thesis compiles the results of three internationally published studies from 2014, as well as analyzes their results further by using the students' published theses as a new source. The first study describes working in the environment. The second study uses narrative interviews to gain a deeper understanding of the student participants' experiences. The third study is participatory, which enabled new observations from the perspective of information systems, as well as the collection of data on which and what kind of factors affected the evaluation of the results.

The main strength of the learning environment is the co-operation of students from multiple fields, enabling the collective utilization of each other's expertise. The results of the student projects were useful for the MACICO partners, and students gained diverse expertise, abilities to adapt to constantly changing environments, and resilience in situations where there is no one correct solution. From the information systems perspective, the study emphasizes the meaning of adequate and balanced student recruitment. The good results and the students' evaluations suggest that students can be given as much responsibility as they are willing to take. The study also proposes improvements for future learning environments and encourages developing new co-operation models between students from different degrees and fields.

Keywords: multidisciplinary learning, learning environment, research project, Learning by Developing, authentic evaluations, information systems development, explanatory case study

Laurea-ammattikorkeakoulu
Laurea Leppävaara
Tietojärjestelmäosaamisen koulutusohjelma

Tiivistelmä

Esa Jokinen

**Monialainen oppimisympäristö tietojärjestelmien kehittämisessä**

Vuosi 2015 Sivumäärä 49

Laadukkaiden tietojärjestelmien kehittäminen minkä tahansa alan käyttöön vaatii sekä teknistä osaamista että kyseisen alan tuntemusta. Tämä voidaan saavuttaa monialaisessa yhteistyössä. Laurea-ammattikorkeakoulun opiskelijalähtöinen Learning by Developing –toimintamalli yhdistettynä koulutusohjelmien sekä tutkimus-, kehitys- ja innovaatiohankkeiden kirjoon tarjoaa monia mahdollisuuksia tämän toteutumiselle. Hankkeet voidaan nähdä oppimisympäristöinä, jotka luovat uusia taitoja ja kompetensseja niin opiskelijoille, opettajille, tutkijoille, yrityksille kuin julkiselle sektorillekin. Tämä projektimalli kehittää sekä akateemista tietämystä että kykyjä ratkaista oikeita ongelmia todellisissa tilanteissa.

Tämä tutkimus tarkastelee yhtä esimerkillistä oppimisympäristöä, jossa edellä kuvattu toteutui. Opiskelijat (n=6) tietojärjestelmäosaamisen, turvallisuusalan ja sairaanhoitajien koulutusohjelmista lyöttäytyivät yhteen muodostaakseen autenttisen ympäristön, jossa kansainvälisen Multi Agency Co-operation In Cross-border Operations (MACICO) -tutkimushankkeen synnyttämiä ratkaisuja evaluoitiin palokuntanuorten suurleirin, Viksu 2014:n aikana. Tämän työn tuloksena syntyi viisi opinnäytetyötä, joista kullakin on oma näkökulmansa ja tavoitteensa. Hankkeen demonstraatioissa käytettiin poikkeuksellisen monen alan opiskelijoista koostuvaa tiimiä. Samanlaista tutkimushankkeen autenttisiin evaluointeihin keskittyvää tutkimusta ei myöskään ollut aikaisemmin tehty.

Tämä selittävä tapaustutkimus pyrkii vastaamaan kysymykseen: ”Miten monialaista opiskelua voidaan ymmärtää ja kuvata tietojärjestelmien kehittämisessä?” Tutkimus analysoi monista eri lähteistä iteratiivisessa prosessissa kerättyjä kuvauksia opiskelijoiden vuorovaikutuksesta. Tämä opinnäytetyö yhdistää kolmen kansainvälisesti julkaistun osatutkimuksen tulokset ja päivittää niitä käyttäen julkaistuja opinnäytetöitä uutena tietolähteenä. Ensimmäinen tutkimus kuvasi työskentelyä oppimisympäristössä ja toinen laajensi ymmärrystä opiskelijoiden kokemuksista kerronnallisten haastattelujen avulla. Kolmas tutkimus koostui osallistuvasta havainnoinnista tietojärjestelmien kehittämisen näkökulmasta ja tarkasteli tekijöitä, jotka vaikuttivat hankkeen tulosten arvioinnin toteutumiseen.

Oppimisympäristön suurin vahvuus oli opiskelijoiden välinen yhteistyö, jossa opiskelijat pystyivät hyödyntämään toistensa asiantuntemusta. Opiskelijoiden työn tulokset olivat hyödyllisiä yhteistyökumppaneille, ja opiskelijat kehittivät monipuolisen asiantuntijuuden ohella kykyjä sopeutua jatkuvasti muuttuvaan ympäristöön sekä tilanteisiin, joissa ei ole vain yhtä oikeaa ratkaisua. Tietojärjestelmien kehittämisen näkökulmasta tutkimus tähdentää asianmukaisen ja tasapainoisen opiskelijoiden rekrytoinnin merkitystä. Hyvät tulokset ja opiskelijoiden omat kuvaukset osoittavat, että opiskelijoille voi antaa niin paljon vastuuta, kuin he ovat valmiita ottamaan. Tutkimus antaa myös kehitysehdotuksia samankaltaisten ympäristöjen rakentamiseen sekä rohkaisee kehittämään uusia yhteistoimintamalleja eri koulutusohjelmien ja -asteiden välille.

Asiasanat: monialainen oppiminen, oppimisympäristö, tutkimushanke, Learning by Developing, autenttinen evaluointi, tietojärjestelmien kehittäminen, selittävä tapaustutkimus

List of Publications

P[1] E. Jokinen, J. Rajamäki, K. Karppinen, L. Tarkkanen & S. Tiainen. “Learning within Research, Development and Innovation Projects. Case: The MACICO project” in Interactive Collaborative Learning (ICL), 2014 International Conference On, ISBN: 978-1-4799-4437-8, pp. 877-883.

P[2] E. Jokinen & J. Rajamäki. “Learning Experiences within Authentic Demonstrations. Research Project Demonstrations at Viksu 2014 Camp” in 2015 IEEE Global Engineering Education Conference (EDUCON), ISBN: 978-1-4799-1908-6, pp. 388-394.

P[3] J. Simola, E. Jokinen & J. Rajamäki. ”How situational awareness can be improved by using real-time video? Case: simulated natural disaster at the Viksu 2014 camp”. International Journal of Systems Applications, Engineering & Development, Volume 9, 2015, ISSN: 2074-1308, pp. 85-92. Publisher: NAUN Press.

Publication Forums

The first paper was presented in the International Conference on Interactive Collaborative Learning (ICL2014) organized by IGIP (International Society for Engineering Pedagogy) and IAOE (The International Association of Online Engineering), and was part of the 2014 World Engineering Education Forum (WEEF2014). The second paper was presented in IEEE (Institute of Electrical and Electronics Engineers) Global Engineering Education Conference (EDUCON) that has been qualified by the publication forum initiative of the universities in Finland in 2013–2014. Both of these conferences proceedings were double-blind peer-reviewed and are indexed in the IEEE Xplore digital library.

The third article was published in the *International Journal of Systems Applications, Engineering & Development*, a peer-reviewed journal published by NAUN (North Atlantic University Union) and a WSEAS (World Scientific and Engineering Academy and Society) affiliate. The article was an invited extended version of peer-reviewed paper presented in the 5th European Conference of Computer Science (ECCS ’14).

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# 1 Introduction

Developing quality information systems for any profession or field requires, along with technological expertise, a perception of that specific field. An understanding of the field these information systems are built to assist helps in the recognition of the real needs of the field. Compared to technology-driven solutions, need-based solutions are easier to implement and deploy. Since it is difficult to find a person who is qualified in two or more fields, multidisciplinary collaboration is an option that enables learning opportunities for all collaborators. On the other hand, by having some degree of understanding on how technologies are developed and what technological limitations there might be, a person who understands the needs of the user may be able to point out new innovations that would help the development of the technology.

Laurea University of Applied Sciences' student-centered pedagogical approach, namely 'Learning by Developing' (Raij, 2007), is an applicable framework for creating multidisciplinary learning environments, which can be collaborative as well as develop competencies to work in these kinds of environments after graduation. The wide variety of Laurea's degree programmes and research projects is in support of this aim as well. For instance, the field of security management uses many technological solutions that students from business information technology can develop and evaluate. Similarly, the field of public safety connects nursing and social services to security management, and information systems are likewise needed in those professions. Some degree programmes, such Service Innovation and Design specifically aims to provide (multidisciplinary) solutions for (need-based) problems raised in products and services alike. The possibilities of multidisciplinary work collaboration and co-operation in different variations are enormous.

This study examines one exemplary learning environment where this was actualized. Students (n=6) from Business Information Systems, Security Management and Nursing collaborated to create an authentic environment where solutions from an international research project, Multi Agency Co-operation In Cross-border Operations (MACICO) (Kämppi, Rajamäki, Tiainen, & Leppänen, 2014), were evaluated during Viksu 2014 Camp for Junior Firefighters. This project resulted in four Bachelor's and one Master's Thesis that all had different perspectives and objectives. In this study I aim to answer the research question: "How can multidisciplinary studying be understood and described in information systems development?" The unit of analysis in this explanatory case study (Yin, 2009) is descriptions (of interactions) collected iteratively from various data sources.

In this study, I aim to understand and describe how the MACICO project and its demonstrations are integrated into study units; how this learning environment represents the Learning

by Developing approach; how students experience learning through multidisciplinary collaboration; what kind of competences they gained; and what should be taken into account when creating similar learning environments. The encouraging results can also be utilized in other related learning approaches.

## 1.1 Learning by Developing

Learning by Developing is a student-oriented research, development and innovation project model of Laurea University of Applied Sciences. It is a model where learning happens not through theoretical study, but through student-participation in the progress of development projects as collaboration between university lecturers, students and professionals. The defining features of Learning by Developing are authenticity, partnership, experience, creativity and an investigative approach. In this learning model, not only the individual student but the whole community is learning, producing new knowledge and building up new competencies (Raij, 2007). This student-oriented research, development and innovation model has evolved over the years: currently, students take responsibility of the whole lifecycle of the project from preparation to application, implementation and demonstration (Laurea UAS, 2014).

In this study, the learning environment is seen as implementation of Learning by Developing and is therefore understood and studied in the context of this particular pedagogical approach. Hence, the theoretical framework of learning is built by following references of related pedagogical models and perceiving their relations.

Raij (2007) compares Learning by Developing to other praxis-based learning approaches like problem-based learning, progressive inquiry learning and learning by expanding. Problem-based learning originated in medical school and has two educational objectives: simultaneously with the acquisition of knowledge on the problem, students develop problem-solving skills (Barrows, 1980). Progressive inquiry learning, a pedagogical framework developed in the University of Helsinki, entails that knowledge and understanding are constructed through solving problems and building explanations in a deepening question-explanation process (Muukkonen, Hakkarainen, & Lakkala, 1999; Muukkonen, Hakkarainen, & Lakkala, 2004). Learning by expanding is an activity theory based approach where new knowledge is achieved as ideas or concepts are enriched in an expansive cycle of questioning the old and creating new models and solutions (Engeström, 1987). In these approaches the learning process starts from a problem or a need for a change. According to Raij (2007), Learning by Developing goes further: the process starts by recognizing the phenomenon behind the development project. In practice, this means that students already take part in the very beginning of the project when the project is defined and structured.

Vyakarnam, Illes, Kolmos, & Madritsch (2008) evaluate the model and compare it to other similar models. They question the need for creating a completely new model instead of combining existing models like project-based learning (Krajcik & Blumenfeld, 2006), but also recognize the advantages of a separate, university-sanctioned strategy, since it may increase teachers' motivation and engagement in implementation. For this study, this evaluation is most beneficial in perceiving the relations between the different models, as it is the broadest objective evaluation of the Learning by Developing model.

Furthermore, Learning by Developing is also more open and flexible and has a more holistic view of students than the models that concentrate on projects or problems. This model can also improve students' investigative and social skills (Vyakarnam et al., 2008). If in experiential learning (Kolb, 1984) students just repeat predefined experiences, they will not gain the ability to make circumspect decisions in unpredictable and diverse real-life situations (Rauste-von Wright & Wright, 1994). Learning by Developing reacts to these concerns by enabling the students' learning of and fostering the improvement of these capabilities that are also essential and expected knowledge in the specialized work that studying in a higher education institution is intended to prepare them for.

Pirinen (2014) recognizes the similarities between current learning approaches as well, and describes how almost all of them can be seen, rather than as totally new, as a continuum derived from Dewey's classical educational theories and models. Dewey (1916) sees education and learning as active and constructive social processes: and the purpose of learning as the enabling of student's full potential instead of learning pre-defined skills and knowledge. This revises teacher's role from a lecturer to a facilitator and a guide who prompts the students to discover the meanings within the subject area independently (Dewey, 1938).

Taatila (2009) discusses similar ideas on the perspectives of the teachers' role in Learning by Developing: if teachers do not 'feed' students with instructions, do not show the way or impart knowledge, but rather create problems, challenge the views of students, concentrate on motivating and supporting them in collecting the information they need, can they even be called 'teachers' anymore? The learning environment in this study is an example of this kind of nontraditional participation of teachers, which is more thoroughly described in subsection 4.2.

In order to work, as a student-centered and self-guided model Learning by Developing also requires commitment, motivation and personal learning skills from students. Kolb (1984), in his theory of experiential learning, recognized four essential abilities needed in order to learn from personal experiences: a learner must be actively involved and able to reflect on the experience, conceptualize it and then use it in decision-making. Merjanaho (2011) examines

how using the Learning by Developing model influences student motivation and well-being in reflection to the self-determination theory (Ryan & Deci, 2000) and to the goal setting theory (Locke & Latham, 2006). His observations of the supporting qualities (atmosphere, freedom, feedback, sufficient guidance, and feeling of equality) and thwarting qualities (work load, stress, defective guidance, and unclear instructions) are mostly present in this study as well.

In addition to these theories of motivation, attribution theory helps in the understanding of students' experiences of achievements and failures. According to Weiner (2000), success and failure evoke an attributional process where personal history, social norms and the performance of others are all influencing the outcome. This internal causation can affect the level of performance on a task that is considered challenging. Knowledge of the attribution process allows making predictions about reactions to success and failure (Weiner, 2000), which can further help in finding ways to affect this outcome: motivation can be improved by demonstrating how effort can make a change.

## 1.2 Related Projects and Demonstrations

As a central feature of Learning by Developing, Laurea University of Applied Sciences' students have been involved in many student-centered projects. As of present, there are 20 ongoing and 78 completed projects funded by, amongst others, Finnish Funding Agency for Innovation, European Commission (FP7, ESR) and the Ministry of the Interior.

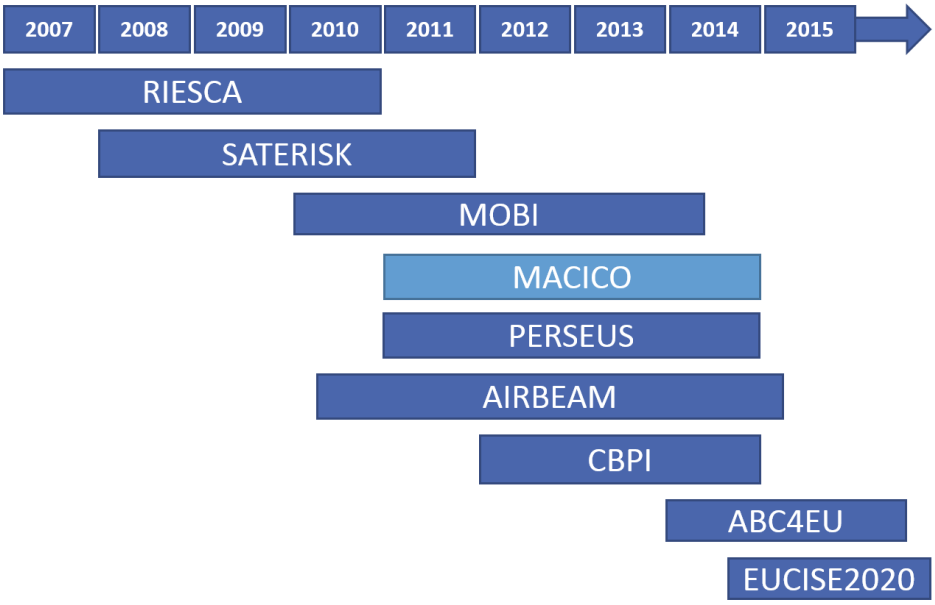


Figure 1: Timeline of related projects.

Other projects can relate to this project in two ways: through similar targets and through similar demonstrations of project outcomes. This subsection introduces public safety research

projects that are derived from the RIESCA (Rescuing of Intelligence and Electronic Security Core Applications) project as examples. Figure 1 presents the project names and their timeline to clarify their relations. The MACICO project is highlighted as this study is related to the demonstrations of the MACICO project.

The aim of RIESCA was to offer contributive and constructive solutions, such as design science research based solutions, to improve the reliability and security of information systems related to critical infrastructure. This critical infrastructure protection includes transport and logistics, power and telecommunication and power plants (Pirinen & Rajamäki, 2010). The aim of SATERISK (Risks of Satellites and Satellite Tracking System) was to study the risks connected to satellite tracking, and also to find possible indirect risks (Rajamäki, Pirinen, & Knuuttila, 2012). The MOBI project focused on emergency vehicles in order to create a common hardware and software infrastructure for them, including voice and data communication, computers, screens, printers, antennas, cabling and batteries (Tikanmäki, Rajamäki, & Pirinen, 2014). The project focal to this study, MACICO (Multi-Agency Co-operation in Cross-Border Operations) project concentrated on improving interoperability of communications between different authorities both within the country and across the borders (Kämppi et al., 2014). The relations between the scopes of these projects are visualized in Figure 2, as adopted from Rajamäki (2014).

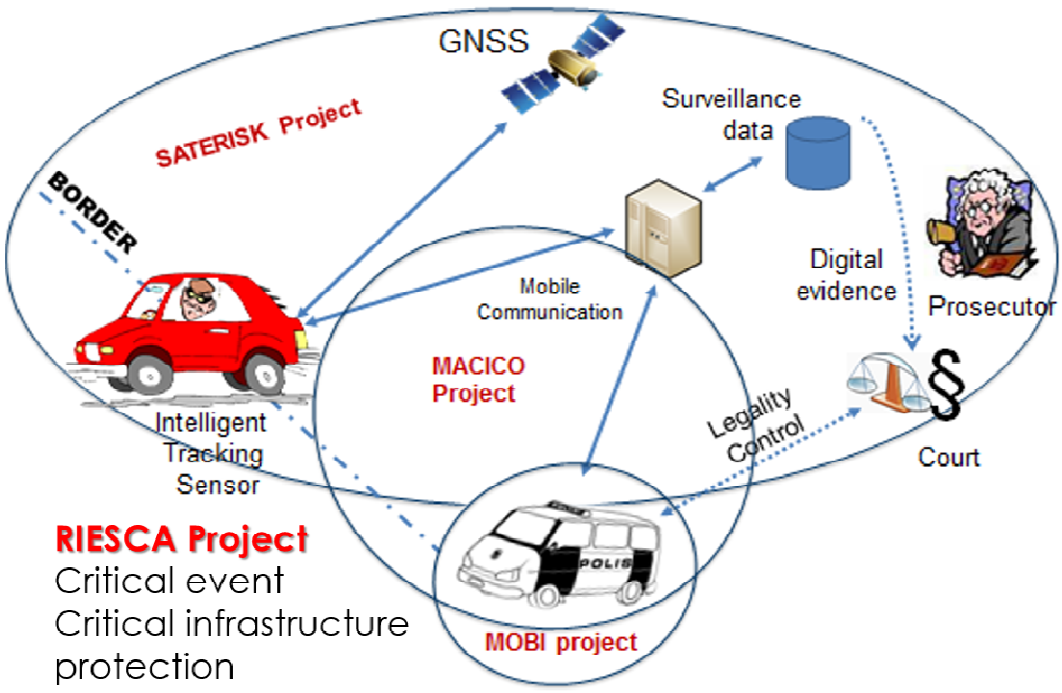


Figure 2: The traversing scopes of related projects (Rajamäki, 2014).

The PERSEUS (Protection of European borders and Seas through the Intelligent Use of Surveillance) developed and tested a European system for maritime surveillance and addressed the

large-scale integration, validation and demonstration of novel security systems. The AIRBEAM (AIRborne information for Emergency situation Awareness and Monitoring) project's objective was to develop tools for crisis management, especially through the usage of unmanned aerial platforms, including satellites. The CBPI (Cross-Border Photonics Initiative) project was related to AIRBEAM as the focus of Laurea UAS was to test similar unmanned aerial vehicles in simulated border areas. The ABC4EU (Automated Border Control Gates for Europe) and EUCISE2020 (European Union's information Sharing Environment) are the currently ongoing projects. The purpose of ABC4EU is to improve automated border control gates to enhance the flexibility of border control. Meanwhile, EUCISE2020 focuses on improving common information sharing between European maritime institutions (Kämppi et al., 2014).

As can be concluded, related projects focus on public safety research. The field of national and industrial safety is broad and therefore able to provide various approaches for many Laurea UAS degree programmes: students from Business Management, Business Information Technology, Security Management, Nursing and Service Innovation and Design programmes are all somehow related to the field. The common domains between the projects make it possible for the achievements of the projects to be frequently utilizable in other projects: technologies and practices developed for one project may be tested and their use can be furthered during later projects. That also gives more flexibility to students, since even though their studies may not be on the same timeframe as their project's duration they are still able to report their results to another ongoing project, thereby providing them a channel for publication.

This study focuses on the phase of the projects where the outcomes are evaluated and demonstrated, i.e. actualized in practice. In the RIESCA and the SATERISK projects demonstrations were held, but there seems to be a scarcity of information on them, since no theses focusing on the demonstrations themselves were written on these projects. Another reason for the lack of documentation may be that the results may have been too confidential due to the nature of the field of Public and Industrial Safety, allowing only the publishing of the models and applications but not sharing the observations made while testing them in real life. In relation to the field of the MACICO project, as a part of RIESCA project, four students tested and demonstrated the usability of Terrestrial Trunked Radio (TETRA) networks in a large multi-organizational event by monitoring the communication and organizing an opinion poll (Pirinen & Rajamäki, 2010). Lastly, during the MOBI project, several outcomes were demonstrated at once by building a demo emergency response vehicle with field-proven technology: onboard computers, voice communications by TETRA, data communications by distributed systems intercommunication protocol (DSiP), smart batteries and smart inventory system based on RFID technology. This demonstration vehicle was one of the eight work packages the project was split into (Tikanmäki et al., 2014).

## 1.3 The MACICO Project and Viksu 2014 Camp

The aim of the MACICO project was to develop a new interworking concept for security organizations which do not use the same communication network on a daily basis, but could benefit from sharing their respective infrastructures. It was a Celtic-Plus project with nine project consortium partners from Finland, France and Spain (Kämppi et al., 2014).

The project was divided into six work packages: WP1: Project management, WP2: End users requirements capture, WP3: Architecture & standard operating procedures, WP4: Implementation for multi-agency interoperability, WP5: Demonstration, and WP6: Dissemination and standardization. Along with this international research community work, Laurea UAS also had local individual projects with partners in Finland. Thus, the MACICO project also worked as a learning environment that implemented the Learning by Developing approach (Kämppi et al., 2014). This study concentrates on WP5 Demonstration, and evaluates the MACICO project as a learning environment.

Students from Laurea University of Applied Sciences have participated in several MACICO related studies: writing reports about TETRA and TETRAPOL usage around the world; conducting innovation projects that led to commercialized mobile communication service increasing safety and security in urban areas; studying opportunities of social media in crisis situations, et cetera.

Ahokas, Guday, Lyytinen, and Rajamäki (2012) apply solutions from MACICO to the field of power distribution by studying Distributed Systems intercommunication Protocol (DSiP) in combining multiple telecommunication channels in Supervisory Control and Data Acquisition (SCADA) systems. SCADA systems are used for controlling power stations and protecting power distribution. Therefore, secure data transfer between the control center and power stations is critical. Current telecommunication networks used for the SCADA do not provide the capacity required for real time video streaming, and standard Internet connection does not provide the required reliability and security. DSiP combines all these telecommunications resources into a single system.

In another paper, Ahokas, Rajamäki and Tikanmäki (2012) discuss using DSiP as a highly redundant and secure data communications network solution in European Public Protection and Disaster Relief (PPDR) organizations. The paper addresses interoperability and other issues both between different services and different systems used by the same service. It describes what kind of benefits DSiP solution can offer. In his Master's Thesis, Ahokas (2013) summarizes these papers and compares DSiP to other solutions available. Actual development was not done, so all of the findings are based on theoretical evaluation and comparison. Therefore,

the thesis recommends testing the proposed solution in order to find its practical limitations. DSiP based gateway was in use at the Viksu 2014 camp.

Viksu 2014 was an international camp for junior firefighters that was held from June 29 to July 5, 2014 in Pori, Finland. Over 2,800 attendees from volunteer fire brigades participated in the camp. Laurea UAS was participating in the camp through the MACICO project, since the project needed an authentic environment for demonstrating the project outcomes, the various communications-related methods provided by the partner organizations (Kämppi et al., 2014). The MACICO project held scenario exercises related to communication and performance in exceptional circumstances. The objective of the scenario exercises was to examine practices in crisis situations and seek for ways to make use of modern technology solutions in improving performance efficiency. The technological solutions used in the scenario exercises were using a temporary TETRA network and TETRA phones, satellite connection and an Android application in helping to gather situational awareness information.

The original plan was to build a temporary, local TETRA network for the camp organization and to connect it with the Government's Official Radio Network in Finland (VIRVE) using an Inter-System Interface (ISI) that provides a terminal with the possibility to roam in another TETRA network. For security reasons and due to lack of time, connecting the local TETRA network of Viksu 2014 to the VIRVE network was not possible, and those networks were used separately. Therefore, the main interoperability problems in the MACICO project were related to people and organizations, not technology, and thus the objectives of the demonstration were steered more towards the communicative aspects. This meant that the alternative technological solutions to be used at the demonstration became more important.

The Eye Solutions system was used at the camp in order to get situational awareness information. The system was gathering live audio and video feeds from the field to the camp security management using the cameras and microphones of contemporary smartphones. The system consists of a PC that is used to administrate the system, some screens to monitor the situation, Android smartphones to gather the live information from the field, and Ajeco's multichannel 4Com router implementing the DSiP protocol. The system administration software is browser and java based and was run local on a PC. The smartphones can be remotely controlled by the administration software. The situational awareness system of Eye Solutions and the reliability of communication through the 4Com router were tested in the camp by Ajeco personnel and Laurea's students. Picture 1 presents the DSiP gateway, command and control center interface on a screen and one of the mobile phones used for recording video and sending locational information as they were set up during the Viksu camp.


Picture 1: Information systems utilized in authentic situations. (Photo: Tapio Mäkinen)

Six students from Laurea UAS collected data for their theses during the camp by planning and executing the scenario exercises, observing camp organizations' communication and performance, comparing the outcomes to safety and security plans, and interviewing the personnel. The roles of the students, as well as the expertise of this multidisciplinary team are briefly described in section 4. This study examines the work of these students as a multidisciplinary learning environment where information systems were utilized and evaluated in authentic situations. These situations were planned and arranged by students from security management and nursing since they had skills in these areas from the user's perspective.

The aim of this study is to understand and describe how the MACICO project and its demonstrations were integrated into study units, and how this learning environment represents Learning by Developing. It also aims to understand and describe how students experience learning through multidisciplinary collaboration, what kind of competences they gain and what should be taken into account when creating similar learning environments in the future.

# 2 Research Methodology

## 2.1 The Main Research Approach

The planning of this study started in March 2014. Viksu 2014 related student works formed a unique and experimental multidisciplinary learning environment that was interesting to study in order to further understanding on what should be taken into account when creating similar learning environments. From this perspective, the project was selected for this case study it was an unusual, extreme case. Concepts are often defined by their extremes: prototypical, paradigmatic or ideal cases (Gerring, 2007).

In past research and development projects demonstrations had been made, but there is a scarcity of written information on the demonstrations and how they were carried out. One possible reason for this is that the fields may have been too confidential: only the result models were published, not the observations made during the process or implementation. Silverman (2011) recognizes this aspect of case selection when addressing generalizability of case studies: a case is often chosen simply because it allows access.

The MACICO project demonstrations also differed from the earlier project demonstrations in two ways: demonstrations were held in authentic situations in an authentic environment, and students formed a multidisciplinary group from different research orientations. Since the learning environment was unique, and since in the duration of this study, there has not been other similar environments, a single case study was a natural choice.

Case study research is chosen for the main research approach in this study as it is suitable for explanatory research questions asking “how” and “why” on a contemporary set of events over which the researcher has only a little control, or a contemporary phenomenon. Case study also has strength in its ability to deal with a full variety of evidence like documents, artifacts, interviews and observations (Yin, 2009). It also has a strong tradition in the academic field of management information systems (Lee, 1989) and software engineering (Runeson & Höst, 2009) and is also present in the theses of the students attending the camp, including the study in publication P[3], where I helped one of the students share his results in the form of a journal article.

## 2.2 Design and Data Collection of the Study

The first source of data was a wiki platform that the MACICO project used for information sharing as it had all the information needed to get familiar with the ongoing project. Planning of the demonstrations had already started and the wiki had records of the former meetings of

the students, their teachers and the MACICO partners. After familiarizing myself with the project, I attended the next three meetings on April 8, April 29 and June 13, 2014. Soon it became clear that in order to gain a deeper knowledge on the subject, I also needed to participate in the camp and make observations on the students' work there along with conducting clarifying conversations with the students.

The design of this study evolved during data collection as new possible data sources were found. This is in line with Yin's (2009) depiction of the nature of case study research as a linear but iterative process: the phases of the study go in a specific order (plan, design, prepare, collect, analyze and share), but the findings of later phases can lead to adjustments in the design in order to form a better understanding on the phenomenon. Figure 3 represents this process.

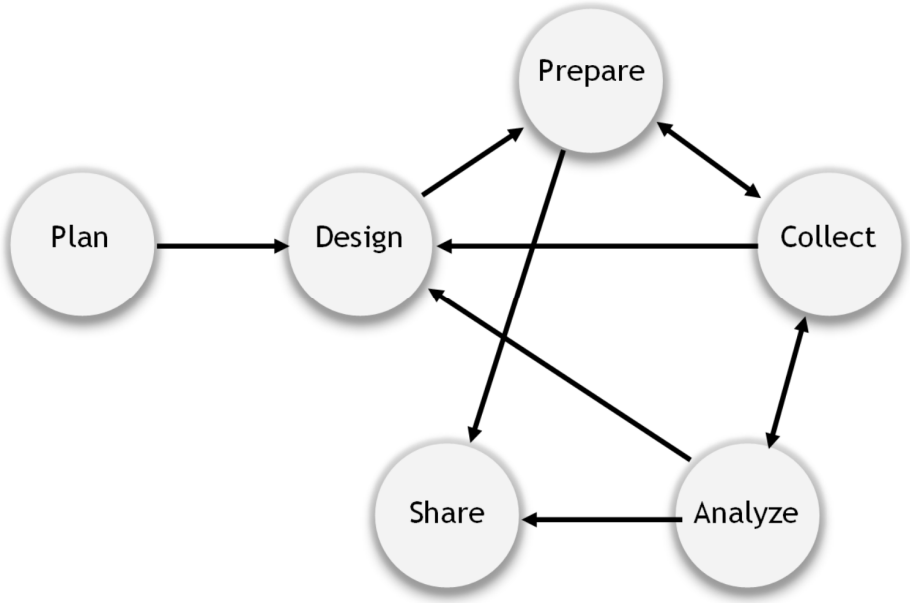


Figure 3: The Case Study Research Process (Yin, 2009).

When using case studies for building theories, Eisenhardt (1989) adds two steps after analyzing: shaping hypotheses and enfolding literature. However, this study does not attempt to shape the theory of Learning by Developing but rather attempts to examine an exemplary implementation of the framework and how it reflects the pedagogical model and its values.

The evidence consists of the documents on the wiki platform, notes from the meetings, observations at the camp and conversations with the students. During summer 2014 the students also provided information on their progress by sending extended abstracts on the data analyses and conclusions made so far. This data triangulation formed the first data set analyzed in publication P[1]. The unit of analysis for this data was descriptions (of interactions).

## 2.3 Increasing Triangulation with Supplementary Approaches

The data collected during the first study was able to describe the learning environment and how the co-operation between the students worked. However, this did not illuminate how the students experienced the environment or the learning process. Therefore, I started to design a new study for further triangulation and to gain more in-depth knowledge on the subject. Narrative interviews seemed to be the best approach for acquiring this kind of information.

According to Runeson & Höst (2009) data can be collected incrementally in case studies with the limitation that the objectives of the study must remain intact: otherwise it forms a new case rather than expands the old one. Although the different studies had supplementary research questions, they all add information to the same base research question, too. This is more of a matter of classification and can be discussed. I saw the issue simply as beneficial to increasing both the data (source) triangulation and methodological triangulation (Patton, 1999; Yin, 2009).

When analyzing this particular data for study II, the unit of analysis was a verbal depictions of students' learning experiences (during planning, executing and analyzing the outcomes of demonstrations held at Viksu 2014 camp) (Jokinen & Rajamäki, 2015). This unit of analysis is, however, in line with the overall unit of analysis of this conclusive study, as those depictions can be seen as a new data source forming new descriptions (of interactions) due to their shared descriptive nature.

A narrative can be seen as a story that consists of a series of events that are meaningful to the narrator and his audience (Denzin, 1989). In semi-structured interviews, the interviewer already has a framework of themes. Narrative interviews give more space for the interviewee to tell stories. They give answers to the pertinent questions but allow the interviewee to decide where to start, what to tell and how to tell it (Hyvärinen & Löyttyniemi, 2005). Since the interest was in themes the students see as meaningful for their learning, narrative method was deemed suitable for finding new themes and factors.

Learning can be seen as gaining knowledge and competences, but also as building an identity as a professional. According to Ricœur (1992), a person builds and defines his identity by telling stories and the story told reflects the current identity. Listening to students' stories opens a window to how the process has influenced their identity. The interviews took place four to five months after the camp, when their thesis work was near completion. Students had already formed impressions on their overall work and given meanings to events during the process. Therefore, the chosen timing for the interviews seemed ideal for getting the information wanted.

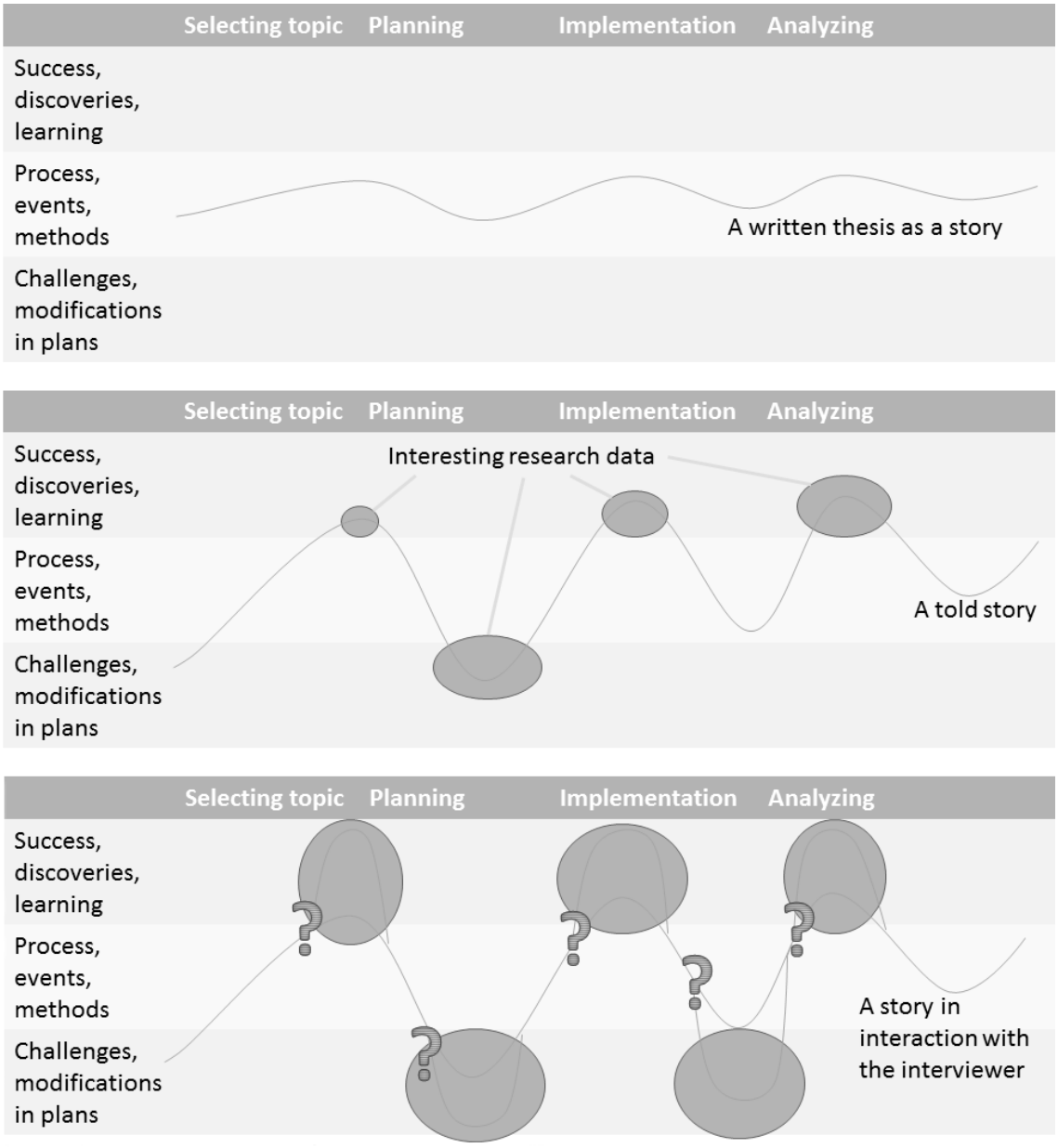


Figure 4: Comparing a written thesis, a told story and a story in interaction.

Figure 4 represents the design of the interviews. The chronological course of events was selected for the base storyline: the stories started form selecting the topic for a thesis through planning the study and implementing it on the camp, ending in analyzing the data and writing the report. This is similar to a written thesis, which can be seen as a story, too. However, a thesis usually concentrates on relevant events that form a progress: what was actually done, what kind of methods were selected and why.

A told story is more explanatory by its nature. Therefore, it was expected that the stories would meander more to the areas of experienced success and discoveries, as well as faced

challenges and modifications in plans, even when their depiction is not directly needed for explaining the decisions made. Learning often takes place in these areas, which made narrative interview a suitable research design for getting more factors that affected learning.

Data collection on the interviews was ended due to data saturation when the last interview did not provide any completely new themes, but rather new perspectives on themes already familiar. These interviews (n=4) also covered one student from all the perspectives that were studied at the camp. It was predicted that interviewing the remaining two or three students would not offer any new findings.

The interviews were transcribed and split into sections according to themes. Similar sections were combined in order to form knowledge on the factors affecting that particular theme. This analysis on categorical-content perspective was chosen because the focus was on phenomenon instead of individual holistic experience (Lieblich, Tuval-Mashiach, & Zilber, 1998). Since the amount of the transcribed data was easy to handle on paper, no programs were utilized for analyzing it. The transcriptions, however, had line numbers to make revalidation of overall context possible, and to enable recognition of where the interviewee might have been influenced by the thought of interviewer. Picture 2 represents the process of categorizing the transcriptions.

Picture 2: Categorizing of the transcribed research data.

Following the second study, study III added more triangulation through participation in the work of one of the students. How this deepened the understanding of the phenomenon from the perspective of information systems is further described in section 4.3.

## 2.4 Attributes of the Study

The following research attributes (table 1) are established for the description of the level of methodological rigor in this study (Dubé & Paré, 2003). The data collection was done during three separate studies: in this attribute list the research data is handled as combined data collection that increased the data triangulation (Patton, 1999; Yin, 2009) through the iterative process.

| | |
|---|---|
| *Title of study* | A Multidisciplinary Learning Environment in Information Systems Development |
| *Research questions* | How can multidisciplinary studying be understood and described in information systems development? |
| *Research agreement* | Assignments on lectures of a course. Email confirmation. |
| *Unit of analysis* | Descriptions (of interactions). |
| *Importance of study* | The multidisciplinary learning environment was unique and experimental and therefore interesting to study.<br>Laurea UAS gained important knowledge for creating similar learning environments in the future. |
| *Methodological focus* | Case Study Research (Eisenhardt, 1989; Gerring, 2007; Lee, 1989; Runeson & Höst, 2009; Yin, 2009) with triangulation through narrative interviews (Denzin, 1989; Hyvärinen & Löyttyniemi, 2005; Lieblich et al., 1998; Ricœur, 1992). |
| *Form of analysis* | Qualitative analysis. Categorical-content perspective. |
| *Nature of study* | Explanatory study on Learning by Developing implementation through student works related to demonstrations in Viksu 2014 Camp. |
| *Research approach* | Explanatory study, iterative explanation building. |
| *Specification of constructs* | Learning by Developing and its implementation on student works during authentic evaluations of research project outcomes. |
| *Theoretical approaches* | Learning by Developing (Raij, 2007), Learning by Research and Development (Pirinen, 2014). Comparison to similar approaches listed in attribute “Theoretical literature”. |
| *Theoretical literature* | (Dewey, 1916; Dewey, 1938; Engeström, 1987; Kolb, 1984; Muukkonen et al., 1999; Muukkonen et al., 2004; Ora-Hyytiäinen & Rajalahti, 2009; Piirainen, 2008; Pirinen, 2014; Raij, 2007; Rauste-von Wright & Wright, 1994; Vyakarnam et al., 2008) |

| | |
|---|---|
| *First research target* | To understand and describe how the MACICO project and its demonstrations are integrated into study units and how this learning environment represents Learning by Developing. |
| *Second research target* | To understand and describe how students experience learning through multidisciplinary collaboration, what kind of competences they gain, and what should be taken into account when creating similar learning environments. |
| *Research design* | Case study design including thesis works related to the MACICO project's (Kämppi et al., 2014) authentic evaluations on Viksu 2014 Camp. |
| *Data collection* | Documents on the wiki platform, notes from the meetings, observations at the camp and conversations with the students, students' narrative interviews (n=4), extended abstracts and published theses. |
| *Logic of evidence* | Internal validity mainly through iterative explanation building. |
| *Data analysis literature* | (Lieblich et al., 1998; Patton, 1999; Silverman, 2011; Yin, 2009) |
| *Interviews* | Narrative interviews (n=4) in November and December 2014. |
| *Coding* | The interviews were transcribed and split into sections according to theme. Similar sections were combined together. |
| *Notes* | Notes from the meetings and the camp. |
| *Main results* | Descriptions for progress of learning environment in this context. |
| *Role description* | Researcher mainly as outsider (interference with the phenomenon documented and described within section 4) and students as insiders. |
| *Research consortium* | The research was part of the MACICO project. |
| *Research associations* | Institute of Electrical and Electronics Engineers (IEEE); International Society for Engineering Pedagogy (IGIP); Association for Computing Machinery (ACM); North Atlantic University Union (NAUN). |

Table 1: Attributes of the Study (Dubé & Paré, 2003).

# 3 Student Works at the Camp and Their Contributions

The student works at the Viksu 2014 Camp resulted in four Bachelor's and one Master's degree theses: three for Bachelor's Degree Programme in Security Management, one for Bachelor's Degree Programme in Nursing by two students, and one for Master's Degree Programme in Information Systems. This section describes the students' roles in the Viksu 2014 Camp as well as the theoretical frameworks of these theses.

## 3.1 Roles of the Students in Creating Demonstrations at the Camp

Two students from the Degree Programme in Security Management were studying camp organization readiness, activity and communications in emergency situations. One of them concentrated on emergency situations caused by nature, while the other studied disturbances caused by human activity. This variance made it possible to create different kind of scenarios during the first weeks of planning in spring 2014. The students' roles and their relations, as well as the technologies used are visualized in Figure 5.

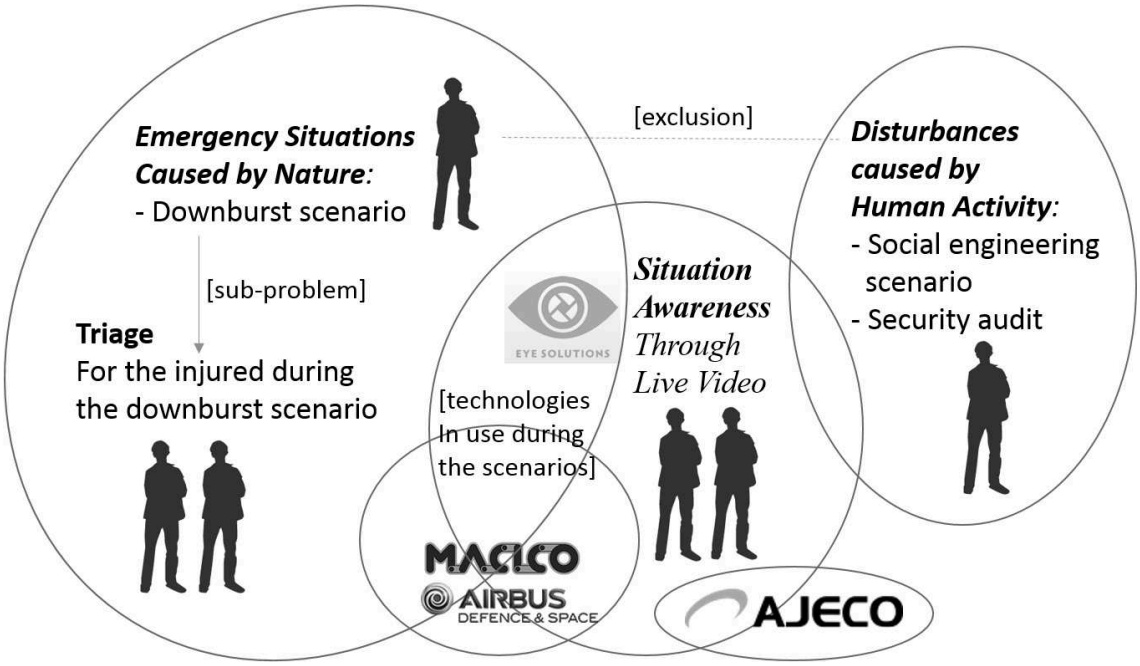


Figure 5: Relations between the student works and the technologies tested.

Readiness in emergency situations caused by nature was studied in one scenario that simulated how an organization was prepared for a downburst during a thunderstorm, and to handle the emergency situation after the disaster. The research problem was the lack of objective information about the capabilities and efficiency of crisis plans in major disasters, and the main objective was to develop an internal multi-disciplinary co-operation model for the or-

ganization (Aaltonen, 2015). Data collected during the scenario exercise was analyzed and compared to the organization's emergency plans. Then, as a result, a new multi-disciplinary co-operation model was suggested to the organization (Aaltonen, 2015). In this study, the TETRA network was in use, although the study concentrated on communication rather than the usability of the system. However, the exercise revealed that the capabilities were not sufficient with current amount of TETRA training and the radio communication skills of the camp organization (Kämppi et al., 2014).

In order to simulate the damage caused by a natural disaster, the scenario exercise necessitated the creation of a multi-casualty situation. Two students from the Degree Programme in Nursing were recruited for creating this scene: 25 patients with varying trauma descriptions were placed in an area that contained 16 tents. On one hand, this was to help the other student's study, but it was also a separate study that focused on multi-casualty situation management and primary triage (picture 3). The study compared the multi-casualty event protocol to the actual work of the emergency medical service, as well as observed the implementation of primary triage algorithms. The work of the emergency medical service was mainly successful, though the study showed that there were communication problems between the triage units and fire department units (Assinen & Kemppainen, 2015).


Picture 3: Primary triage of a victim during scenario exercise. (Photo: Jussi Simola)

Readiness for disturbances caused by human activity was studied mainly by inspecting security and rescue plans and other written instructions, in addition to observing how well the plans

were executed. The objectives of the study were to perform a security audit and to see how well information was shared between different camp units. The importance of communication was also present in this particular study, as it suggests e.g. that if any unit observes an outsider; the security personnel must be informed (Iiskola, 2015). Several scenarios were planned, including an intruder in the camp area, stealing of valuable objects, food poisoning, brawling, and a fire. For different reasons these scenarios were suppressed to hypothetical inspection only. However, one scenario was held: stealing money from camp kiosk using social engineering methods, which gave valuable information on money handling and related communication at the camp. As mentioned in the thesis, this work was mainly done to evaluate human communication between the camp organization, and did not directly utilize nor test the technologies provided by the MACICO project (Iiskola, 2015).

Two students were studying situational awareness though live video with the Eye Solutions system, also utilizing Ajeco's DSiP router. A Security Management student was conducting a case study on utilization of real-time video in rescue operations: how it is currently used, what is its potential in future, and how it adds value to the situational leading (Harvio, 2014).

A study within the Master's Degree Programme in Information Systems was one case in a broader multiple-case study on the usage of real-time video in PPDR services. In the context of Viksu 2014 it also concentrated on the implementation of the Eye Solutions provided. The study indicated that watching the real-time video ties persons down: command and control management needs separate persons for operational action and for monitoring the video footage (Simola, 2015). Cameras installed on vehicles also need remote control from the command center (Simola, 2015).

## 3.2 The Variety of Background Theories on Multidisciplinary Team

In addition to the actual work done at the camp, the qualities of the multidisciplinary team can be understood though the various theoretical frameworks they utilized in order to arrange the scenario exercises and to collect their research data during the camp. Some of these frameworks were prepared for the camps and some evolved during the process of data analysis. This overview has been updated using the published theses.

Due to context, the theoretical frameworks are described as they were perceived by the students and therefore cited only through their theses. Despite understanding that some of the frameworks needed revision from the original references, using this way to address them arguably gives a more realistic view from the perspective of student interactions and learning. Furthermore, delving any deeper into these theories than introducing them this way would be out of the scope of this study and unnecessary for following the logic of evidence.

While the data collected on individual studies answers to various separated research questions in every study, all of the separate knowledge was needed to get the scenario exercises running. As this study shows, students from just one degree programme could not have combined all these frameworks together in the time given due to a lack of general knowledge of the subjects that could only have been learned through a more involved study. Even in this broad set of students from different degree programmes, the students needed to collect background information on several subjects they were not familiar with. Figure 6 is a modified version of the last figure, where the active roles of students are replaced with the theoretical frameworks they became acquainted with for the Viksu 2014 camp.

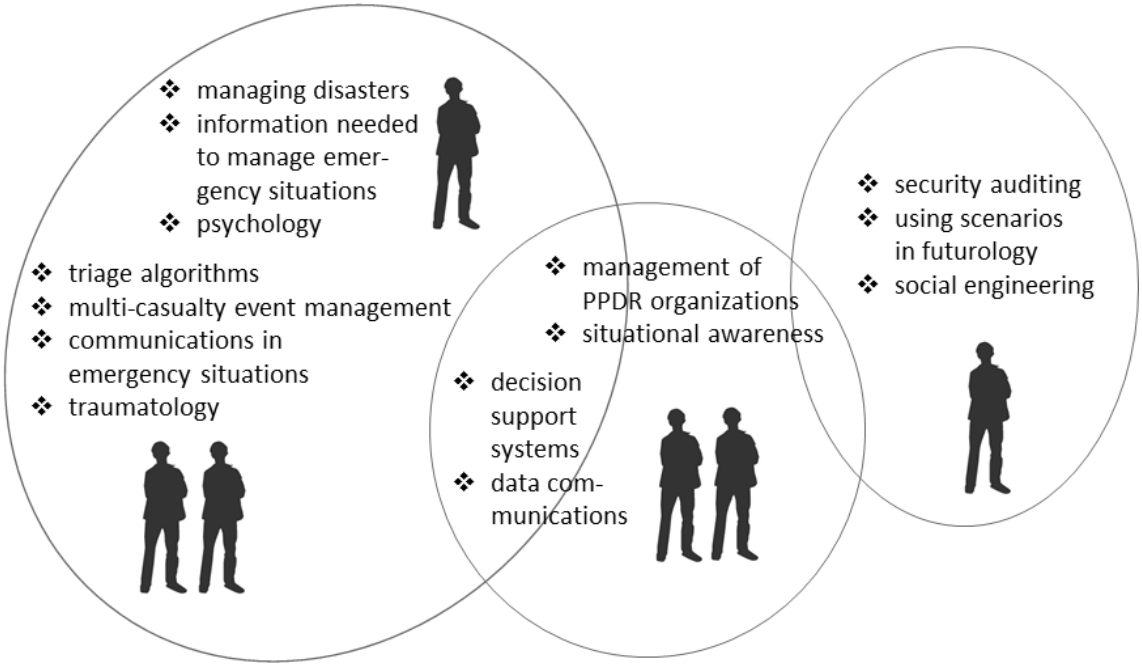


Figure 6: The variety of background theories.

In the study on readiness in emergency situations, the theoretical framework of co-operational model was based on literature about managing disasters; the information needed to manage emergency situations; as well as psychology, since making decisions and solving problems are social processes (Aaltonen, 2015). Therefore, a co-operational model was defined as different parties collaboratively creating, selecting and evaluating procedures, and standards that support mission-oriented decision making. Theoretical literature was discussed to clarify the need for prepared models in comparison to deciding the actions in situ during the emergency situation. Then, the literature review on later studies surveyed both international and national research on the subject. While the models of the authorities and the volunteers supporting the authorities had been studied before, before this case study, there has

not been all that much research on co-operational models of civilian organizations (Aaltonen, 2015).

In the planning of the simulated multi-casualty situation, the theoretical framework was based on triage algorithms and evidence-based practices in multi-casualty event management, including the organizational structure and managing of medical services and communications in multi casualty situation (Assinen & Kemppainen, 2015). This knowledge was based on both domestic and international academic material. In addition to these theories, becoming acquainted with traumatology was necessary in order to create realistic trauma descriptions. While the study concentrated on the actualization of primary triage, knowledge on secondary triage helped in creating the trauma descriptions (Assinen & Kemppainen, 2015).

The study that inspected camp's readiness for situations caused by human activities utilized three main theoretical frameworks: security auditing, scenarios and social engineering. Security auditing means systematic evaluation by a third party observer in order to measure how well the quality assurance conforms to established criteria. In this context, it meant searching for security vulnerabilities and possible improvements (Iiskola, 2015). Scenarios are used in futurology as logical chains of events that demonstrate how a possible situation evolves step by step from the current situation. They answer questions such as "what can happen?" and "what happens if?" and can therefore be used in risk management. In futurology terms, the scenarios planned for the camp can be classified as explorative, mono-sectoral scenarios. Social engineering is a term used in information systems security. The objective is to gain confidential information by impersonating a person who should have access to it. In this context the technique was applied outside information systems (Iiskola, 2015).

The studies on situational awareness are based on recent research on public protection and disaster relief as an organization, and how the management works on the scene of an accident. The procedures of the organization must produce suitable information for decision making from the very beginning of the situation, and the need for real-time information is acknowledged internationally (Harvio, 2014). These studies concentrate on the value added by real-time video footage from the scene and how it supports the formation of situational awareness in comparison to other information sources (Harvio, 2014).

The wider study on real-time video in PPDR services was done within the Degree Programme in Informarion Systems and combines both knowledge on the PPDR organization preparedness and the decision support systems as information systems, including the technologies that support each other when combined. In the context of Viksu 2014, the DSiP gateway enabled a secure and robust data communication for the system that was used for distributing the real-time video from the scene to the command and control center (Simola, 2015).

# 4 Contribution of the Study

Data collection and analysis for this study is formed through three studies that discuss the subject from different angles. Results of these studies have been published as conference proceedings P[1] and P[2] and as journal article P[3]. This section describes how these studies answer my research questions as well as provides information on my participation in the studies of other (collaborating) authors. Conclusions of each study are summarized and explained from the perspective of this study.

The following Figure (7) portrays the overall timeline of these studies and my participation in them. The first two lines compare my timeline to the schedule of WP5 of the MACICO project and the schedule of the relevant thesis workers. Study III was done in co-operation with one of the thesis workers.

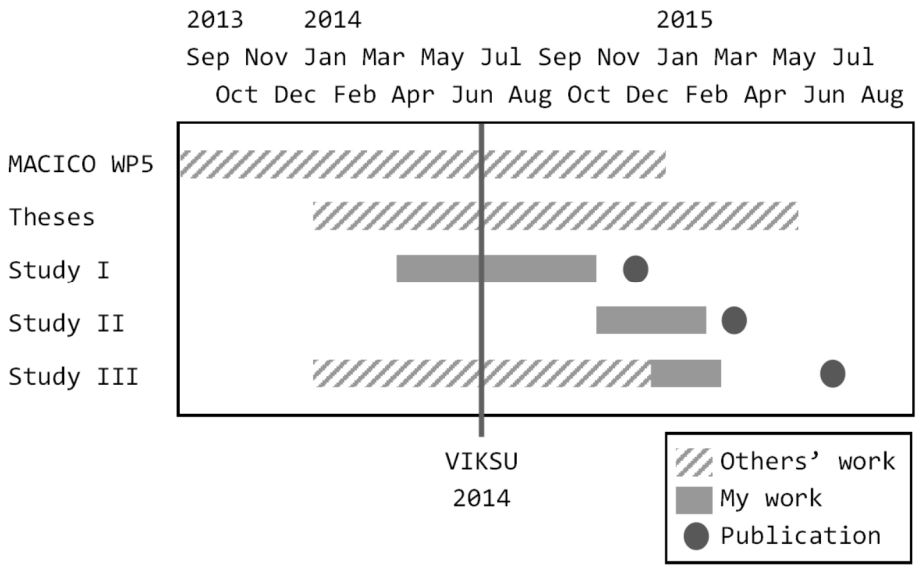


Figure 7: Timeline of the Viksu 2014 related studies.

## 4.1 Study I: Working in a Multidisciplinary Learning Environment

The aim of the first case study P[1] was to describe how the MACICO project and its demonstrations were integrated into the studies. The former MACICO-related learning achievements were described in previously published theses about the information systems developed during the MACICO project. The P[1] paper also describes how student groups were involved in the projects through different courses during autumn 2013 and 2014.

> "Abstract— Externally funded research, development and innovation (RDI) projects can be seen as a learning environment creating new skills and competen-

> cies for students, teachers, researchers, companies and public organizations. Laurea University of Applied Sciences' RDI project model develops academic knowledge and competencies by solving real problems in real-life situations. This paper describes the model through the MACICO project. This paper describes how the MACICO project and its demonstrations are integrated into the study units and studies in general, as well as providing a description of the roles and benefits of different stakeholders when creating a learning environment. Conclusions also reflect what needs to be taken into account when creating research demonstrations as student works." (Jokinen, Rajamäki, Karppinen, Tarkkanen, & Tiainen, 2014)

The study took special interest in the ongoing MACICO Work Package 5 Demonstrations, which consist of showcasing the MACICO project achievements. As described in this paper's introduction, these demonstrations were held at Viksu 2014 Camp for Junior Firefighters. Whilst P[1] describes all the studies related to the MACICO project, this particular focus makes this particular study also the basis for my further studies related to multidisciplinary teamwork in relation to the Viksu 2014 Camp. In this context the study P[1] also answers the research question "How can studying in a multidisciplinary learning environment be described?" by providing a description of such an environment, and conclusions about the benefits and differences of having this kind of arrangement in comparison to traditional team of thesis workers within the same degree programme.

The study began by collecting data on the student works in March 2014, after students were recruited and had formed a multidisciplinary group. Therefore, the first stages of planning were analyzed through the internal wiki notes and records from the meetings. After planning the data collection, I took part in the meetings where the students planned the demonstrations together with the camp organization and the MACICO partners. My role in these meetings was not limited to silent observation but I also took part in the planning by providing some ideas and knowledge on the subject from my background in information systems and as a communications specialist in volunteer rescue services. My input helped in refining the details but did not affect the overall plan.

Then, in order to get a deeper understanding, I also participated in the camp by monitoring the students and by helping some of them in practical tasks, e.g. collecting data through monitoring and recording the radio conversations during the scenario exercise (Picture 4). The P[1] paper was published in December 2014. As the theses of the students had yet to be published by its deadline, I used the extended abstracts of the students' theses as one data source along with my own notes.

Picture 4: Recording the radio conversations during the scenario exercise.

My work on publication P[1] started by describing the learning environment of Viksu 2014 Camp and the related student works. As my part in the study increased, I decided to finalize the paper for publication as well, and made my final conclusions in autumn 2014. Most of the background information described in the introduction was collected during the writing of publication P[1].

The conclusions of study P[1] notice a minor incoherence between the aim of the MACICO project work package 5 and the work done at Viksu 2014 Camp: the potential of the technologies provided by the MACICO project had not been fully utilized during the camp or during the scenario exercises. However, the studies and participation in the camp in general gave valuable information to all of the MACICO partners, helping them improve their solutions. Additionally, the camp organization also gained systematic, objective and evaluated knowledge about their readiness in combating threats caused by humans and the nature.

For the students, the arrangement served as a basis for studying the technological solutions from both operational and communicational perspectives. The scenario exercises provided a real-life platform for creating new knowledge about the field and for gaining new competencies that are useful in life after graduation. Therefore, the advantages are not limited to the MACICO framework. Also, though the project's aim was to evaluate technical solutions, the environment provided opportunities of authentic environment work for students of Security

Management and Nursing as well. The opportunities included testing theories and concepts in practice, and learning to write scientific reports on practical demonstrations.

The conclusions of P[1] also reveal that the students were given a lot of responsibility and high expectations. Due to the nature of the learning environment, data collection happened within a short period of time, as the simulations were held in specific places and circumstances that were not repeatable. Under such constraint, good preparation plays an essential role: it is not possible to repeat the scenario nor the camp even if the data collected does not fit the requirements. This is further emphasized since the participating organizations invested money in the project.

## 4.2 Study II: Deeper Understanding on Student Experiences

During the analysis of the research data of the first study, new questions arose, which the data was not able to answer. It was concluded that the students were given numerous responsibilities and were under a lot of expectations. However, this did not answer how the students experienced it and how they coped with the pressure. Also, as my knowledge on the Learning by Developing strategy and its possibilities fostering new competencies increased during the course of the first study, I gained an interest in studying what kind of competencies students felt they had gained through the process of creating authentic demonstrations of their projects.

As the methodology used did not provide any tools for collecting information on student experiences, I started searching for alternative methodologies. The eventually selected methodology of narrative interviews is briefly described in the section 'Research Methodology'. From the perspective of this study, the main research question of publication P[2] was: "What does a multidisciplinary learning environment imply for students?"

Study II and publication P[2] was mainly my own work in all planning, implementation, analyzing and publishing. My teacher, Dr. Jyri Rajamäki worked as an adviser and supervisor for my work; gave valuable viewpoints on the methodology I had chosen; and helped in understanding the history of related research and development projects Laurea had participated in.

> "Abstract—Externally funded research, development and innovation (RDI) projects can be seen as a learning environment creating new skills and competencies for students, teachers, researchers, companies and public organizations. Laurea University of Applied Sciences' RDI project model develops academic knowledge and competencies by solving real problems in real-life situations. This paper describes how this learning process is realized and integrated into a

> RDI project in an environment, where students from various degree programmes were creating demonstrations for evaluating the project outcomes. These demonstrations were planned within the Multi-Agency Cooperation in Cross-Border Operations (MACICO) project and were held during Viksu 2014 International Camp for Young Firefighters. The demonstrations will result in five theses. Narrative interviews of the students gave knowledge on how learning has happened in such environment, what kind of competences the students have gained and what should be taken into account when creating similar learning environments. Especially the good experiences from co-operation between the students encourages to combine students from different orientations into multidisciplinary teams." (Jokinen & Rajamäki, 2015)

Research findings on motivation concluded that the students that had selected to work on Laurea's research and development projects are motivated to work in such environments. They are capable for co-operation and altering their plans to help other students with their work. The freedom and flexibility of the Learning by Developing model was considered a good thing. The students enjoyed having free hands to plan and decide on matters by themselves, but, as one of the students said, they were not "left drifting and allowed to do whatever [they] wanted". Thus, the findings on motivation cannot be seen as proof of the LbD model's effects on students' motivation: it is more likely that students involved in these kinds of projects have already assimilated the basic principles of LbD.

The concerns of how the students experienced their responsibilities and the expectations did not play a greater role in the students' (self-evaluative) stories at all. Though there were moments of uncertainty, constantly changing plans, and even anxiety, all problems faced by the students were overcome by altering the plans. Afterwards, these adversities were seen as educating. For example, they helped the students value the importance of preparation and planning with consideration for different possible outcomes. Students also formed useful links between theoretical and methodological studies as well as real-life platforms through strong general knowledge of the fields and methods to help in finding alternative solutions faster. This suggests that the guidance provided was sufficient and suitable, and that the expectations were not too high: "It wasn't easy, but it was pleasant."

During the interviews, four themes were reoccurring: the importance of co-operation between the students; the teachers' role in the setup; the importance of continuous writing; and the variation on who was seen as the main partner. These themes were not predefined but arose independently during the research.

The importance of co-operation between the students was portrayed in several ways. As students did not have all of the required knowledge by themselves, they used other students' expertise, thus providing them multidisciplinary topics for their theses. The co-operation helped all students focus on their own research questions. The process of exclusion and delegation as the students distributed their workloads is something that is impossible to teach in a classroom, but is easy to learn naturally in these kinds of environments. Along with their own studies, students also helped each other in various minor tasks during the camp. They recognized each other's strengths and competences and were able to utilize them effectively.

In the Learning by Developing Strategy (Laurea UAS, 2014) students are seen as equals and colleagues. Students find this to be one of the main supporting qualities of the model (Merjanaho, 2011). In the narrative interviews this equality was highlighted in concrete examples: the teachers took part in the studies by assisting in the practical tasks during the camp. During the whole process, the teacher's main role was to give guidance, to show alternative viewpoints, to question the solutions made, and to ask for clarifications. However, by questioning the solutions the teacher did not force changes on the students, but rather launched a process of improving and rationalizing the plans, and of clarifying communication. As such, by reporting to the teacher, the students had opportunities to clarify their own thoughts.

The students realized through practice that they should have been writing more, and earlier, since writing things down forces a rethinking of the subject and explaining your own thoughts to someone else helps in clarifying them. Written text is also easier to send to the teacher or the project partners than constantly arranging meetings. Continuous writing is necessary in both planning and reporting. Learning to think through writing might be hard to teach, but occurs naturally during the writing process. Students from the Degree Programme in Nursing benefit from the mandatory requirement to have the theoretical framework of their studies ready before participating in practical exercises.

As was noted in Study I, the MACICO technologies were not fully utilized at the Viksu Camp. This was not perceived as a problem since the camp demonstrations were considered useful and gave valuable information to the participants. However, Study II gave a possible solution that could help improve future collaborative environments in a way that gives better quality information for project partners. Students who started working on the project during the evaluation phase, perceived that after Viksu 2014 had become a partner in the project they were doing work mainly for the camp. The MACICO project was seen as a partner that provided the TETRA network and other systems used during the camp.

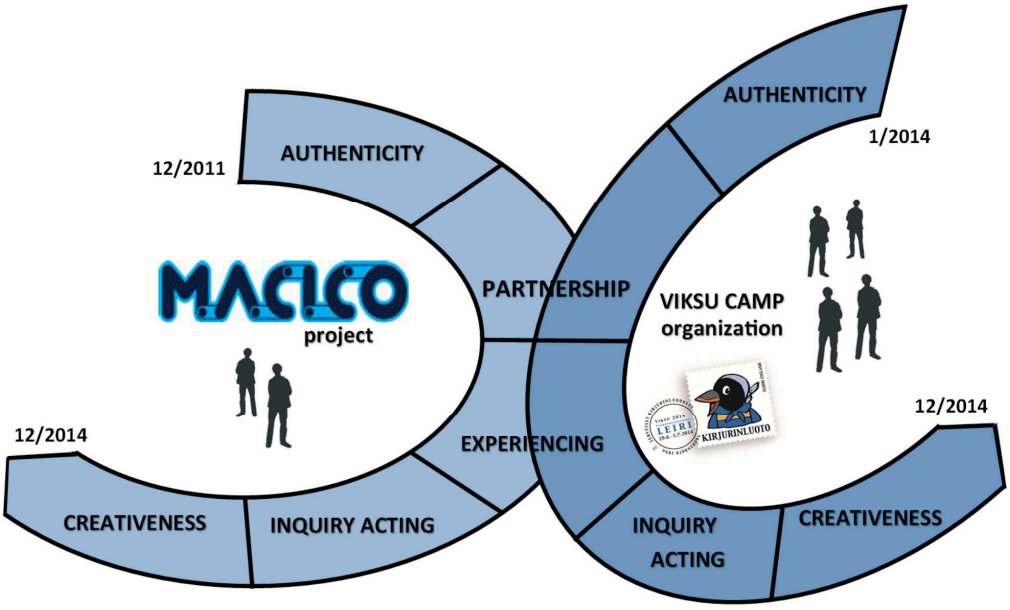


Figure 8: Stages of Learning by Developing (modified from Raij, 2007) in this study.

Figure 8 shows how learning in the project followed the stages of Learning by Developing model (Raij, 2007) but was linked to the main partner during planning. The camp organization became more focal to the students for several reasons: the students were given more freedom to test their own development ideas; and the camp organization provided students with more information on their needs and commented more actively on their plans. It was also noted that the students from non-technological programmes did not have the competence to evaluate the systems, which also influenced the main partner selection. However, there could have been more students from Information Technology Programmes concentrating solely on technology.

The conclusions of Study II state that working in an authentic environment provides an opportunity to improve the ability to adapt to constant changes since most of things were not readily prepared for the students. Teachers and partners helped the students find ways to work around inconveniences and obstacles. The main strength on this environment was the co-operation between the students from different programmes. It was a suitable arrangement for an environment where technological solutions were tested in authentic use. This kind of co-operation may offer engineers and designers a deeper understanding of the field they are assisting with technical solutions, thus aiding the building of need-based solutions rather than technology-driven ones. In contrast, by having a better understanding on how technologies are developed and what is or is not possible, the user may be able to point out new innovations that could help the field evolve.

## 4.3 Study III: Implementation from Information Systems Perspective

In November 2014, while I was finishing publication P[2], I was offered an opportunity to participate in the publishing of the research of one of the students participating in my earlier studies. Jussi Simola's paper was accepted by the 5th European Conference of Computer Science (ECCS '14) in Geneva, Switzerland. Extended version of the paper was requested for the journal of either North Atlantic University Union (NAUN) or World Scientific and Engineering Academy and Society (WSEAS). However, there was only two months' time for writing the extended version, and there was still a lot of work to do. As I was already familiar with Simolas's research and I had also been present at the camp, I had a good understanding of the subject. Therefore, I was a natural selection for helping Simola with his work.

The research was also utilizing the case study approach (Yin, 2009) and its research data was gathered through interviews, observations in the field and literature reviews. I did not affect the planning or designing of the study. The data was already collected and analyzed, but I familiarized myself with and gave a second view of the data by listening to tapes of the original interviews and by accessing the original notes. That way I could comprehend what analysis had been done so far, and discuss the findings and conclusions. In combination with the observations I made at the camp, this increased investigator or analyst triangulation, thus increasing the credibility of the research, since by comparing their findings two researchers can avoid selective perception and blind interpretive bias (Patton, 1999).

My main contribution to publication P[3] can be summarized in that I was helping to improve the analysis and the sharing of the results in a better, more in-depth form for a possibly wider audience. For instance, I improved the academic tone of the paper by replacing some of the electronic webpage references on the theoretical framework with academic papers addressing the same subject. I made several improvements to the language and translated several paragraphs from Finnish to English, which freed his linguistic self-expression and helped Simola communicate his thoughts more succinctly. Reflecting on each other's thoughts made the writing process more efficient as well.

> "Abstract—Public safety authorities all over the world have recognized that the lack of interoperability of information and communication technology (ICT) systems limits the effectiveness of rescue operations. Whether natural or man-made, catastrophes can happen at any time, and with no warning. This creates major problems for public safety agencies set up by governments to provide for public protection and disaster relief (PPDR). The ability of these agencies to cope with unexpected disasters and emergencies of any scale is dependent upon the infrastructure and support that they have in place for their day-to-day

> operations. Need of overall situational awareness has increased during the past decades. Research data of this case study consists of a literature review, interviews, on-field observations and discussions during an exercise, where a technology providing live video was tested during simulated natural disaster at the Viksu 2014 Young Firefighters Camp. The results of the study indicate that watching real-time video ties persons down and they cannot participate in operational action at the same time. Different departments have their own situation centers, which means that the same real-time picture has to be available for every organization involved. The amount of situation centers affects the distribution of resources, organizing and forming of the situational awareness. A command center requires more than one person to manage situational information flow. Responders are usually carrying their own smartphones on the field. Used solutions enable PPDR officials and partners install and deploy applications easily. Applications might allow first responders to use their own smartphones for emergency communications in situations where communication with primary network becomes difficult. Decision-makers must establish priorities for response in large-scale disaster when the total demand for rescue services is greater than the PPDR organization's capacity to respond. Distributed real-time video improves decision support systems by allowing command center to allocate resources in the right proportion." (Simola, Jokinen, & Rajamäki, 2015)

In addition to publishing Simola's research findings, collaborating with him, i.e. one of the students from the learning environment I was studying further deepened my understanding of my own subject. It especially helped to deepen my knowledge from the information systems perspective, since the original purpose of the work done during the camp was to evaluate and demonstrate the outcomes of the MACICO project. The nature of those outcomes was mainly (information) technological solutions. These observations also answered to the research question: "What kind of factors affected the actualization and evaluation of the project outcomes?"

Since the research question of a single thesis or an academic paper must be narrowed down and defined well, one study cannot answer all of the questions that arise from the topic. As mentioned, four of the students' theses concentrated solely on the non-technological aspects of the project, and of the two theses studying the situational awareness through live video, only one is by a student of Information Systems. Therefore, the research data collected during the camp was limited to these perspectives.

Though they are not the focus, the systems utilized during the camp are present in the non-technological theses and some observations have been done. However, these observations were not done within the theoretical framework of information system research, nor tested using methods utilized within the framework. For instance, the need for concurrent active channels in the TETRA network was underestimated since the users did not have training in disciplined radio communication. The usability of the network and the devices was not systematically studied from either the perspective of user experience or that of interaction design.

In addition to the systems used during the scenario exercise at the camp, there were plans to study the utilization of social media in crisis communication. The aspects of social media in crisis communication were studied before the camp by analyzing similar experiences from abroad and by doing SWOT analysis. Social media can be used during disasters in two ways: the authorities can use it for announcements about the situation, and the civilians can both consciously and unconsciously collect data from the scene that can then be analyzed for improving situational awareness (Rajamäki et al., 2014). However, using social media in an authentic simulation is hazardous at best, since it does not offer any reliable, restricted ways to announce that the scenario is only an exercise. If emergency messages from the scenario leaked to the public sphere, it could cause a need for real crisis communication since parents and other 'civilians' may become needlessly worried.

In both these cases, if a phenomenon needs to be observed from the information system design perspective, there must be students from that discipline to work on this kind of research. In a multi-disciplinary environment every student can learn from the other's perspectives and to take different viewpoints into account. However, everyone mainly works within the framework of their disciplines and use their student-centered freedom to find solutions. For example, people from the user-side can make observations and have opinions on e.g. usability issues, but since they do not study the subject objectively and systematically, they therefore cannot associate the findings with available technical possibilities or limitations. The main advantage is not to have a multi-disciplinary environment to work with, but to have the multi-disciplinary team to work on a shared issue.

## 4.4 Summary of Results and Overall Conclusions

Overall, Study I described the learning environment, and studies II and III deepened the knowledge on the subject by increasing triangulation and giving answers to some of the questions that arose from Study I. This thesis summarized the work done and also updated the information gathered from them, since the theses of the students have all been completed and published at this point. From the point of view of updating the information, the timing of this

thesis seems ideal: the Laurea Publications book on the MACICO project (Kämppi et al., 2014) was published in a rush immediately after the completion of the project. Therefore, the project book's article on the authentic evaluations is based on extended abstracts of works in progress, rather than the finished theses.

The MACICO book states that Laurea's pedagogical approach was carried out ideally during the camp (Kämppi et al., 2014). The studies examined here come to the same conclusions: student participation within the camp was an exemplary case study show-casing the principles of Learning by Developing. The first study gave concrete examples of the students' participation in an authentic environment. Study II indicated that students' evaluations of the teacher's role have attributes similar to those discussed in related literature, and that the process followed the different stages of Learning by Developing. Therefore, the evidence supports the conclusion that the camp was an exemplary case of Learning by Developing.

The main strength of the students' role during the Viksu 2014 Camp was the co-operation between the students from several fields. As stated in the conclusions of P[1], the scenario exercises acted successfully as a real-life platform for creating both new knowledge and new competencies. As a learning environment, the advantages of the student co-operation at the camp was not limited to MACICO project's framework, but also helped the students build diverse expertise, abilities to adapt to constantly changing environments, and resilience in situations where there is no one correct solution. When testing technologies in authentic environments, the co-operation between a technology-oriented student and a student from the field where the technology is used could be deepened. In closer co-operation, the students might benefit more from each other's perspectives, stimulate each other to get work done, and even establish new innovative solutions.

The results of P[2] the concerns raised in P[1] about the expectations the environment placed on the students: both the good results and the evaluations of the students suggest that the students can be given as much responsibility as they are willing to take, and can be encouraged to take on even more.

The results of how the main partner selection was conducted in P[2], combined with the observations made in P[3] about the need for more students from information systems perspective give valuable contributions and considerations for creating and conducting similar environments in the future. This knowledge gained in these studies may aid in binding the objectives of the national research community and the learning environment closer to the goals of the international research community, while preserving the student-centered approach. While the MACICO project partners got valuable feedback, upcoming projects could benefit from authentic evaluations even more.

# 5 Discussion

## 5.1 Advice for Creating Multidisciplinary Learning Environments

As has been established, the main strength of the learning environment is the co-operation between the students from different orientations and programmes. Multidisciplinary learning environments could be utilized more frequently, in many innovative scenarios, ways and varieties. There are no statutory restrictions against students from different programmes even writing their theses together. The purpose of a thesis in a University of Applied Sciences is to indicate and improve the professional capabilities of students, of which collaboration and co-operation is an essential one. Multidisciplinary theses have already been written with encouraging results in other Finnish Universities of Applied Sciences: in Turku University of Applied Sciences, students from different programmes can choose courses from other fields, which supports the formation of multidisciplinary contacts, and has already lead to the publication of some joint theses (Kankaanpää, 2007). In Seinäjoki University of Applied Sciences, a Master's student of Development and Management of Health Care and Social Work co-worked with her sister from the Degree Programme in Entrepreneurship and Business Competence. They improved marketing knowledge in occupational health care (Keto & Mäenniemi, 2011).

Similar arrangements could be a feasible option, and should be piloted in similar environments, where technological solutions and project outcomes are evaluated or demonstrated in authentic situations, and by authentic users. For instance, a student with technological competencies can work as an expert on information systems development or information systems evaluations, while a collaborating student from the application side is better equipped to understand, describe and study the needs of the target field.

The phase where students start a project seems to affect the main partner selection; if students have the freedom to start from recognizing the needs for development, rather than from pre-established conditions. If the problems recognized seem to already have solutions, Learning by Developing oriented students may innovate new ways to improve their fields. Regional development is an acceptable goal as well, since it is mandated by Polytechnics Act (Finnish law, Act 2014/932, §4). However, if there were a need to bind the research objectives closer to an international project's goals, the collaborating students could be introduced to the project sooner. This could be done by involving the students in the same project during other courses before starting thesis work. If the thesis is about evaluations of project outcomes, like in this case, the former courses could be construed as background or preliminary research. In the MACICO project the (two) collaboration objectives were carried out by different students.

Additionally, this could also help tie the academic knowledge from an international research project to practical implementations, which in turn would support regional development. Thus, the implementation would also encompass the "last mile of research", wherein the designed product can only be fully understood after it has been actualized (Nunamaker, 2010). If separated, only one benefits from the other; working life benefits from academia, without giving feedback to further academic theories. Furthermore, developers of technologies, systems and services need to know how the international innovation system works, since such research and development projects play an increasingly important role in many organizations' research and development investments (Rajamäki, 2015).

Additionally, as was concluded in this research, the balance in student recruitment plays an important role in the outcomes of co-operative projects. As such, in similar situations, the research would benefit from having more technologically-oriented students. However, a more balanced recruitment requires some additional efforts from teachers of different fields to interact and discuss possible commonalities and mutual benefits for their students. Instructing students from different fields together might foster networking between them, but a goal-oriented collaboration needs active participation from the teachers in guidance and arrangements.

In many Master's programmes, management and leadership are central features. Taking responsibility in a management situation is the only way to achieve these competencies. Students from Master's programmes should be encouraged to consider different perspectives, and to work as supervisors in teamwork. In Finnish Universities of Applied Sciences students must have at least three years of working experience before entering Master's degree programmes; it is common for them to work simultaneously while studying. Bachelor's degree students could also benefit from the Master's degree students' collaborative experiences and work-life contacts – or even attain employment after graduation. Along with internships this could form new co-operation models between higher education and businesses.

## 5.2 Reliability and Validity

When judging the quality of research designs in social science methods, four tests are common: the *construct validity* of identifying correct operational measures; the *internal validity* of causal relationships; the *external validity* of generalization; and *reliability,* i.e. if the study is repeated, the results would be the same (Yin, 2009).

Construct validity can be considered during data collection: in this study, it has been established through the usage of multiple sources of evidence (data triangulation). As elaborated on in subsection 4.1, the first study left some questions unanswered, which were then ad-

dressed by increasing both data triangulation as well as methodological triangulation (Silverman, 2011). Especially the narrative interviews of the second study helped in overcoming possible subjective judgement bias (Yin, 2009), since the chosen methodology allowed the interviewees to raise the discussion topics, rather than having the investigator directing the themes.

In case study research, internal validity has two concerns: correct analysis of causal relationships and subject inference that cannot be observed directly (Gerring, 2007; Yin, 2009). Again, adequate triangulation helps in avoiding biases: if X seems to be in causal relationship with Y without interfering with the third factor Z, and none of the data sources conflict with the reasoning, a causal relation probably exists. Therefore, in narrative interviews the descriptions of the interviewees are trusted by default. For example, if the students say they were motivated, they probably were. The observations of the students and the results they gained do not give reason for doubt; the strategy has involved checking findings against other sources and perspectives (Patton, 1999).

In a single case study, external validity cannot be measured in terms of sampling: where a survey research is based on statistical generalization, case studies use analytic generalization to reflect on some broader theories (Yin, 2009). In this study, the single case approach was acceptable since the environment formed in an unusual way: it was not planned as a study course or a static set of events, but as a genuinely student-centered approach where students were recruiting each other and using each other's competencies to supplement their own. This learning approach was examined in the context of the Learning by Developing model, which is well-documented, evaluated and discussed, and thus forms a suitable theoretical framework. During the different studies understanding about the Learning by Developing model and the relationships between related projects increased, which helped in comparing the results with earlier findings and the goals of the strategy. The findings of this study can encourage the effort needed for creating similar possibilities for multidisciplinary student work in the future. The results are usable in improving the benefits for students and collaborators in many ways, not just in learning and building competencies, but also in research, development and even in business.

Measuring reliability is challenging in single case studies of unique situations since there are no directly comparable environments where the study could be repeated. However, that is not generally required. Some social research even argues that reliability is only a concern of the quantitative research tradition (Silverman, 2011). In this study, reliability is addressed with the approach of documenting all the steps of the study instead. That is where I have matured during this process, as the documentation of the phases increased along the way. From the beginning, this research was not conducted "as though someone is always looking over

your shoulder" (Yin, 2009), but the documentation problem was addressed by continuously reflecting on the data with supervisors and peers. Additionally, the iterative process with active peer-reviewing increased the quality of the study as well as my ability to follow the evidentiary path.

The research attribute list in subsection 2.4 has also been established in order to increase the methodological rigor of these studies. It has been a beneficial instrument in perceiving and managing the entirety of the data.

## 5.3 Limitations and Future Research

Future research consists of two layers: research on similar learning environments, and research done by students and other participants within those environments in the same domain, i.e. the further projects evolving from the projects introduced in subsections 1.2 and 1.3. The studies related to Viksu 2014 formed a novel learning environment that managed to represent the principles and values of Learning by Developing in an exemplary way. Since this encourages the creation similar, authentic, multidisciplinary and student-centered environments, those environments should be studied as well in order to expand and compare the results with this research. Comparing multiple similar cases would also further increase the external validity of research on this topic, as generalization of the findings on the nontraditional parts of this environment is one limitation of this study.

I first became interested in the MACICO project and especially in the Viksu 2014 camp because of my background in voluntary rescue services (Vapepa, i.e. Vapaaehtoinen pelastuspalvelu). As a radio amateur working in the sector of communications during search and rescue operations, I have knowledge of radio communication in third sector organizations on both technological and practical levels. The operational environment of the voluntary rescue services had similarities with the Viksu 2014 organization, since both of them are joint ventures between independent organizations: they do not work together regularly, and they have separate administrations. Furthermore, the radio communication system that was to be tested during the camp, as well as the possibility of connecting the radio network with the networks of public authorities seemed to be a feasible solution to some of the everyday challenges we have faced in radio communication during our operations. Solving these problems could increase efficiency, usability and the protection of privacy.

During spring 2015 a new project of the third sector of public safety operations has been planned. Along with Vapepa rescue services, this new project plans to survey the possibilities in many similar third sector associations in Finland, e.g. voluntary fire brigades, voluntary maritime rescue associations (through The Finnish Lifeboat Institution), voluntary defense

training (The National Defense Training Association of Finland), air rescue (The Finnish Air Rescue Society) and the Red Cross. In the actualization of this new project there are many possibilities for thesis research in several fields: security management, information technology, business management, hospitality management, nursing, and possibly others. During the planning of this project, I have been working as a consultant: it is not directly a part of my studies in Laurea, but I have had opportunities to utilize my expertise in radio communications, third sector work, and experiences about the learning environment in this study. Making changes and improving competencies does not always have to be measured in ECTSs.

Also, further publication of the results of this thesis in combination with related studies has been discussed. There are plans for writing one more academic article for a journal to share these combined results with interested audiences. One possible form of publication is *ACM Transactions on Computing Education*, as it has a scholarly interest in teaching and learning with a clear connection to student learning. Along with traditional computer science and engineering, its topics also cover applications of computing in other disciplines, which makes this multidisciplinary environment study likely to fall in its scope.

In order to be suitable for *ACM Transactions on Computing Education* (TOCE) the article needs to fulfill strict criteria, of which many are already met by the current paper. This study has a broad audience in computing education, addresses significant problem of lasting value, evaluates teaching intervention and uses appropriate methodology. However, it is yet necessary to become acquainted in the theoretical frameworks and current discussions in the journal, and to adjust and update my theory to correspond to them. Then, the main concern is the direct application of my findings to classroom instructions or curriculum designs, and the possibilities to replicate and evaluate it. As the environment was genuinely student-centered and student-generated, it was not conducted in a conventional manner. On the other hand, if taken too far to the direction of well-clarified, applicable and replicable implementation, e.g. by developing too-detailed instruction, the instruction would no longer be in line with the spirit of freedom of the Learning by Developing approach, nor of the research data. By credibly and justifiably overcoming this dilemma, the quality of this research will increase notably, and the work could meet all the requirements of ACM TOCE.

## 5.4 Improved Competencies

As a student and a thesis worker from Laurea, I was a part of the phenomenon I was studying. I limited the research to other students, since my perspective differed from theirs, and I wanted to keep some distance as an observer. However, an awareness of the fact that the results should also be valid for my learning partially helped in evaluating the findings. In addition to the pedagogical approach I also learned a lot about the subject from many viewpoints,

as well as the meaning of collaboration in systems development. Since the environment was authentic, the experiences during this study could be utilized in my work, too. Furthermore, studying learning in the same context aided in perceiving my own learning; and familiarization with the theoretical framework of Learning by Developing explained e.g. why specific methodologies were selected for our mandatory courses: case study research for understanding and describing, information system research for building and testing products, and action research for investigating organizational change (Pirinen, 2014).

The thesis was formed in an iterative process and was not initially meant to be extended into a full thesis. However, in January 2015 I finally realized that I should not choose another topic, as I had already done so much work on this one. When I first started studies in Laurea, I did not think of writing in English or becoming published in international conferences and journals. Overcoming this mental barrier was one of the greatest experiences I gained during my studies, and is probably something that I will benefit from significantly in the future, since the field is becoming more global all the time. It may also open a path to further postgraduate studies.

As a part of my participation in IEEE Global Engineering Education Conference, i.e. EDUCON 2015, I also reviewed others' contributions to the conference. This was a first time in Laurea's history when a student from this programme has worked as a reviewer for IEEE. For me, it was both an honor and challenge, since I had to familiarize myself with completely new subjects in a short period of time, among other tasks, in order to write useful, good-quality reviews. I compiled a list of questions to be able to evaluate the quality of a paper against the criteria it should meet. I also took special care in writing the feedback in a form that would benefit the authors in improving their contributions. The best reward was seeing the improvements in the final contributions. Understanding the reviewer's perspective helps in regarding the factors a reader sees as important in my own writing. I shared this experience giving a presentation to other students, and my example has been used in encouraging students of the later courses to offer themselves as reviewers for publications.

As a final statement, based on my own experiences and in line with the results of my study, I recommend giving students more responsibility, and encouraging students to take on new challenges. The studies can be seen as a safe environment to redefine one's own limits. Learning is not simply about gaining new knowledge and building new competencies, but rather about changing the way one thinks and works.

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Pictures



Figures



Tables