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Kari-Pekka Heikkinen

EXPLORING STUDIO-BASED HIGHER EDUCATION FOR T-SHAPED KNOWLEDGE WORKERS, CASE LAB STUDIO MODEL

UNIVERSITY OF OULU GRADUATE SCHOOL;
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Abstract

Speed of information, uncertainty and complexity are increasing in the work-life of the knowledge worker. In addition, solving complex and wicked global problems require cooperation skills as well as ability to learn in collaboration across the disciplines, meaning skills in crossing boundaries. These requirements set new challenges for educating knowledge workers in higher education. Metaskills, such as learning by utilising networks, communication and critical thinking, have become as essential as discipline-specific skills. Metaskills combined with discipline-specific skills are called T-shaped skills. Individuals possessing these skills, so-called T-shaped professionals, are exposed to the experience and the knowledge of other disciplines and thus are recognised as carrying the skills for crossing boundaries.

This dissertation examines how a Finnish studio-based pedagogical approach to bachelor education, the LAB Studio Model (LSM), contributes to the education of boundary crossing competence. This qualitative dissertation utilises exploratory as well as design research as its research approach and contains four original publications. First, the characteristics of LSM and the utilisation of studio-based practices in higher education are studied by conducting literature reviews. Second, the internal and external boundary crossing activities are studied by performing case studies, where the new knowledge creation and establishment of learning networks are in focus. Empirical data has been collected by conducting web-based surveys, theme-based student and student team interviews, direct observation, and participative observation.

The outcome of this dissertation suggests that LSM offers a potential educational model for learning the skills of boundary crossing, resulting in a T-shaped skill base. The results of this dissertation include new findings on how commonly studio-based education is utilised world wide in higher education, how LSM differs from the existing configurations that utilise the studio-based model in higher education, as well as active internal and external boundary crossing among students. This dissertation contributes to the discussion of university-society collaboration by the new learning configurations, and to the interdisciplinary education of knowledge workers. The results of this dissertation can be utilised in the development of studio-based configurations in higher education.

Keywords: boundary crossing, higher education, interdisciplinary, knowledge worker, LAB studio model, studio-based education

Heikkinen, Kari-Pekka, Studiomalli T-mallisen tietotyöläisen korkeakoulutuksessa, tapaustutkimus LAB-mallista.
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Tiivistelmä

Tiedonvälittämisen nopeus, epävarmuus ja monimutkaisuus lisääntyvät tietotyöläisten työssä. Lisäksi yleismaailmallisten ja monimutkaisten ongelmien ratkaisemisen vaatima monialainen yhteistyö, sekä yhdessä oppiminen edellyttävät taitoja erilaisten rajojen ylittämiseen. Nämä vaatimukset asettavat uusia haasteita tietotyöläisten korkeakoulutukselle. Metataidot, kuten vuorovaikutustaidot, verkostojen avulla oppiminen ja kriittinen ajattelu, ovat tulleet yhtä tärkeiksi kuin alakohtaiset taidot. Metataidot yhdistettyinä alakohtaisiin taitoihin muodostavat niin kutsutut T-malliset taidot. T-mallisia taitoja omaavat ammattilaiset ovat altistuneet muiden alojen ammattilaisten kokemuksille ja tietotaidolle, ja siten omaavat taitoja rajojen ylittämiseen monialaisissa työryhmissä.

Tämä väitöskirja pyrkii vastaamaan kuinka suomalaisessa korkeakoulussa kehitetty, studiomallinen ja monialainen tietotyöläisten koulutusmalli, LAB-malli, vastaa rajojen ylittämisen taitojen kouluttamisen haasteeseen. Tutkimus toteuttaa laadullista tutkimusstrategiaa käyttäen eksploratiivista ja kehittämistutkimuksen lähestymistapaa tutkimusprosessissaan. Alkuperäiset julkaisut keskittyvät studiomallin hyödyntämisen yleisyyteen korkeakoulutuksessa maailmanlaajuisesti, LAB-mallin ominaisuuksiin studiomallina ja opiskelijoiden rajojen ylittämiseen monialaisen koulutuksen aikana. Ensimmäinen julkaisu keskittyy LAB-mallin ominaisuuksien analyysiin ja toinen studiomallin hyödyntämisen selvittämiseen kirjallisuuskatsauksien avulla. Kolmas julkaisu keskittyy rajojen ylittämiseen koulutuksen sisällä uuden tiedon tuottamisen teorian kautta ja neljäs koulutuksen ulkopuolisten rajojen ylittämiseen oppimisverkostojen muodostamisen kautta. Tutkimus tehtiin keräämällä tietoa kyselyillä, teemapohjaisilla opiskelija- ja tiimihaastatteluilla, sekä suoralla, että osallistuvalla tarkkailemisella.

Tämä väitöskirja osoittaa, että LAB-malli tarjoaa koulutusmallin rajojen ylittämisen oppimiseen ja siten T-mallisten taitojen oppimiseen. Tulokset osoittavat, että studiomallin hyödyntäminen on lisääntynyt korkeakoulutuksessa, LAB-malli on omaleimainen verrattuna muihin studiomallia noudattaviin korkeakoulutuksiin ja että koulutuksen aikana opiskelijat ylittävät rajoja aktiivisesti. Tämä väitöskirja osallistuu keskusteluun korkeakoulujen yhteiskunnallisesta yhteistyöstä, sekä monialaisen ja studiomallisen oppimisen mahdollisuuksista tietotyöläisten kouluttamisessa. Tämän väitöskirjan tuloksia voidaan hyödyntää edelleen kehitettäessä studiomallisia korkeakoulujen oppimisympäristöjä.

Asiasanat: korkeakoulutus, LAB-malli, monialaisuus, rajojen ylittäminen, studiomalli, studiomallinen oppiminen, tietotyöläinen

"The most beautiful experience we can have is the mysterious. It is the fundamental emotion that stands at the cradle of true art and true science."

Albert Einstein

Acknowledgements

Once turning forty, people tend to look for a change to their lives. In my case, the change happened in my professional career. In 2012, the change of my professional discipline from the ICT industry to higher education was a crucial step towards this dissertation. Learning about academic research practices has been a journey I'm happy I chose. Now, looking back at the past few years of a combination of work and studies, I acknowledge the contribution and inspiration of many important people.

My supervisors, Professor Pekka Kess and Docent Jukka Majava, gave me invaluable support through their gentle guidance from the beginning to the end of the research process. The extensive experience of Professor Kess in academics, as well as his knowledge of the practical matters of writing a dissertation accelerated my learning process significantly. I am indebted to Docent Majava, not only for his constructive criticism and decisive suggestions which contributed to the results presented in this dissertation, but also his encouragement that ultimately made it possible for me to accomplish this work. I also wish to thank Doctor Kris Law and Docent Tauno Kekäle, the pre-examiners of my work. Their valuable comments and recommendations increased the academic contribution of this dissertation research.

Throughout my studies I received support from a number of people. I wish to thank the Oulu University of Applied Sciences (Oamk) LABs development team for having fruitful debates about the development of the LAB studio model. The group has been recognised to be world-class in developing methods for higher education. I am especially grateful for the co-writers of the articles for this dissertation; Doctor Blair Stevenson, Master of Science Ulla-Maija Seppänen, Doctor Jouko Isokangas and Doctor Teppo Räisänen for their effort and guidance in scientific research practices. I have been privileged to work with and learn from you. In addition to those listed here, I would like to thank all of those individuals with whom I have had exciting discussions over the themes touched upon by my research topic. I am also grateful for the direct financial support provided by Tauno Tönning's Foundation for completing my dissertation.

Finally, above all, my warmest thanks are to my parents, parents-in-law and family. You have always encouraged me in my life and career. I wish to especially thank my wife Anna-Maria and son Juho for giving me the chance to focus on my research and dissertation. Your strong support during these years made this possible.

Dammisaari, Oulu, 2017 Kari-Pekka Heikkinen

Abbreviations

AT	Activity theory
Expo event	Event for customer oriented and professional feedback
Gate event	Event for selecting the most promising projects for continuation
HLC	Hybrid learning configuration
IPR	Intellectual property right
I-SP	I-shaped professional
LAB Master	Specific staff member responsible for a LAB studio
LAB part	Solution and business development part of the LAB studio model
LAB studio	Industry focused learning configuration utilising the LAB studio model
LEAD part	Concept development part of the LAB studio model
LSM	LAB studio model
Oamk	Oulu University of Applied Sciences
OAL	Oulu App LAB, a LAB studio focusing to application industry
OGL	Oulu Game LAB, a LAB studio focusing to game industry
RQ	Research question
SECI model	Dynamic theory of organisational knowledge creation
T-SP	T-shaped professional

Original publications

This dissertation is based on the following publications, which are referred throughout the text by their Roman numerals:

I Heikkinen, K.-P., & Stevenson, B. (2016). The LAB studio model: enhancing entrepreneurship skills in higher education. *International Journal of Innovation and Learning*, *20*(2), 154-168.

II Heikkinen, K.-P., Seppänen, U.-M., & Isokangas, J. (2016). Entrepreneurship education in studio based learning practices. *Proceedings of the 11th European Conference on Innovation and Entrepreneurship,* 247-256.

III Heikkinen, K.-P., & Räisänen, T. (2016). Studying the aspects of knowledge creation in the LAB studio model. *International Journal of Management, Knowledge and Learning*, *5*(1), 5-22.

IV Heikkinen, K.-P., Seppänen, U.-M., & Isokangas, J. (2015). LAB studio model: developing external networks for learning entrepreneurship in higher education. *Education in the North*, *22*, 49-73.

This dissertation research was performed under the supervision of University of Oulu and all articles were written in cooperation within the Oulu University of Applied Sciences (Oamk) LAB's multidisciplinary research group (Oamk LABs Research, 2017). The author of this dissertation was responsible for planning and conducting this dissertation research; conducting the survey planning; reading and analysing the surveys; writing the narrative memos of the interviews, conducting the analysis, and analysing the interview memos; being responsible for the publishing process and performing the article presentations in the scientific conferences. The author was responsible, in co-operation with the co-writers, for reading the literature and analysing the literature reviews, analysing the studies findings and writing the articles with equal contribution.

Contents

1 Introduction

1.1 Background and research environment

Global problems such as the climate change create an ingenuity gap, a critical gap between our need for ideas to solve complex problems and the actual supply of those ideas (Homer-Dixon, 2001). At the same time there is general agreement that the knowledge society (e.g. Bell, 1974; Drucker, 1993, 1994; Toffler, 1990) will have profound effects on educational, cultural, health, and financial institutions, and will create an ever-increasing need for lifelong learning and innovation. Because of the past shift from manufacturing-based to knowledge-based economies (Blinder, 2006; OECD, 1996b), based directly on the production, distribution and use of knowledge and information, nations are tied to competing of the innovative capacity of their citizens and organisations (Baldwin, 2006). This shift has effect to the knowledge work (e.g. Alvesson, 2004; Blackler, 1995), as eventually "it will not anymore be about jobs, but about tasks, assignments, gigs and interdependence between people" (Kilpi, 2016).

Professionals operating in the knowledge society are supposed to be able to create new solutions and innovations. The creation should also happen across disciplines, professions and perspectives. New solutions and innovations are needed for creating economically and ecologically sustainable communities (Capra, 2009; Dumont & Istance, 2010), which are dependent on the capacities of people; organisations and networks to create and utilise knowledge (Boreham & Lammont, 2000). These so-called knowledge workers are lifelong learners who continually acquire and develop new knowledge. They must be able to critically select, acquire and use knowledge, wherever this is available (Engeström, Engeström, & Kärkkäinen, 1995; Konkola, Tuomi-Gröhn, Lambert, & Ludvigsen, 2007) and by continually constructing and reconstructing their expertise in a process of lifelong learning (OECD, 1996a; Tynjälä, 1999). Knowledge workers are supposed to be functioning in societal structures and organisations that are constantly changing, while being able to solve challenges, which are characterised by confusing data, multiple users with differing values, and not having a right or wrong answer. These challenges have to be addressed by experts from different fields collaborating across different contexts (Engeström, Engeström and Kärkkäinen 1995; Tynjälä 1999). By the collaboration multiple stakeholders, defined as persons or parties with an interest at hand (Freeman, 1984), are

expected to co-create new knowledge when collaboratively facing present complex societal problems (Oonk, 2016). As a summary, knowledge workers are supposed to master skills which will help people to utilise and create new knowledge (OECD, 2007; Ruohotie, 1996, 2000, 2003, 2006, 2007; Ruohotie & Nieminen, 1997), entrepreneurial mindset and skills (European Commission, 2005), and meta-cognition where new knowledge is produced, used and shared within and between communities of practice (Lave & Wenger, 1991; Wenger, 1998; Wenger, McDermott, & Snyder, 2002) and within teams (Katzenbach & Smith, 1993, 2002).

Performing successfully in the above-described multi-dimensional setting requires all actors to have skills to cross boundaries. In order to do that, the knowledge workers need to possess deep disciplinary knowledge along with a keen ability to communicate across, for example, social, cultural and economic boundaries (T-summit, 2017). These so called T-shaped professionals are characterised by their deep disciplinary knowledge and understanding of systems in at least one area, and their ability to function as adaptive innovators and cross the boundaries between disciplines. The concept of persons with skills of boundary crossing was originally proposed by Guest (1991) and Iansiti (1993), later also by Hansen & von Oetinger (2001), where a skill is defined as something able to be learned in order to be able to carry out one or more job functions (Green, 2011). In other words, skill answers ’what can one do’, where as competence is a behaviour that demonstrates the ability to perform the job requirements competently, answering ’how one does it’. T-shaped persons are experts in specific areas (T’s vertical stroke), called as I-Shaped Professionals (I-SP) and know how their discipline interacts with others (horizontal stroke) (Iansiti, 1993). Figure 1 illustrates the concept of a T-shaped professional (T-summit, 2017).

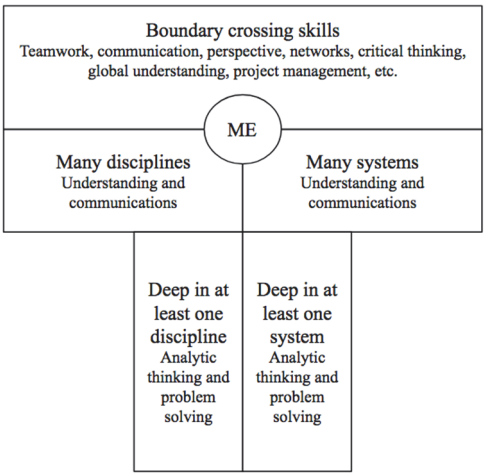

Fig. 1. Concept of a T-shaped Professional. Adapted from (T-summit, 2017). Reproduced by permission from T-summit.

In addition to their specific disciplinary and systemic knowledge, T-shaped professionals are exposed to the experience and knowledge of other disciplines and systems (Karjalainen, Koria, & Salimäki, 2009; Karjalainen & Salimäki, 2008). T-shaped professionals skills have breadth as well as depth. Breadth implies ability to cross a range of disciplinary areas, in other words, boundary crossing. A person with breadth is able to understand the vocabulary of a discipline, use it to understand and re-describe problems they may not be able to solve, but are able to reason about which discipline experts might be the ones able to solve them. Thus, the T-SP is supposed to have better communication, teaming, and project experience than an I-SP, and hence is potentially more highly valued in the work-life. (Hansen, 2010; Spohrer, Golinelli, Piciocchi, & Bassano, 2010.)

Higher education institutions globally have a significant role for educating new knowledge workers. Higher education is defined as an optional final stage of formal education that occurs after the completion of secondary education and is usually realised at universities, academies, colleges, seminaries, and institutes (UNESCO, 1998). In Finland, the higher education system is a dual system, consisting of two parallel sectors: scientific universities and universities of applied sciences. Despite of this division between scientific and work-related higher education, all Finnish universities are supposed to develop their education of knowledge workers towards to the needs of the surrounding society. For this the Universities Act (Ministry of Education and Culture of Finland, 2009) assigns

missions to the Finnish universities: "to promote free research and academic and artistic education; to provide higher education based on research; and to educate students to serve their country and humanity." In carrying out their mission, the universities must "promote lifelong learning, interact with the surrounding society and promote the impact of research findings and artistic activities on society." (Ministry of Education and Culture of Finland, 2009.)

One solution for universities emphasising the interaction with the surrounding society is to establish innovation- and collaborative-friendly learning configurations that are connected to their surrounding operational environment. Therefore, a collection of scholarship focusing on new learning configurations has been produced (e.g. Brandt *et al.*, 2013; Bull & Whittle, 2014a; Carter & Hundhausen, 2011; Collison, Cody, & Stanford, 2012; Long, 2012; Mor & Mogilevsky, 2013), with the belief that learning that is closely connected to these kind of configurations also supports the modernisation of labour markets, and has the potential to empower people by developing their skills. Oonk (2016) and Cremers (2016) indicated several studies about the experiences of students, teachers, and other partners involved in these configurations, resulting in varied suggested guidelines for the educational design (e.g. Balassiano, 2011; Kuhn, 2001; Long, 2012; Pak & Verbeke, 2012; Peterson, Frankham, McWhinnie, & Forsyth, 2015; Shraiky & Lamb, 2013). In addition, attempts for categorising and defining these learning environments have been made. Cremers (2016) defined the Hybrid Learning Configurations (HLCs), where different stakeholders co-create knowledge and learn in the process (Wals, Lans, & Kupper, 2012). HLCs are referred to alternatively as, for example; living labs, knowledge labs (Cremers, Wals, Wesselink, Nieveen, & Mulder, 2014), regional learning environments (Oonk, Beers, Wesselink, & Dubbeldam, 2013), or vital coalitions (Wals *et al.*, 2012). Cremers (2016) conceptualised the learning environments for knowledge workers in higher and vocational education, which do not only include acquisition and utilisation of knowledge, but also include the co-creation of new knowledge across disciplines, professions and perspectives (Cremers, 2016). As another example, Finnish Metropolia University of Applied Sciences (Savander-Ranne, Lindfors, Lankinen, & Lintula, 2013) divided the learning environments into three different categories; sustaining, renewing, and innovating learning environments. The sustaining learning environments include sufficient current practices, which however are not developing the learning environment. Within the renewing learning environments, the developing factors are included in the practices. Thus, in the innovating learning environments, the existing practices

are changed, which can be often seen by the changing target of the activity. (Savander-Ranne *et al.*, 2013.)

One example of the above-described innovating learning environment is Oulu University of Applied Sciences' (Oamk) Oamk LABs educational program, which can be defined as a business pre-incubator established to educate new self-aware professionals and self-directed teams. Oamk LABs has a mission to "provide interdisciplinary studies for future industry professionals by building students' capacities for an entrepreneurial mindset, professional skills and creativity for the future working-life" (Oamk LABs, 2017), where the interdisciplinary way of working is defined as integrating separate discipline approaches to work together towards a common result (Jessup, 2007). Together with bachelor and master level undergraduate students, Oamk LABs also integrates unemployed postgraduate students into the program. Oamk LABs utilises the LAB studio model (LSM), a specific form of studio-based model as its pedagogical model. The studio model as a pedagogical approach suggests a more practical approach to education and its objective is to practice students' T-shaped skills in a small group configuration. Practical configurations of the Oamk LABs are LAB studios, each focusing on a certain industry, for example educational technology, health, sustainability and game industries. (Seppänen, Heikkinen, & Stevenson, 2016; Stevenson, Seppänen, & Heikkinen, 2017.)

Although there's a great interest towards new educational environments, quite little is known about the learning processes that occur when students work across practices in multi-disciplinary and multi-stakeholder collaboration (Oonk, 2016), and also if the established learning configurations include actual collaboration outside the studio. Moreover, the effects of typical learning configuration characteristics that address working across practices on student learning are hardly understood (Oonk, 2016). This dissertation contributes to the discussion concerning the new learning configurations for higher education. The establishment of the new learning configurations is due to the requirements of teaching, for instance, entrepreneurial competence and T-shaped skills, which both require skills for boundary crossing. This dissertation aims to gain new knowledge for the education of T-shaped professional by studying the LSM's ability to enhance activity for boundary crossing. Students' boundary crossing activity is studied by the new knowledge creation activity and by the establishment of new learning networks. Theories of knowledge creation are used to study the LSM contribution to enable boundary crossing between students from different disciplines inside a LAB studio. The boundary crossing activity outward

from the LAB studio is studied by the establishment of new external connections, in other words, a learning network, where the size and the characteristics of the established network are studied.

1.2 Objectives and scope

The key motive for this dissertation is the global need of T-shaped knowledge workers possessing skills for boundary crossing. Since the higher education institutions are challenged to renew their education for T-shaped knowledge workers, there's is an increasing interest towards establishing new configurations for educating the T-shaped professionals. However, little is still known about the effect of studio model education on T-shaped skills and more specifically, skills for boundary crossing. The objective of this research is to explore the ability of a new approach to bachelor's-level education, the LAB studio model, to contribute to the education of the T-shaped professionals in a Finnish University of Applied Sciences. The main research question of this dissertation is formulated as follows:

> "What are the characteristics of the LAB studio model and how does it contribute to the development of boundary crossing skills among students?"

There are several options to approach the above research question. For this dissertation, the research was done in two phases by the following research themes. In the first phase, the studio-based configurations were studied by the following themes; characteristics of the LSM (Theme 1) and interest towards utilising the studio model in higher education (Theme 2). In the second phase, the research focused on exploring LSM in the context of students' boundary crossing activity during their studies in a LAB studio. The above was studied by two themes, first by studying the student boundary crossing activity inside a LAB studio (Theme 3), for which the dynamic theory of organisational knowledge creation (Nonaka & Takeuchi, 1995) was chosen. Second, students' boundary crossing activity outwards from a LAB studio (Theme 4) was studied by the learning network established during their studies. The research framework is illustrated in Figure 2.

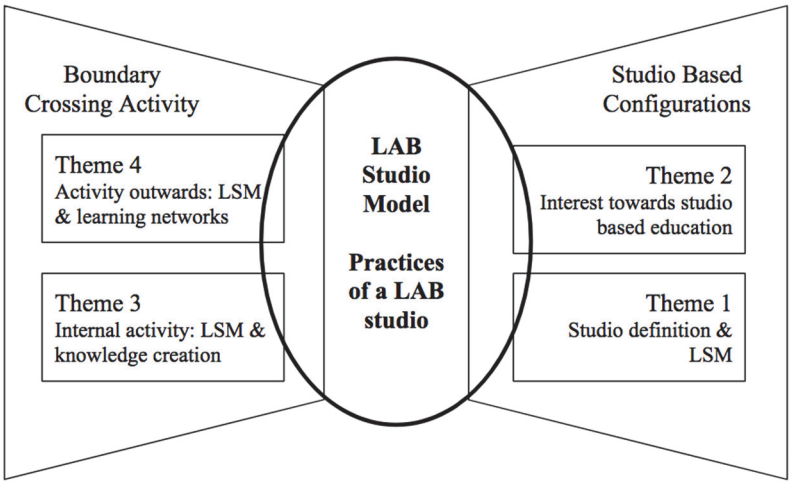

Fig. 2. The research framework.

The research themes are expressed by the following four research questions (RQ) summarised in Table 1.

Table 1. The research questions.

RQ#	Research question
RQ1	How do the characteristics of LAB studio model differ from the existing definition of studio model and what are the unique practices of LSM compared to the other studio-based higher education configurations?
RQ2	How commonly are 'Studio Model Education' and 'Studio-Based Learning' used in the higher education recognised by the literature?
RQ3	How do the practices of LSM support knowledge creation?
RQ4	What types of external learning networks did students establish and engage in as part of the LSM program?

The four research questions listed in Table 1 focus on the main research question from four different perspectives building on each other. RQ's 1 and 2 are focusing on the overall characteristics of the studio model and the LSM. More specifically, RQ1 focuses on the distinguishing and unique characteristics of the LSM compared to the existing definition of the studio model, and RQ2 focuses on the overall usage of the studio model in higher education learning configurations. RQ's 3 and 4 are focusing on the boundary crossing activity within and outwards from a LAB studio. More specifically, RQ3 focuses on the student knowledge

creation activity inside a LAB studio, and RQ4 focuses on the establishment of an external learning network during their studies in a LAB studio.

Research questions are addressed in detail with scientific articles, summarised in the Table 2. RQ1 is answered by the articles I and II, RQ2 is answered by article II, RQ3 is answered by article III, and RQ4 is answered by article IV. This dissertation compiles the key contributions of the articles.

Table 2. Original articles in relation to the research questions.

Article	RQ#	Article title	Journal
I	1	The LAB studio model: enhancing entrepreneurship skills in higher education	International Journal of Innovation and Learning
II	1,2	Entrepreneurship Education in Studio Based Learning Practices	Proceedings of the 11th European Conference on Innovation and Entrepreneurship
III	3	Studying the Aspects of Knowledge Creation in the LAB Studio Model	International Journal of Management, Knowledge and Learning
IV	4	LAB studio model: Developing external networks for learning entrepreneurship in higher education	Education in the North

Article I identifies the main characteristics; the main pedagogical principles and practices of the LSM in contrast to the existing definition of the studio model education. In other words, article I identifies the similarities and differences of LSM characteristics compared to the recent definition of studio model education. Article II identifies the unique characteristics of LSM in contrast to the existing educational configurations utilising studio model education. In addition, article II studies the relation between definitions of entrepreneurial education and studio model education, as well as the utilisation of the studio model in entrepreneurial education. Articles III and IV address the activity of boundary crossing in LSM. Article III analyses how the knowledge creation is supported by the practices of LSM used in a LAB studio. Article IV studies the new learning networks established by the students during their studies in a LAB studio.

This dissertation focuses on a specific higher education configuration in a Finnish University of Applied Sciences. Overall, the scope of this dissertation research is on the potentiality of a LAB studio model for teaching T-shaped skills to knowledge workers. This dissertation research is supposed to be exemplary for other authentic and hybrid learning environments in higher education regarding the many similarities between the existing multi-stakeholder learning environments. As such, the target of this dissertation research is to support the

evidence-based effective educational design of all authentic learning environments in higher education.

1.3 Research approach

While clarifying the philosophical grounding of the research, a researcher must consider various viewpoints. The selection between research methodology and conducting the analysis and presenting the results is a choice, which reflects the researcher's viewpoint of the reality and its construction. Three interconnected, generic activities define the research process, including theory, method, and analysis; or ontology, epistemology and methodology (Denzin & Lincoln, 1994). Table 3 summarises the research approach of this dissertation.

Table 3. Research approach.

Principal theoretical orientation	Approach	Justification to this dissertation
Ontology	Constructionism	The context and people shape truth; the effect of LSM to boundary crossing activity is contextual and personal.
Epistemology	Interpretivism	Researcher shapes the perception of the social context under study; researcher has to be familiar with the context and LSM.
Methodology	Explorative with Educational Design Research	Effectiveness of a new and evolving phenomena is studied, researchers role inside the context; has effect to the validity of the results.
Methods	Case research with Mixed methods	Methods produce more information about the phenomena.

Ontology (theory) refers to a reality wherein studied phenomena are understood to reside and the manner in which the studied phenomena are positioned in this reality. Ontology has two extreme positions, objectivism and constructionism, where objectivism considers that phenomena are independent of social actors, whereas constructionism assumes that phenomena and meanings are created by the actors (Bryman and Bell, 2007). Epistemological (methodical) questions consider the nature and scope of knowledge, for instance, 'what can be known and how can new knowledge be acquired?' Positivism and interpretivism are two extreme epistemological positions (Saunders *et al.*, 2009). While the first position is typically applied in the natural sciences, the latter is mainly applied in social science. Based on these philosophical categories, the research in this dissertation

is considered epistemologically and ontologically to be interpretivism and constructionism respectively. The research strategy for designing and conducting research implies deductive or inductive reasoning. In the deductive approach an existing theory is used as the foundation for new observations and findings. Respectively, in the inductive approach, new theories are developed based on observations and findings. (Jaynes, 2003.) This approach accounts for the observation, ideally seeking to find the simplest and most likely explanation for the theory. Since the research in this dissertation is empirical, mainly explorative and descriptive, it applies inductive reasoning.

The research methodology, in other words analysis, in this dissertation uses the principle of exploratory research aiming to obtain a better understanding of a new phenomenon, the LAB studio model. Even if there are studies about the studio model, the LSM and boundary crossing have not been studied earlier. In addition, typical to educational research, the LSM is not a static educational phenomenon, as it evolves over time. Exploratory research is research conducted for a problem that has not been clearly defined. The term exploratory research or exploration refers to broad-ranging, intentional, and systematic data collection designed to maximise discovery of generalisations based on description and direct understanding of an area of social or psychological life (Stebbins, 2012). Or, as indicated by Creswell (2013), "[exploratory research] may be needed because the topic is new, has never been addressed with a certain sample or group of people, and existing theories do not apply with the particular sample or group under study" (Creswell, 2013). In other words, exploratory research is essential to obtain a better understanding of a less clear phenomenon and establish guiding principles for further research. Explorative research doesn't aim for a practical solution; instead it tries to explore the effectiveness of the system under study.

As the world is complex and in general there are no simple explanations for phenomena, events that happen are the result of multiple factors coming together and interacting in a complex and often unanticipated way (Strauss and Corbin, 1990). Thus, when studying the complex phenomena of the world, the researcher will benefit from using multiple methods for one's research. A mixed methods procedure (Creswell, 2012, 2013) combining both quantitative and qualitative forms, was used with the purpose of addressing the research problem from multiple perspectives and strengthening the overall contribution. Qualitative research refers to the meanings, definitions, concepts, characteristics, symbols, metaphors, and descriptions of things, whereas quantitative research refers to measures and measurements of things (Berg, 2004). Thus, mixed methods

combine the strengths of both qualitative and quantitative research methods to overcome the weaknesses and limitations of the individual methods (Creswell, 2013).

There are two major applied research methods used widely in educational research; design research and action research (e.g. Cohen, Manion, & Morrison, 2013; Johnson & Christensen, 2008; van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). Design research is especially useful when existing knowledge about a certain phenomenon is wanted, as is often the case with innovative curriculum improvement initiatives (cf. Collins, Joseph, & Bielaczyc, 2014; Herrington, McKenney, Reeves, & Oliver, 2007; McKenney & Reeves, 2013). Action research instead, is an interactive inquiry process balancing the problem solving actions in a collaborative context with data-driven collaborative analysis to understand underlying causes and enabling future predictions about personal and organisational change (Reason & Bradbury, 2001). Typical to action research is its nature of solving a commonly recognised problem by individuals working with others in teams or as part of a community of practice (Lave & Wenger, 1991) to improve the way they address issues and solve problems.

Methodology in this dissertation utilises design research, as it emphasises the underlying theories more, while action research involves social activity in a community of practice. Design research is not for testing theories. Instead, it discovers ways to change and build systems based on theories and to define the effectiveness of these systems in practice (Kananen, 2013; van den Akker *et al.*, 2006). Action research is an interactive inquiry process that balances problem solving actions implemented in a collaborative context with data-driven collaborative analysis or research to understand underlying causes enabling future justifications about personal and organisational change (Reason & Bradbury, 2001). Both strategies are iterative and the validity of their results and the role of the researcher are similar.

In the design research, the role of the researcher differs from the traditional role of the researcher. In-depth understanding of the phenomenon often requires some degree of involvement; the researcher is required to possess participative observation skills, participation skills, social skills, and empathy. Process and research know-how are also required (Kananen, 2013). Tamminen (1993) summarises the tasks of the design researcher as a whole to be familiarisation, creative thinking, evaluation and engagement. As a summary of the above, in design research the researcher must be familiar and engaged with the organisation and the context in which evaluation and development take place, in addition to

mastering the research process, so that one can get to the core of the phenomenon to be developed.

Design research credibility relies on the combination of scientific approach and research methods, and requires a group of researchers familiar with the phenomenon as well. If design research has qualitative research elements, the credibility of the results is evaluated as in qualitative research. The group of these researchers that reads the text and confirms the researcher's interpretation and research results also confirms the credibility of the results. (Kananen, 2013.) As design research respects a process of (re-) designing and testing instructional activities and other aspects of the design (van den Akker *et al.*, 2006), it consists from cyclic processes of thought experiments and instruction experiments. This dissertation has only one iterative cycle for the studies, which is due to the explorative nature of the research aiming to study the effectiveness of the phenomenon rather than to practically develop it.

1.4 Dissertation structure and research process

The structure of this dissertation is article based, each article focusing on a specific research question. Therefore, a dedicated research is designed and conducted by utilising one or several research methods to find the answers to the identified research questions. Each article has a theoretical foundation that can be used to explain why or how such phenomena occur, which leads to answering the research questions. The dissertation is a constructive research ensemble utilising mixed methods for data collection and analysis primarily through the qualitative approach combined with the quantitative approach applied in article IV. The research methodology is known as exploratory research, in which several research approaches have been conducted to answer the research questions with the aim of synthesising the research findings to produce the results.

Both literature review and empirical research are used to answer the research questions. As the researcher is acting as a participant in the education configuration being researched, the research process includes also case analyses and case observation. Each study began with a literature review to form a theoretical base for the research. Second, a literature study or survey structure was designed. The third phase involved data collection, which included either interviews or web-based surveys. The final phases of the research process included analysis and drawing conclusions. The main data sources were divided to two categories; published and indexed research literature, and students

studying in LAB studios. The data for the research was collected using a systematic literature review and qualitative methods of observation, a survey for individual students and semi-structured interviews for the student teams. Table 4 summarises the methods and data sources per each individual article and are further explained through the following paragraphs.

Table 4. The methods and data sources for individual articles.

Article	Research method	Data source
I	Case study	Literature review and observation
II	Part 1: Text content analysis	Literature review for the Scopus indexed scientific
	Part 2: Content analysis	articles published between
		Part 1: years 1984-2015, N: 92+164
		Part 2: years 2010-2015, N: 23
III	Case study, content analysis	Survey for the students studying in Oulu Game LAB
		between years 2013-2014, N: 72
IV	Case study, mixed method with fixed	Semi-structured team interviews for the students
	design	studying in Oulu App LAB year 2015, N: 35

The article I, "The LAB studio model: enhancing entrepreneurship skills in higher education", was designed to be a case study by a literature review. In the study, the characteristics of the LSM were compared against the recent studio model definition as defined by Bull, Whittle, & Cruickshank (2013). The comparison was structured by using the categories studied and outlined by Bull *et al.* (2013) and the data for the comparison was gathered through the literature review and researchers' observations of the LSM. In order to explore how the LSM supports the studio model definition, the different aspects of a studio model were compared in relation to the characteristics of the described LSM. The differentiating characteristics were drawn together by the researchers to conclude the study.

The study in article II, "Entrepreneurship education in studio based learning practices", was done in two major parts. Firstly, an overview of the articles in the higher education studio context published during the past thirty years was performed. Secondly, a literature review to identify more detailed and recent understandings of the core studio model practices described in the literature was performed. The overview study was done by a text content analysis (Krippendorff, 2012) for the keywords and abstracts in articles published between the years 1984-2015. The searches were directed to Scopus, one of the biggest bibliographic databases having more than 60 million records (Scopus, 2017).

After the searches, the non-relevant and duplicate articles were removed and the Nvivo-tool (Nvivo, 2017) was used for the analysis of the relevant articles in two patches for achieving the best coverage for the study. Two different search terms for the published articles were used; 'studio model education' and 'studio based learning'. The total amount of published articles, called 'studio articles', from the first batch using a 'studio model education' as the search term included 92 articles and the second batch using 'studio based learning' as the search term included 164 articles. These studio articles were used for the basis of the following literature review, for which the Activity System Model (Engeström, 1987) was used as an analysis tool. The Activity System Model was chosen because of its viability in analysing the activity of a system in general and the social aspect of the activity (Jonassen, 2000). The literature review was performed for the most recent studio articles written between the years 2010 and 2015. A total amount of 23 studio articles were read by three researchers between February and May 2016 and analysed by content analysis using the Activity System Model. The findings were debated and written down in seminars between the researchers, after which two experienced coaches, both working in Oamk LABs, reviewed the findings and the conclusions of the researchers.

For the study in article III, the "Studying the aspects of knowledge creation in the LAB studio model", case study method was chosen. According to Creswell (2012) and Yin (2013), a case study can include either quantitative or qualitative evidence, maybe even both, and it usually relies on multiple sources of evidence and benefits. Oulu Game LAB (OGL) has been utilising LSM for the longest time out of the LAB studios, since September 2012. With its focus to the game industry, OGL includes students from different disciplinary areas, such as graphical artists and software and audio designers. In addition to being multidisciplinary, OGL includes bachelor and master level, as well as postgraduate students. Due to its above-described diversity among students OGL was chosen for the LAB studio to be studied. A total amount of 72 students were surveyed anonymously while taking part of the OGL between the years 2013 and 2014, conducted at the end of the each semester. In these surveys, the aspects of the knowledge creation model were in focus, as also the other aspects of the LSM were asked about. The survey was carried out as an electronic web survey, where all the questions were of open type. After uploading all the 648 answers to the Nvivo analysis tool, researchers read through all the individual answers and made a thematic and keyword match to find similarities between them.

For the study in article IV, "LAB studio model: developing external networks for learning entrepreneurship in higher education", a case study with mixed method and fixed design was chosen. In this study the quantitative data was collected for the purpose of measuring the number and structure of the established learning networks, and the qualitative data was collected to study the effectiveness of these networks. The researchers collected the data from a LAB studio called Oulu App LAB (OAL), during semi-structured team interviews held in May 2015. OAL focused on developing applications for various industries, such as wellbeing, sustainable energy and cleantech, by six project teams consisting of 33 post-graduate students of different disciplines. Before conducting the team interviews the interview questions were piloted with two students, after which two researchers interviewed each team. During the interview process a map of the specific learning network under discussion was drawn on a large piece of paper. This activity helped both students and researchers to follow and remember what had been already discussed as well as find the connections between different parts of the network. Each interview took from 1.5 to 2 hours and was video recorded for later analysis. For the qualitative data portion, student teams described the content and meaning of their co-operation with the external partners. For the quantitative data portion, the student teams were asked to estimate how often they had been in contact with different external network partners. For this purpose, the number of single contacts, face-to-face meetings, emails or phone calls were counted. The data was analysed according to the principles of mixed method research (Creswell, 2013; Driscoll, Appiah-Yeboah, Salib, & Rupert, 2007) with both quantitative and qualitative data collected simultaneously. An iterative and reflexive process of analysis was undertaken simultaneously with the data collection. The data was collected as a network map, then coded into key actors according to the categories, where the number of connections with external networks and the amount of single contacts were counted.

This dissertation consists of the four scientific articles presented above, as well as this compilation part. The structure of this compilation part is as follows. The chapter 2 presents the theoretical foundation for the research while chapter 3 summarises the research contributions of the four articles. These two chapters are combined in chapter 4 to discuss the scientific and practical implications of the results, the reliability and validity of the research, and potential directions for future studies.

2 Theoretical foundation

2.1 Studio model education

The basic objective of the studio model is to practice professional skills in small groups where peers and mentors challenge one's professional skills. In essence, studios create the need for collaboration and creativity existing in work-place environments of creative disciplines, for instance design and art. Traditionally, studios have been focusing on visually-centred work and 'reflective practice' (Schön, 1987; Ruohotie, 2003a, 2003b) by observing and refining practice in a continuous cycle, supported by coaching and peer-learning. In describing the learning process Schön (1983) challenges practitioners to reconsider the role of technical knowledge versus 'artistry' in developing professional excellence. He does this to highlight the need for deeper collaboration. Smith (2011) further describes the studio model as a learning system, capable of bringing about continual transformation.

A studio model of education highlights a more practical approach to professional education. Schön (1983) summarises this process as reflective practice or 'knowing- and reflecting-in-action'. Pakman (2000) elaborates that this model of learning can "allow practitioners to reconstruct their theories of action making and form action strategies explicitly open to criticism." Another aspect of the studio model is the use of real world problems around which teaching is constructed (Schön, 1985). Real world problems, however, tend not to be well formed, making for situations that are characterised by uncertainty, complexity, and uniqueness. Additionally, this form of problem-based learning (Savery, 2006) demands a framework that enables an integrated approach towards responding to challenges. Overall, research related to design education suggests that studio model of education is effective for cultivating students' identities as designers; developing their conceptual understanding of design and the design process, and fostering their design thinking. (Brandt *et al.*, 2013; Cennamo *et al.*, 2011; Kuhn, 1998, 2001; Schön, 1983; Shraiky & Lamb, 2013; Wang, 2010.)

Despite the fact that studios are used within professional education, a lack of consensus exists for definition of the studio model (e.g. Bull *et al.*, 2013; Kuhn, 1998; Ledewitz, 1985). In architecture, a definition for the studio pedagogy was made by Boyer and Mitgang (1996) by suggesting that studio-based learning can be characterised to be: "reflective; design project-centred; master craft-person

supervised; with varying group sizes; discussion intensive; individual project driven; highly integrated across multiple knowledge elements of the profession being practiced; and fostering of the learning habits needed for the discovery, integration, application, and sharing of knowledge over a lifetime". Drawing from the description above, a studio model of teaching can be defined as an "instructional strategy that provides students with opportunities to engage in relevant, authentic learning in a school setting". (Boyer & Mitgang, 1996; Burroughs, Brocato, & Franz, 2009) Continuing the above, according to Schön (1985), the physical space of a studio provides a dedicated, collaborative workspace where students collaborate with experts. Since students spend much of their time learning about and designing in response to teacher-crafted cases based on professional practice, the studio learning space is an essential part of the studio experience. The studio space, within which each student has a reserved, personal, learning area in which to respond individually to cases, is a core element of the learning model (Burroughs *et al.*, 2009). One of the recent attempts to define studio model characteristics was performed in a study, where 15 professionals with experience in teaching and being taught in studios were interviewed. Interview participants were from the fields of art, design and architecture, and the results from this study led to the development of categories and parameters for defining the studio model. (Bull *et al.*, 2013.)

2.2 Boundary crossing, knowledge creation and entrepreneurial competences

2.2.1 Boundaries and boundary crossing

Boundaries are often seen as obstacles and barriers for working and learning processes (Akkerman & Bakker, 2011), or "the barrier conditions between the activity and its context" (Katz & Gartner, 1988). Boundaries can relate to the crossing of cultural (Aikenhead, 2001; Brett, 2007), disciplinary (Klein, 1996) and social (Rampton, 2014) borders. The creation of boundaries at the same time creates the need for systems that maintain the boundaries and the distinctiveness of the entity (Klein, 1996). Exchange refers to communications between the entity and its environment and to communication among its members. Through exchange, for instance, entities compete against and cooperate with external parties to procure essential resources for new purposes. (Busenitz *et al.*, 2003.)

Through internal exchange among its members, an entity further refines routines and knowledge about efficient and effective practice. (Aldrich, 1999; Katz & Gartner, 1988.) Boundary crossing, defined as an operation with different discourses and practices within different sociocultural contexts, is regarded as essential to allow for transformation, for instance, for new practices, as a result from working across boundaries (Akkerman & Bakker, 2011). Obstacles to boundary crossing, as perceived by participants in interdisciplinary projects, are the additional time needed, coping with different traditions, and a lack of common terminology. In addition, troubles with agreeing the common problem formulation and the lack of common personal chemistry create hurdles for boundary crossing. (Oonk, 2016; Tress, Tress, & Fry, 2007.)

The concept of boundary crossing is argued to encapsulate the new competencies and as such manifests itself as a key competence. According to the literature, boundary crossing competence is defined to be the "ability to manage and integrate multiple discourses and practices across different sociocultural boundaries" (Akkerman & Bakker, 2011; Lansu, Boon, Sloep, & van Dam-Mieras, 2013; Umemoto, 2001; Walker & Nocon, 2007) and the ability to function competently in multiple contexts (Walker & Nocon, 2007). To make use of the transformative potential of boundary crossing, and at the same time overcome its barriers, people should develop their boundary-crossing competence, in other words, the ability to work and communicate across different practices and become transformation agents. (Augsburg, 2014; Walker & Nocon, 2007.)

Boundary crossing has been recognised to have effects to learning mechanisms. Akkerman and Bakker (2011) reveals four potential learning mechanisms that can take place at boundaries: *identification*, which is about coming to know what the diverse practices are about in relation to one another; *coordination*, which is about creating cooperative and routine exchanges between practices; *reflection*, which is about expanding one's perspectives on the practices; and *transformation*, which is about collaboration and co-development of possible new practices. These mechanisms represent the ways in which sociocultural differences and discontinuities in action and interaction can enhance learning and development of intersecting identities and practices (Kumpulainen & Sefton-Green, 2014).

2.2.2 Boundary crossing and knowledge creation

Due to the overall nature of boundary crossing, there's a strong tendency to believe that the competence of boundary crossing enhances new knowledge creation and the establishment of new contacts for learning purposes. Among the capability to combine or integrate others' skill or knowledge onto one's own knowledge base (Yang, Kang, & Mason, 2008), it has been asserted that multi-skilled persons are more likely to be able to digest diverse knowledge and skills (Schilling, 2005). In addition, persons with T-shaped skills enhance knowledge creation by their improved ways of communication (Truran, 1998), and high level of trust (Lee & Choi, 2003). Supporting the above, Madhavan & Grover (1998) proposed that T-shaped skills influence team performance positively in knowledge creation, as these employees gain and are able to integrate diverse knowledge assets to improve the competitiveness of their organisation. Further on, individuals with such a skills are more likely to understand phenomena from a higher level of abstraction and thus be able to form meta-theories (Leonard-Barton 1995).

The concept of T-shaped professional approach proposes that vertical skills (I-SP) are a prerequisite for creation of new knowledge within the teams (Karjalainen *et al.*, 2009; Karjalainen & Salimäki, 2008). In addition, creativity and new ideas can be resulted by the interaction of different knowledge sets (Madhavan & Grover, 1998; Simon, 1985), thus potentially speeding the creation of new innovations (e.g. Hamdi, Silong, Binti Omar, Mohd Rasdi, & Nisar, 2016). Multidisciplinary interaction can create what Madhavan & Grover (1998) call creative abrasion, a deliberate conflict of different ideas at a cognitive level leading to increased effectiveness and efficiency, as well as innovativeness of new product development. Those with T-shaped skills retain both good knowledge of discipline and know how to cooperate with others to function as a team. Aiming for innovation, exploration focuses on gaining new knowledge, which, resulting from exploration, is categorised as original, complex, and ambiguous, which is likely to be synergistic with T-shaped skills. (Levinthal & March, 1993; Madhavan & Grover, 1998.) For effectively utilising unfamiliar knowledge, T-shaped skills are required, in addition to maintaining the ability to combine theoretical and practical knowledge and to sustain meaningful conversations with others, also for possessing the capability of expanding one's ability across different areas and developing systematic thinking skills (Lee & Choi, 2003; Madhavan & Grover, 1998).

2.2.3 Boundary crossing and entrepreneurial competencies

In the field of entrepreneurial activity, boundary crossing is connected to the opportunity finding perspective. Entrepreneurial opportunities are defined as being situations in which "new goods, services, raw materials, markets and organising methods can be introduced through the formation of new means, ends or ends–means relationships." (Casson, 1982; Shane & Venkataraman, 2000.) Venkataraman, Sarasvathy, Dew and Forster (2012) suggest that entrepreneurial action and interaction at the borderline, exchange at boundaries, is about "telling stories of the past, creating spaces for new thinking, convincing others of the better scenario, and narrating the value of something novel." In this process, the constructive contradiction linked to opportunity finding is typically not an either-or situation in which two opposing views are competing, but a both-and situation in which balancing the conflicting priorities is not possible (Jones & Holt, 2008; Mainela, Puhakka, & Servais, 2015). Shane and Venkataraman (2000) state that the reasons some people will discover opportunities while others will not is contingent on two issues: the possession of prior information necessary to identify an opportunity and the cognitive properties necessary to value it. In this process T-shaped skills are essential. As a summary, information processing, knowledge creation, innovation, and opportunity identification are closely related to one another (Nooteboom, 2000; Ward, 2004) and opportunity is a critical attribute of entrepreneurship (Shane & Venkataraman, 2000).

Discovering opportunities and, ultimately, boundary crossing is a social activity, which brings together various intellectual, linguistic and practical tools that the actors from different activity systems carry (e.g. Hill & Mudambi, 2010; Kuemmerle, 2002; Zander, 2004, 2007). By the activity theory Engeström (1987, 2001) and Holt (2008) stress the process of meaning-making, which is primarily a social practice. Constructivist perspective argues that opportunities are produced through a process of social construction and cannot exist apart from the entrepreneur (Baker & Nelson, 2005; Sarasvathy, 2001; Shackle, 1979). To collect information and establish business relations, the entrepreneurial actor needs to get in contact with other people who can provide complementary knowledge and resources (Johannisson, 1988; Larson, 1992). These people might be reached directly or indirectly through private or business-related ties. Individual and collective social networks compose social capital (Coleman, 1988); ties and structures that help the individual get access to information and know-how (Bøllingtoft & Ulhøi, 2005).

Thus, entrepreneurial learning is all about sharing ideas, creativity, looking for new combinations, trying new things and learning from each other's successes and mistakes. In addition, entrepreneurial activity in the borderline is linked to opportunity finding with the intention of creating something new and a more relevant solution to the existing problem. In summary, boundary crossing and skills related to that activity are connected to the development of new solution and business and thus developing new entrepreneurial opportunities.

2.3 Knowledge creation

There are many different models and theories trying to explain how new knowledge is being created. For instance in Engeström's (1987) expansive learning, Nonaka and Takeuchi's (1995) organisational knowledge creation, and Bereiter's (2005) knowledge building, a key characteristic appears to be that collaboration is organised around long-term efforts to develop shared, tangible objects, such as products, articles, models, and practices (Hakkarainen & Paavola, 2009). Nonaka, Toyama, and Konno (2000) state that "knowledge is created in the spiral that goes through two seemingly antithetical concepts such as order and chaos, micro and macro, part and whole, mind and body, tacit and explicit, self and other, deduction and induction, and creativity and control." The dynamic theory of organisational knowledge creation, also called the SECI model, has four modes of knowledge conversions that are created when tacit and explicit knowledge interacts. The modes are socialisation, externalisation, combination and internalisation, as illustrated in Figure 3 (Nonaka, 1994; Nonaka & Takeuchi, 1995).

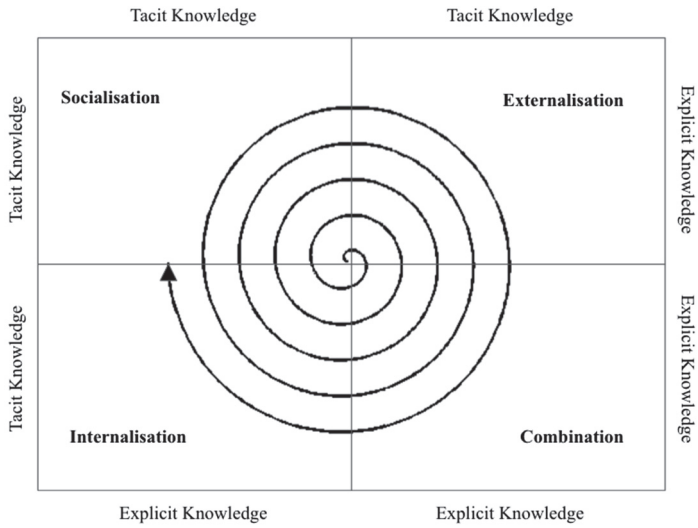

Fig. 3. The SECI model of knowledge creation. Adapted from (Nonaka, 1994; Nonaka & Takeuchi, 1995).

Socialisation is a process of sharing experiences, which creates new tacit knowledge from existing tacit knowledge. For example, by observing a colleague, the observer can learn through imitation or practice. Typically the new tacit knowledge is in a form of shared mental models or technical competences. Externalisation is a process of articulating tacit knowledge into explicit concepts. Externalisation is the key process in the theory, as it is the process that creates new explicit concepts from the tacit knowledge. Combination is a process of systemising concepts into a knowledge system. It creates new explicit knowledge from existing explicit knowledge. It is the kind of knowledge creation that happens in formal education or training at schools. Internalisation is a process of embodying explicit knowledge into tacit knowledge Reading documentations or watching videos is an example of the kind of re-experiencing that internalisation requires. Also learning by doing can be seen as an example of internalisation. (Nonaka, 1994.)

In addition to SECI model, Nonaka and Takeuchi (1995) provide a five-phase model of the organisational knowledge-creation process. The model consists of the following phases: sharing tacit knowledge, creating concepts, justifying concepts, building an archetype and cross-leveling knowledge. Figure 4 illustrates the process (Nonaka & Takeuchi 1995).

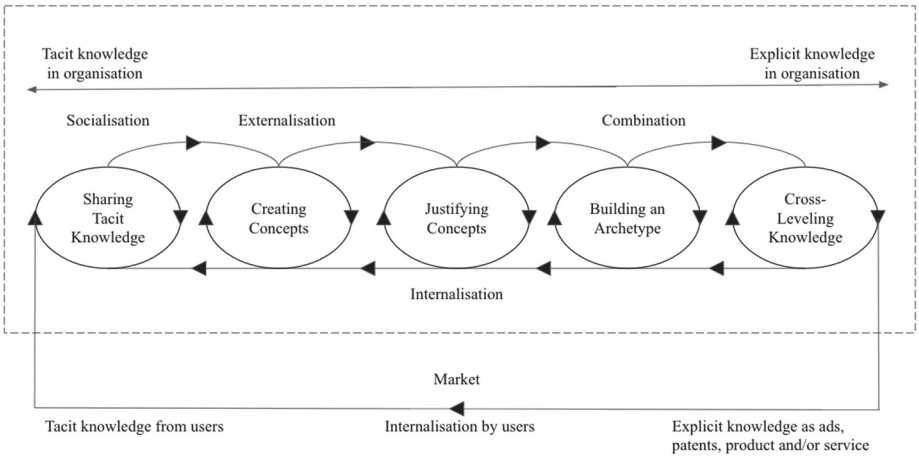

Fig. 4. Five-phase model of the organisational knowledge creation process. Adapted from Nonaka & Takeuchi (1995).

As organisations cannot create knowledge by themselves, the knowledge creation starts by harnessing the tacit knowledge residing in the individuals, sharing tacit knowledge. This phase matches with the socialisation mode of the spiral. The second phase, creating concepts, uses collective reflection to verbalise the shared mental models into words and phrases and, finally, into explicit concepts. The externalisation mode of the knowledge creation spiral is similar to the creation of the concepts phase. As these concepts are created, the organisation must screen them in order to justify the 'true beliefs' among the rest. This third phase, justifying concepts, does not have an equivalent in the knowledge conversion modes. The organisation needs some sort of criteria for the justification. For example, some concepts may be too expensive or otherwise not feasible. The justified ones can be taken to the fourth phase, building an archetype, which can be, for instance, a prototype of the product under development. As the prototypes are usually built by combining existing knowledge with the newly built concept, this phase is close to the knowledge conversion mode of combination. The fifth and final phase of the model is cross-leveling knowledge. In this phase, the newly created, justified and modelled concept moves on to another ontological level where a new cycle of knowledge creation process can begin. (Nonaka & Takeuchi, 1995.)

Table 5 summarises the aspects related to the SECI model and organisational knowledge creation process. Sharing of tacit knowledge is omitted because it is equal to the SECI model of socialisation.

Table 5. Models and aspects related to SECI model and organisational knowledge creation. Adapted from Nonaka & Takeuchi (1995).

Aspect	Description
Socialisation	Sharing experiences, creating new tacit knowledge from tacit knowledge
Externalisation	Process of articulating tacit knowledge into explicit concepts
Combination	Creating new explicit knowledge from existing explicit knowledge, combining existing knowledge into new knowledge
Internalisation	Process of embodying explicit knowledge into tacit knowledge
Creating concepts	Collective reflection to verbalise the shared mental models and into explicit concepts
Justifying concepts	Process of justifying that the created concepts are true
Building an archetype	Build a prototype of the product under development
Cross-leveling knowledge	Move the justified concepts on to another ontological level where new knowledge creation process can begin

2.4 Learning networks

Connecting education and the development of working life requires the construction of a learning network. As a result, one of the significant objectives of a learning activity (Engeström, 1987) is to increase the social capital within a learning network. Historically, formal education has differed from learning in the informal sector and in working life (Engeström, 1987; Miettinen, 1990). Teaching has typically been teacher-led, involving textbook- and individual-centred learning in classrooms with few connections with actors outside of the education context. Tangibly, the focus of classroom-based learning has been the textbook. In contrast, the objective of educational change is to move beyond the lesson and textbook structure and move towards connecting more strongly with activities focused on societal use (Ruohotie, 2000), eventually resulting a ‘networked ecosystem‘ for learning. The networked educational structure is a relevant developmental factor for the overall development, competitiveness and attractiveness of a surrounding region (OECD, 2016b). Achieving this, networking with actors outside the education environment and the formation of learning networks is required (Miettinen, 1999; Miettinen & Peisa, 2002).

Social networks are defined as a set of social relations created by interaction of actors that influence the behaviour of those involved (Reupold, 2009). The activity within the social networks maintains the network. Social exchange within the network is a set of linkages among a defined set of persons, with the additional property that the characteristics of these linkages as a whole may be used to interpret the social behaviour of the persons involved (Mitchell, 1969). Thus, social interchange means that actors do not only act individually but also interact and communicate with one another, exchanging feelings, experiences and knowledge. Networked learning is a process of developing and maintaining connections with people and information, and communicating in such a way so as to support one another's learning. Learning takes place both in relation to others and in relation to learning resources (Dirckinck-Holmfeld, Jones, & Lindström, 2009).

Ensuring interaction between education and society requires network-like structures for learning, in which experts external to education share their experiences, insights and knowledge within a learning network (Coombs, Chappells, & Shove, 1985). For instance, entrepreneurship education research has shown that entrepreneurship learning methods should include functional project-based learning (Pittaway, 2004), which contains a sufficient level of challenge and uncertainty (Cope, 2003). This type of education requires students to be active and self-directed (Bird, 2002; Cope, 2003). Additionally it requires the strengthening of the social dimension and networking (Rae & Carswell, 2000), encourages the student to take part in educational planning (Fiet, 2001), and uses versatile assessment (Honig, 2004). Entrepreneurship as new business creation is linked to changes in the environment and societal phenomena. Educational activities related to the recognition of business opportunities have increased as part of entrepreneurship education (DeTienne & Chandler, 2004). Ultimately, linking the recognition of business opportunities to learning requires a detachment from traditional classroom pedagogy (Fiet, 2001; Honig, 2004) and building bridges with learning networks outside the education environment (Deakins & Freel, 1998; Elfring & Hulsink, 2003; Isokangas, 2009).

2.5 Activity system model

Activity theory (AT) defines that the behaviour of an individual cannot be separated from the changing environment. In addition to Vygotsky's (1978) definition of mediated action from the individual's perspective, AT emphasises the

concept of object-oriented, collective and culturally mediated human activity and the role of artefacts on it (e.g. Engeström, 1987; Leontjev, Hakkarainen, & Helkama, 1977). The production of any activity involves a subject, the object of the activity, the tools that are used in the activity, and the actions and operations that affect an outcome (Nardi, 1996). The subject of any activity is the individual or group of actors engaged in the activity (Engeström, 2001; Jonassen & Rohrer-Murphy, 1999). A tool can be anything that is used in the transformation process, including both material tools and tools for thinking (Jonassen & Rohrer-Murphy, 1999). The activity in the system should have an object, which is clearly defined. According to Leontjev *et al.* (1977) the object of the activity is the real motive for the activity. Objects and motives are collective (Engeström, 1987; Engeström *et al.*, 1995), and the individual activity is always part of a system activity and activity among other actors in the system (Engeström, 1983, 1987; Leontjev *et al.*, 1977). Figure 5 illustrates the concept of Activity System Model (Engeström, 1987), where individuals participating in an activity are in relation to the environment via artefacts, signs and other individuals.

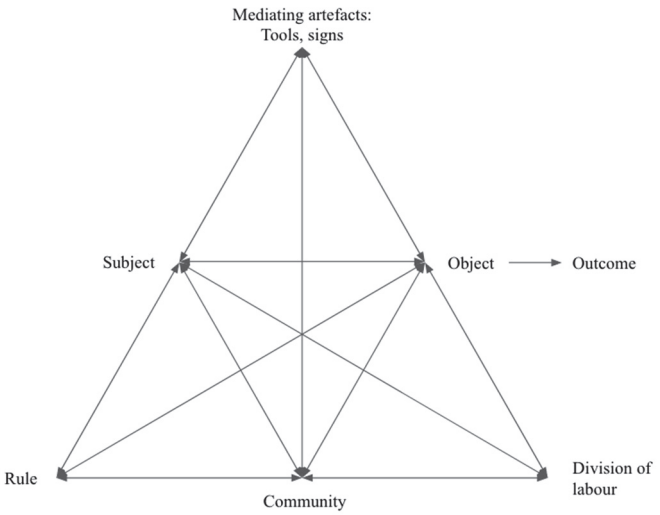

Fig. 5. The structure of a human activity system. Adapted from Engeström (1987).

The activity is social, only the actions are individual (Engeström, 1987). Engeström (1987) expanded the AT to include collective motivated activity towards an object, making room for understanding how collective action by social

groups mediates activity by the inclusion of community, rules and division of labour. The community consists of the interdependent aggregates, which share an objective (Jonassen & Rohrer-Murphy, 1999). Rules inherently guide actions or activities acceptable by the community, so the signs, symbols, tools, models, and methods that the community uses will mediate the process. The division of labour prescribes the task specialisation by individual members of groups within the community or organisation as related to the transformation process of the object into the outcome. The outcome is the form of instruction that is developed and implemented from the object. (Jonassen & Rohrer-Murphy, 1999.)

3 Research contribution

3.1 LAB studio model and the recent definition of studio model

Article I addresses research question 1 by focusing on the characteristics of a specific configuration of studio model education, the LAB studio model. More specifically, the research question was stated as "How do the characteristics of the LAB studio model differ from the existing definition of studio model recognised by the literature?" Table 6 summarises the comparison of various characteristics of the studio model definition by Bull *et al.* (2013) and the LSM.

Table 6. Comparison of the studio model and LAB studio model characteristics. Adapted from Heikkinen & Stevenson (2016). Reproduced by permission from Inderscience Enterprises Ltd.

Category	Parameter by Bull *et al.* (2013)	LAB studio model parameter
Physical environment	Open environment	Open, company like environment
	Reconfigurable furniture	Reconfigurable furniture and spaces
	Students control aesthetic factors (lighting, heating)	Students control aesthetic factors and shared, individual, social and private spaces
	Shared and individual spaces	Located in city centre
	Social and private spaces	
Facilitation of studio	Studio belongs to the students	Studio belongs to the students
	Staff do not dictate use of space	The students create the rules, staff create the safety rules
	24 hour access	24/7 access
	Food and drink allowed	Food and drink allowed with kitchen facilities
	High availability of staff	High availability of staff
	Small group size (about 10)	Small project team size
Modes of education	Switch approach based on activity	Learning-by-doing
	Mentoring/coaching	Peer-learning, learning community
	Peer-learning	Coaching and mentoring
	Impromptu teaching	Impromptu teaching
Awareness	Visual work	Prototypes and visuals
	Displaying work	Showing progress and history
	Visual history of progress	Prototypes lying around
	Easily observe other people's work	Common events for progress
	Social interactions	

Category	Parameter by Bull *et al.* (2013)	LAB studio model parameter
Critique	Direct feedback	Formal and informal feedback
	Develop ideas	Direct and constructive feedback
	Multiple formats (formal and informal,	Culture of excellence
	individual and group)	Industry feedback
	Peer-coaching	Peer feedback
		Development discussions
		Funnel method
Culture	Sharing	Common values: care and trust
	Social	Treated as an own company
	Treated like second home	Commonly created work ethic
	Good work ethic	Permission to fail
	Peer-learning	'Bazaar' of activities
	Serendipity	Tolerance of ideas
Individual's	Personalisation of space	Respect for the individual needs to work
characteristics	Private and quiet spaces	
Inspiration	Proximity to other people	Proximity and virtual presence
	Relevant available media	
	Library of liked/fun things	
	Playful space	
Collaboration	Impromptu collaborative spaces	Team work, leadership
	Supporting equipment	Supported by open access premises and
		social media
		Entrepreneurial thinking
		Multidisciplinary, multi-generational
Digital	Not essential for studio	Essential for a LAB studio
technology	Access work outside studio	Enhances social interaction
	Reduces social interactions	Invites all to collaborate
	Reduces visibility of activities	

The results of article I indicated that the LAB studio model can build competencies in an authentic and industry specific work environment, and is more closely aligned with industry needs and workplace realities in contrast to the existing studio model. The LSM accomplishes this by focusing on a number of key factors. These factors include:

- offering a form of instruction that is more competitive in structure in contrast to other studio model;
- integrating experienced professionals and coaches from the industry;
- including problems or ideas directly from targeted industries; and

– building multidisciplinary project teams that cross professional and higher education faculty boundaries. (Heikkinen & Stevenson, 2016.)

The results of the article also indicate that the LSM can build competencies for T-shaped professional in an authentic and industry specific work environment.

3.2 Studio model in higher education and unique practices of the LAB studio model

Article II focuses on the utilisation of studio model education and the unique practices of the LSM compared to other studio-based educations in higher education. The utilisation is studied by an overview study and the comparison is done by a literature review and by utilising the Activity System Model theory. More specifically, article II addresses the research question 2: "How commonly are 'Studio Model Education' and 'Studio-Based Learning' used in the higher education recognised by the literature?" and research question 1: "What are the unique practices of the LAB Studio Model compared to the other studio-based higher education configurations?" Scientific articles regarding studio education published between the years 1984-2015 were the source of the overview study data. The result of the article II overview study is illustrated in Figure 6.

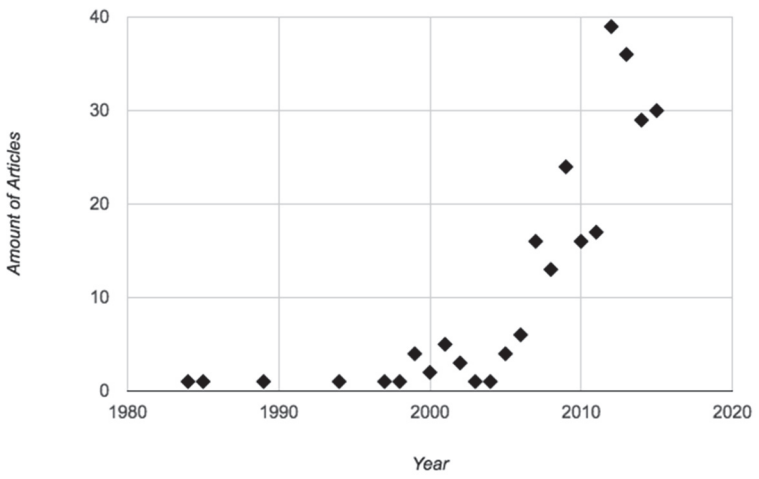

Fig. 6. Amount of the published 'Studio Model Education' and 'Studio Based Learning' articles between the years 1984-2015. Adapted from Heikkinen, Seppänen & Isokangas

The results of the overview study suggested that the amount of studio model related publications has been significantly increasing during the past ten years. This trend can be interpreted to demonstrate an increasing interest towards the establishment of new studio configurations and overall interest towards the studio-based pedagogy.

The overview study studio articles were used for the article II literature review, for which the Activity System Model (Engeström, 1987) was used as an analysis tool. Results of the literature review are presented first by Table 7 summarising the common artefacts indicated by the study and secondly by presenting the unique features of LSM.

Table 7. Common artefacts found from Studio articles.

Artefact	Common elements of an artefact	Articles
Subject	Students either bachelor or master level with different phases of studies and from one or two professions	(Bosman, Dedekorkut, & Dredge, 2012; Bull & Whittle, 2014b; Collison *et al.*, 2012; Hundhausen, Fairbrother, & Petre, 2012; Khan & Mahmood, 2013; Schnabel & Ham, 2012; Shraiky & Lamb, 2013)
Object	Prototype fulfilling the needs of the curricula practices within the particular discipline	(Bosman *et al.*, 2012; Brandt *et al.*, 2013; Bull & Whittle, 2014a; Gattie, Kellam, Schramski, & Walther, 2011; Wang, 2010)
Outcome	Product or a service, student personal and professional development	(Bosman *et al.*, 2012; Bull & Whittle, 2014b; Bull *et al.*, 2013; Carter & Hundhausen, 2011; Clinton & Rieber, 2010; Collison *et al.*, 2012; Forest *et al.*, 2014; Habash, Suurtamm, & Necsulescu, 2011; J. Lee, Kotonya, Whittle, & Bull, 2015; Mathews, 2010; Peterson *et al.*, 2015; Schnabel & Ham, 2012)
	Understanding the connection between theory and practice and between work life and academic context	
Tools	Pedagogical models; project-based learning, learning by doing and problem based learning	(Bull & Whittle, 2014b; Bull *et al.*, 2013; Collison *et al.*, 2012; Habash *et al.*, 2011; Hundhausen *et al.*, 2012; Schnabel & Ham, 2012)
	Critique; self- and peer-critique, receiving critique from the coaches and external experts	(Brandt *et al.*, 2013; Bull & Whittle, 2014b; Bull *et al.*, 2013; Carter & Hundhausen, 2011; Cennamo *et al.*, 2011; Hundhausen *et al.*, 2012; Mor & Mogilevsky, 2013; Schnabel & Ham, 2012; Shraiky & Lamb, 2013; Wang, 2010)

Artefact	Common elements of an artefact	Articles
Tools	Learning process; interactive process for developing a solution Main issues are the problem, iterative nature of the progress, length of the project, learning theoretical knowledge and ownership of intellectual property	(Bosman *et al.*, 2012; Brandt *et al.*, 2013; Carter & Hundhausen, 2011; Cennamo *et al.*, 2011; Mor & Mogilevsky, 2013; Peterson *et al.*, 2015)
	Problems; challenging, ill-defined with uncertain parameters	(Bosman *et al.*, 2012; Brandt *et al.*, 2013; Bull & Whittle, 2014b; Habash *et al.*, 2011; Hundhausen *et al.*, 2012; Mor & Mogilevsky, 2013; Peterson *et al.*, 2015; Wang, 2010)
	Industry representatives are involved, focusing on developing a solution based on analysed data in order to understand the problem	(Bosman *et al.*, 2012; Bull & Whittle, 2014a, 2014b; Bull *et al.*, 2013; Forest *et al.*, 2014; Habash *et al.*, 2011; Mor & Mogilevsky, 2013; Peterson *et al.*, 2015; Shraiky & Lamb, 2013; Wang, 2010)
	Use of a public space, could be used also by other people, learning environment that belongs to the students Digital tools; learning platforms, virtual environments, social media and videoconferences Log books and journals supporting students to store their documents and to reflect their personal learning process	(Bosman *et al.*, 2012; Brandt *et al.*, 2013; Bull & Whittle, 2014a; Bull *et al.*, 2013; Forest *et al.*, 2014; Hundhausen *et al.*, 2012; J. Lee *et al.*, 2015; Mor & Mogilevsky, 2013; Schnabel & Ham, 2012; Wang, 2010)
Rules	Peers, clients and professionals do the evaluation in academic manner enabling a public critique For the evaluation versatile assessment methods are used Teams own result of their work Learning community is the socialisation for learning purposes	(Bosman *et al.*, 2012; Brandt *et al.*, 2013; Bull & Whittle, 2014b; Bull *et al.*, 2013; Clinton & Rieber, 2010; Forest *et al.*, 2014; J. Lee *et al.*, 2015; Mor & Mogilevsky, 2013; Wang, 2010)

Artefact	Common elements of an artefact	Articles
Community	Social interaction; connections between studio participants and external participants The external participants used for example, as clients for the projects and as giving feedback from the professional context In the process of creating innovations the activity of producing personal relationships is enhanced by the mix of students with different levels of knowledge	(Bosman *et al.*, 2012; Bull & Whittle, 2014b; Bull *et al.*, 2013; Carter & Hundhausen, 2011; Forest *et al.*, 2014; Habash *et al.*, 2011; Harinarain & Haupt, 2015; Khan & Mahmood, 2013; K. Lee & Brett, 2015; Pektaş, 2015; Peterson *et al.*, 2015; Shraiky & Lamb, 2013)
Division of labour	Students and staff members, coaches	(Brandt *et al.*, 2013; Bull & Whittle, 2014b; Carter & Hundhausen, 2011; Habash *et al.*, 2011; Hundhausen *et al.*, 2012; Mor & Mogilevsky, 2013)

In the following sections the unique features of LSM indicated by the study are presented.

Subject

In this study the subject is a group of higher education students. When comparing the findings between Studio articles and entrepreneurial education, none of the articles mentioned students from the field of business or entrepreneurial studies. Oamk LABs includes students from the field of business and other fields of higher education studies. Before entering, the students are ensured to realise the curriculum including entrepreneurial subjects, as well as the possibility for establishing their own enterprise.

Object

The object is defined to be a prototype of the desired solution to a given problem in this study. The solution is based on a recognised need of a client. The object in studio articles is defined to be prototyping a viable solution, while in entrepreneurial education object is defined to be making new viable business. Unique for Oamk LABs object is the combination of both of these, prototyping a viable solution with a viable business model, as solutions developed are based on customer's real need. This setup creates a need for business opportunity

recognition, as well as the requirement of scalable solutions, enabling the growth of their possible business.

Outcome

The outcome in this study is defined to be a concrete result of the development activities. Findings about students' personal and professional development are connected to their personality, teamwork skills, and networking skills. Common for both entrepreneurship education and studio model learning is that the student will develop their agility, self-regulation, -awareness and -esteem. Also, competencies to confidently network and become a team worker will be developed. It is also common to see different ways of cooperating with the external experts, while targeting to develop meaningful networks. Being able to execute and evaluate the process from a need to a solution is one of the outcomes. This requires the student to connect theory and practice as well as acting, and adapting their product and their own ways of working according to the changes that occur throughout the process. In Oamk LABs learning by an interactive process with business model development will enable understanding of the client centered product development. By having concrete results as an outcome of the activities, students will learn how to develop a viable solution fitting the needs of a client.

Tool

In this study, the tool is defined to include practices within four different categories; pedagogical models; culture of critique; iterative problem solving process; and practical equipment and spaces. In this study common for all tools is the aim of using them to support the reflective nature of learning, reflective practice.

Teaching in the studio model is based on different pedagogical models. The most commonly used models are project-based learning, learning by doing and problem based learning - used in Oamk LABs as well. Unique to Oamk LABs culture of critique is the principle of competitiveness that also enhances the skills of coping with uncertainty. The competition between projects enables the culture of excellence, as only the most viable solutions will be finished as demonstrations. The decision to continue the projects is made by external industry experts, which will increase the credibility of the solution. Studio articles showed no evidence of

business development process being included in other studio-based education. In Oamk LABs' case, an iterative process is used both for the solution and the development of the business model, as the process is repeated several times. Oamk LABs students own the intellectual property rights (IPR) of their work. In contrast, Studio articles describing the ownership of the student IPR were not found. Main categories for the equipment and space are defined to include: learning tools, visualisation and description of the space. For supporting students to be more active and self-directed in Oamk LABs, different tools are used, for example a digital platform for team communication and mutual feedback. In studio learning, versatile assessment tools are used to support students' reflection of their professional and personal development. The main difference compared to Studio articles was the location of the LAB studio during the study; outside of the university campuses and in close co-operation with a start-up community, called Business Kitchen (BusinessKitchen, 2017).

Rules

In this study, the rules are divided into four different categories; academic rules; co-operation rules; community rules defined between the studio actors, and personal rules for a person's internal behaviour. When comparing the findings between studio articles and entrepreneurial education, academic rules, community rules and personal rules are recognised as shared categories. In the Oamk LABs rules are defined by the university, for instance, in the curriculum; by the community; for example, 'how to take care of the premises'; and by students, for example, 'what are one's own goals for learning'. A common rule characteristic to Oamk LABs is that student teams own the IP of their own product. Also, a strong focus on solving problems from topics of economicality and sustainability in the projects is one of the learning rules. Rules enable the process of creating knowledge development as well as new businesses and networks without economical constraints.

Community

The community is an important factor for the process of innovating and creating new business. In this study, the community includes students, university staff and external participants. In Oamk LABs students are at least on their 3rd year since the model requires a basic knowledge of their own profession. In addition, student

teams include seasonally unemployed but experienced professionals. Staff members have background from different industry fields and at least a master's level education as well as pedagogical studies. The external participants are experts in various fields of industry.

Division of labour

In this study, the division of labour is divided between two groups of actors: students and staff members. In Oamk LABs students are always working in teams, in which every member has to decide their tasks and roles. Different tools and team coaching are used to support each team to recognise the roles and members suitable for each role. Students are also encouraged to try roles and tasks they find challenging. In Oamk LABs students require supervision and coaching several times in a week. There are specific staff members, called LAB Masters, responsible for taking care of operational activities such as planning of the learning activities in the studio and the evaluation of the students. Student teams also have possibilities to receive coaching from experienced coaches, who have different areas of expertise. In the beginning of the semester these coaching moments are organised by LAB Masters and coaches, whereas by the end of the semester students are expected to be fully independent in recognising the need for coaching and contact coaches themselves.

The results of the literature review suggest that the current studio practices are mainly established based on academic and disciplinary needs. Further on the comparison of the characteristics indicate that a unique quality for LAB studio model practices is their establishment from the needs of renewing and bridging higher education and work-life practices. The uniqueness of LSM practices compared to the other studio practices include:

- true interdisciplinarity;
- conscious support of self-awareness development; and
- conscious development of team working abilities.
- Uniqueness of LSM as a process include the characteristics of
- production of new, innovative solutions with related business models; and
- the competitive nature of the development process.

The characteristics of the process aims to generate the culture of excellence, where the student teams have a common goal to work together in order to develop the most viable solutions and business models.

3.3 Knowledge creation in LAB studio model

The article III focuses on the LAB studio model and knowledge creation. The study is made through a case study method and by utilising SECI model (Nonaka & Takeuchi, 1995) for the knowledge creation study. The article III addresses the research question 3: "How the practices of LAB studio model support knowledge creation?" The results of the article III are presented in the following chapters.

Socialisation

Based on the study, it was evident that LSM supports socialisation to a great extent. For socialisation, the results indicated that the interdisciplinary nature of a LAB studio was the biggest benefit. Working together with other disciplines is a good source of tacit knowledge, as for example, it is very beneficial for a graphic designer to see how a programmer thinks and vice versa. In addition, students worked together and talked with like-minded professionals. All the students interviewed in the survey felt that they were provided with an opportunity to experience what the development is like in a company-like environment. The socialisation, the experience, and the overall environment were probably the main source of tacit knowledge. Lastly, one other aspect of socialisation and working together was that students were building networks for learning. The excursions to the industry events and parties arranged were also considered to be beneficial for the socialisation. While this was not directly beneficial to knowledge creation processes it would surely be important later on in their careers.

Externalisation

The LSM does not explicitly emphasise externalisation. Instead, externalisation happens naturally by working and collaborating together; many aspects in LSM support it. The teams had to produce high-level concepts of their ideas, as well as prepare short and longer presentations about the games. When the students were designing the game concepts, they felt that sharing was crucial as it helped the teams develop their ideas further. Sharing plays a major role in externalisation.

Some students also indicated that they liked the peer group meetings, where, for instance, all the software programmers discussed the problems they had faced. Within these weekly peer group meetings externalisation was probably easier than normally. The reasoning for this is that people in these peer groups had similar backgrounds and knowledge, so articulating tacit knowledge might be easier than with somebody with no relevant background. Besides the peer group meetings, presentations were also excellent places for sharing ideas and giving feedback.

Combination

Interdisciplinary teams seem to provide a good starting point for combination. By working together, students were able to learn how to focus their initial ideas and combine them into the design concept. Designing high-level concepts seemed to require the most combination. All team members had some ideas and solutions and it was up to the teams to combine them into one, at the same time this was a challenge and opportunity for the teams. Some students indicated that they had gained understanding of the big picture and the whole meaning of the concept development. This could indicate that they managed to see how their own and their colleagues' competences and knowledge relate to game industry and game design. During the development, understanding new knowledge from other disciplines caused new learning in one's own discipline.

Internalisation

Internalisation was best characterised by learning-by-doing. Working with actual projects with actual deadlines made students to realise the importance of teamwork and leadership. Another simple thing that students had not internalised before was communication. Everybody knows communication is important but usually students fully realise it only after they run into some problems with it. As part of the learning-by-doing, students are also required to make most decisions by themselves. This causes them occasionally to make mistakes but in most cases failing was another source for learning. 'Fail fast, fail often' is one of the key elements of the LSM and it seems to be good for internalisation.

Organisational knowledge creation

LSM supports the organisational knowledge creation by its development process. The LSM starts by a LEAD part, where students create concepts including proposals for a solution and a business model to a recognised need. During the concept development, students were sharing their experiences freely in a dialogue with others and external participants, as they own the rights to their work. Justifying concepts, as well as building an archetype concept, play a major role in the LSM development process. Gate events, events, where some of the projects are cancelled, were considered to be one of the most beneficial moments of learning. In particular, the provided professional feedback, in other words, justification, of their developed concept was seen as a learning moment. At the same time, the amount and quality of the feedback was not considered to be equal for all. Cancellation of one's project caused some disappointment, which nevertheless was considered to be a good learning moment. During the solution and business model development in the LAB part, every team and student are involved in the process, where they can utilise their skills in order to turn the concept into reality. The prototypes are tested by the external participants for feedback purposes, which is then analysed for further development. The survey did not include questions about the demo development part. Cross-leveling knowledge can be seen happening in the Expo events, where customer oriented and professional feedback is received from the industry professionals. Students respected the given feedback at the Expo event.

As a summary, the results of article III indicate that LSM offers a promising support for aspects of knowledge creation. The SECI model in particular seems to be well supported. For example, socialisation is about working together and teams solving problems and making mistakes together, resulting in learning from them. In addition, the results indicate that the process of LSM seems to support organisational knowledge creation.

3.4 Learning networks established during a LAB studio semester

Article IV focuses on the social networks established in a LAB studio during one semester. The networks are supposed to be utilised for learning, which is also studied. The study was made by a mixed method and by utilising the concept of social capital (Coleman, 1988; Putnam, 2001) in entrepreneurship, as well as the theory of school learning outlined by Engeström (1987). Article IV addresses the

research question 4: "What types of external learning networks did students establish and engage in as part of the LAB studio model program?"

Layers of the contacts network

The learning network was noticed to be forming groups and layers depending on their relationship to the students. The actual and potential partners for learning are illustrated in Figure 7.

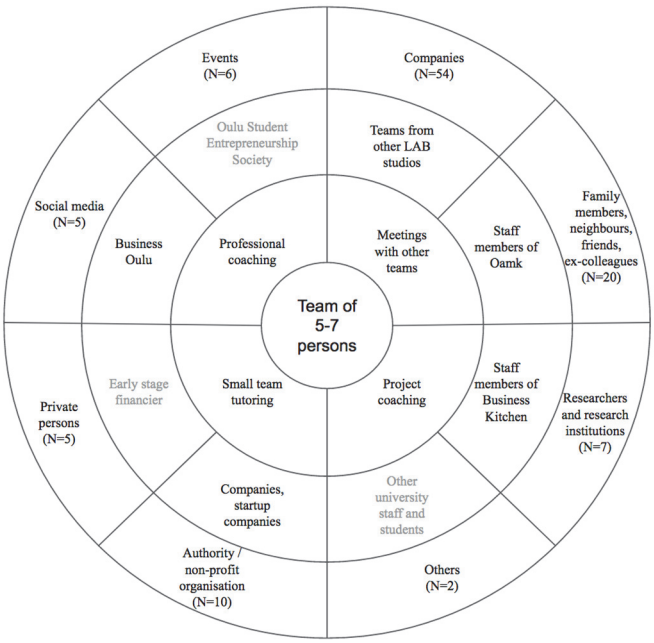

Fig. 7. Potential and actual networks. Adapted from Heikkinen, Seppänen & Isokangas (2015). Reproduced by permission from Education in the North.

The middle of the dialogue represents the student team and the second circle other teams and coaches (teachers) for professional and project coaching as well as for tutoring. In the third circle, external groups that teams named during interviews are located. These groups were teams from other Oamk LABs, nearby start-ups and companies, staff members of Oamk, and other supportive groups. The grey text in the list includes groups with whom co-operation could have been possible in the learning environment, but were not named by the teams. The fourth circle

represents the external network partners who are outside of university and were named by the student teams.

The biggest external partner group included companies (49.5%), the second largest external partner were family members, neighbours, friends and ex-colleagues (18.3%). Since most of the students had been working for several years already, many indicated that they had been discussing with their ex-colleagues about their project. Local authorities (9.1%), and researchers and research institutions (6.2%) were also important partners of the external networks. Other minor partner groups included different events (5.5%), private persons (5.5%), contacts via social media (5.5%) and others (1.8%).

The amount of partners and contacts

Table 8 summarises the amount of partners and contacts with each external network partner. The amount of single contacts; face-to-face meetings, emails, or phone calls, varied from one up to 60 contacts. Student teams reported the combined number of 898 single contacts with their external partner network. The largest amounts of single contacts were with family members (n=354), since some of the students were discussing their project with these actors several times per week. Also, a large number of contacts were through social media (n=191) and with companies (n=162). The amount of single contacts recorded per team varied from 76 to 225.

Table 8. The number of partners and contacts within an external network. Adapted from Heikkinen, Seppänen & Isokangas (2015). Reproduced by permission from Education in the North.

Type of the partner	Total amount	%	Amount of contacts for each team						
			Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	All
Researcher / research institution	7	6.2	2	3	6	4	2	3	20
Events	6	5.5	3	6	6	3	4	5	27
Private persons	5	4.6	3	10	14	44	10	12	93
Companies	54	49.5	18	46	9	16	9	64	162
Social media	5	4.6	0	1	0	140	50	0	191
Authority / non profit organisation	10	9.1	4	6	1	10	1	22	44

Ways of contacts were found

Each team had contacts from outside the university context. The partner groups were divided into three categories; ones teachers arranged for students, ones teachers asked students to contact, and ones the student teams found themselves. Table 9 summarises the different ways of finding the contacts. The most of partners, 68.9%, were arranged by the student teams themselves. The amount of these partners varied from 9 to 64, with the average being 28. Since partners were mostly arranged by the student teams themselves, there is a strong indication that they had an active role in a form of self-initiated learning, similar to the style of learning highlighted by Bird (2002) and Cope (2003).

Table 9. Ways in which contacts were found. Adapted from Heikkinen, Seppänen & Isokangas (2015). Reproduced by permission from Education in the North.

Team / How	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	All together	%
Arranged by coaches	5	10	9	7	4	14	49	20.3
Suggested by coaches	5	7	5	1	3	5	26	10.8
Arranged by the team	20	9	15	64	37	21	166	68.9
	30	26	29	72	44	40	241	100.0

Type of information shared with the contacts

The content of the co-operation with the external partner network was primarily information sharing. The students were developing their concept and product only with 14 out of 241 external partners. The issues discussed together were the need for a certain kind of a product, and the pricing, functionality and viability of the product. Also, issues relating to the development of the concept and developing a test were covered. From eight potential external network partners, student teams received no reply. With the remaining 219 external network partners, student teams noted that they were sharing information and knowledge. Among the information they received concerned topics such as concept development, games for children, technical issues, medical devices, various issues of health and well-being, business, IPR, project funding opportunities, and how to make a funding application.

3.5 Results synthesis

The main objective of this dissertation research is to explore the LAB studio model contributing to the education of the knowledge workers T-shaped skills, more specifically skills for crossing boundaries, within a specific learning configuration in a Finnish University of Applied Sciences. The main research question was divided to four research questions and respectively into four articles all with a specific research question. The research for this dissertation involved two main phases and four themes, cf. Figure 2. In the first phase including Themes 1 and 2, the main characteristics of the studio model education were identified and compared to the LSM. In the second phase, the characteristics of LSM educating skills for boundary crossing were studied. Study in Theme 3 was done by focusing to the boundary crossing activity inside a LAB studio, in article III, and study in Theme 4 was done by focusing to the activity projected outwards from a LAB studio, in article IV. Table 10 summarises the research contribution.

Table 10. Research contribution.

Phase	Theme	Result
1	1: The recent definition of studio model and LAB studio model unique practices	The current studio practices are mainly established based on the academic and disciplinary needs. LAB studio model practices instead are established from the needs of renewing and bridging the higher education and work-life practices. LAB studio model can build competences in an authentic and industry specific work environment.
	2: Interest towards studio model in higher education	Based on the amount of scientific publications, general interest towards studio model has increased in higher education during the past ten years.
2	3: Knowledge creation in LAB studio model	LAB studio model offers a promising support for knowledge creation.
	4: Learning networks established during a LAB studio semester	Student teams gained knowledge from outside the university by using their own initiative.

The results of the first phase indicate the LSM to be a unique education configuration utilising the studio model as its pedagogical basis. The unique characteristics of LSM indicate it to be more of a workplace-like environment than other studio-based higher education configurations. The principles of student owned IPR with business opportunity development and an internal competitive structure (cf. Johnson & Johnson, 2002) have a tendency to enhance the learning activity and project results. The true interdisciplinary-type of project team

structure seems to force students to collaborate between different disciplines. Moreover, the results indicate that the general interest towards the studio model has risen during the past ten years and more new learning configurations utilising studio model are established. Interestingly, the results indicate also that the studio model of education is not widely used in higher education entrepreneurial programs.

The results of the second phase indicate the LSM to be a potential configuration for learning the boundary crossing skills, in other words, the skills needed by a T-shaped professional. As new knowledge creation and establishing new contacts for learning purposes require skills for boundary crossing, the results of the second phase indicate activity of boundary crossing inside and also outward from a LAB studio. More specifically, the results of the internal boundary crossing activity study indicate LSM to have promising support for knowledge creation, which further indicate the support of boundary crossing activity inside a LAB studio. Especially the SECI model (Nonaka & Takeuchi, 1995) is well supported in LSM. Furthermore, the results of the outbound boundary crossing activity indicate the establishment and utilisation of external collaboration, in other words, a learning network, further indicating the outbound boundary crossing activity from the LAB studio. The results also indicate that social capital was created, since true collaboration beyond boundaries was happening.

The results of the learning network study indicate that during the studies in a LAB studio a significant number of contacts between student teams and external groups were formed. The most significant groups of collaboration were companies and the personal networks of the students, where the collaboration focused on areas of clients' needs and user-oriented development. In addition, the results indicate that student teams gained knowledge using their own initiative from outside the university. The fact that the student teams created such large learning networks by their own activity further indicates the creation of self-organised teams and the expansion of meaningful and possibly highly motivated learning activity.

The purpose of co-operation in a learning network was focused on sharing knowledge. Despite the amount contacts with the collaborators outside of the university, cooperative development with these collaborators was rare. In contrast, development mainly took place in the interdisciplinary student teams themselves and in co-operation with the interdisciplinary team of coaches. A possible explanation for this could be the close co-operation inside each student team as a

result of the interdisciplinary nature of the team itself and previous interdisciplinary teamwork experience of the students. For the majority of the student teams, recognising ways for cooperative development during the programme was challenging. The results indicate that product development was enriched by new knowledge gained from collaborators within the learning network.

According to results of this dissertation research there's an indication that the LAB studio model contributes strongly to the development of boundary crossing skills. Furthermore, these results indicate the potentiality of the LSM for educating T-shaped skills for knowledge workers. Based on the study results of unique characteristics of the LSM, it offers students a work-life like environment and methods for learning, and it includes characteristics of enhancing entrepreneurial competences. The demanding process of producing new and innovative solutions with related business models combined with the competitive internal structure potentially contributes to the boundary crossing inside an interdisciplinary team and also outward from the LAB studio. In addition, since learning is also supported by the conscious support of a student's self-awareness development and development of team working abilities, students are provided with a safe environment to practice their T-shaped skills.

4 Discussion

4.1 Scientific implications

The establishment of multidisciplinary education programs and configurations is a fairly new phenomenon in higher education. Thus, educating competence of boundary crossing for knowledge workers within these areas is also a fairly new avenue of research. This dissertation research addresses the importance of boundary crossing competence for all participants in university-society collaborative configurations and contributes to the call for boundary crossing learning processes in which learners are expected to cross boundaries between contexts (Akkerman, 2011; Bakker & Akkerman, 2014; Bronkhorst & Akkerman, 2016; Cremers, 2016; Oonk, 2016). The findings of this research complement earlier research of Oonk (2016) and Cremers (2016) by emphasising the effect of an interdisciplinary environment to boundary crossing competence development compared to working in mono-disciplinary student groups (Oonk, 2016). In more detail the findings of boundary crossing actions and interactions in this research support the findings of Akkerman and Bakker (2011), Cremers (2016), Holst (2007) and Oonk (2016) in regard to that identification and reflection are prerequisites for successful learning mechanisms. In addition to the debate of the further development and implementation of research and education of new learning configurations (e.g. Bawa & Munck, 2012; Koutsabasis & Vosinakis, 2012; Lansu *et al.*, 2013; Salama, Wilkinson, Urban, Press, & Kingdom, 2007), findings of this research also contribute to debates of teaching skills needed to face 21st century societal challenges (e.g. Ananiadou & Claro, 2009; OECD, 2016a).

Compared to the recent studio model definition by Bull *et al.* (2013), the findings of this dissertation indicate some differences in the LAB studio model. As a summary, these differences suggest the LSM to be more aligned with industry needs and workplace realities than the existing studio model definition. The findings of this dissertation contribute to the debate of studio model definition (e.g. Brandt *et al.*, 2013; Bull *et al.*, 2013; Carter & Hundhausen, 2011; Lee *et al.*, 2015; Mor & Mogilevsky, 2013; Shraiky & Lamb, 2013; Wang, 2010; Whittle, Bull, Lee, & Kotonya, 2014), as it reveals the interdisciplinarity and competitive structure to be unique characteristics of the LSM.

The findings regarding the call for learning environments' characterisation in relation to the studio model learning environment (e.g. Brandt *et al.*, 2013; Bull & Whittle, 2014; Lee *et al.*, 2015; Long, 2012), suggest an increasing interest towards the utilisation of studio-based education settings for higher education. In addition, the findings contribute to the debate of making higher education institutions more out-of-school proof, in other words, ready to face university-society engagement (cf. Brundiers & Wiek, 2011; Guzmán-Valenzuela, 2016; Perkmann *et al.*, 2013), and to the debate on the further development and implementation of interdisciplinary research and education in university-society collaborative settings (Blair, 2012; Cennamo *et al.*, 2011; Dole, Bloom, & Kowalske, 2016; T-M Karjalainen *et al.*, 2009; Oskam, 2009; Saghafi, Franz, & Crowther, 2012; Shraiky & Lamb, 2013).

The findings, about the characterisation of learning environments in relation to knowledge creation, complement the earlier research of Cremers (2016) with the need of reflexive learning communities for trans-boundary knowledge creation. In addition, the findings complement the earlier research of Haho (2014) by pointing out the importance of learning in cycles, where the second cycle, knowledge creation, is composed by the interaction between the holistic view, common understanding, and individual and organisational learning, in other words, boundary crossing. Overall the studio-based education and environment seems to be promising for knowledge creation purposes, and thus contributes to the debate of the elements and enablers of knowledge creation (e.g. Lee & Choi, 2003; Nonaka & Takeuchi, 1995). The study also indicates that the degree to which a boundary was perceived differed greatly among individuals, thereby supporting the earlier research that boundaries are highly personal and subjective constructs (Cremers, 2016).

The findings related to external learning networks (Deakins & Freel, 1998; Elfring & Hulsink, 2003; Isokangas, 2009; Tynjälä, 2008), address studio environment potentiality to enhance the establishment of learning networks and thus practicing skills for boundary crossing. Characteristics of a LAB studio in turn offer a sense of opportunity for new business development, and a strong motivation for self-directing and self-organising activity, which by the establishment of learning networks, enhance the learning about entrepreneurial phenomena (Deakins & Freel, 1998; Shane, Locke, & Collins, 2003). Cremers (2016) suggested that teachers should fulfil a set of new out-of-school oriented brokering; roles for which they need to master various skills for boundary crossing. The findings of this dissertation suggest a contradiction to these as

according to the study, roughly only 30% of the new connections outside a LAB studio were established by the support of a coach. The fact that the studied LAB studio included more experienced postgraduate students, the previous work life experience might enhance the readiness for crossing boundaries beyond the LAB studio. Understanding the above, coaches in LSM still probably have an important role in highlighting the importance and enabling the process of boundary crossing activities during the development process.

4.2 Practical implications

This dissertation explores and addresses the potentiality and viability of the studio model education for the mission of educating knowledge workers in higher education. As also pointed out by Cremers (2016), the educational design is often conceptualised as the creation of curricular products within a particular school-based study programme by educators in a certain discipline. Instead the new learning configurations are and should continue to be a complex environment at the interface between school and work, rather than an intervention within an existing curriculum. This dissertation research suggests the LAB studio model to act as a kind of bridge between the academic and work life practices, as LSM practices are established from the needs of renewing and bridging the higher education and work-life practices. Thus, LSM offers a potential benchmark of practices and educational model for the need of renewing knowledge worker education in higher education. The results also indicate unused potential in the studio model for entrepreneurial study programs.

As interdisciplinary activity enhances boundary crossing (Cremers, 2016; Oonk, 2016), the more we can get students from different areas to collaborate together, the more occasions requiring and enabling boundary crossing will happen. Despite several examples of the existing interdisciplinary configurations (Bequette, Chow, & Li, 1999; Erden *et al.*, 2000; Habash *et al.*, 2011; Oskam, 2009; Saghafi *et al.*, 2012), according to the study results usually no more than two disciplines are included in these configurations. By having more disciplines studying within these interdisciplinary configurations, students would be required to cross disciplinary boundaries, as required in practical work-life. In addition, the collaboration should also involve external participants outside of the configuration, resulting in the probable expansion of the learning networks. This kind of multi-dimensional configuration can enhance motivation for self-directing and self-organising activity. Ultimately, the findings of this study indicate that the

LSM represents an example of such form of education and includes methods to increase social capital.

The research of Cremers (2016) and Oonk (2016) has shown that participants such as students, lecturers, researchers and other stakeholders are often enthusiastic and appreciate being part of activities that are relevant and important for society. For the boundary crossing 'boundary brokers', understood as participants who provide bridges between different practices or perspectives, are recognised as important actors during the learning of boundary crossing competence. While understanding the importance of the teacher's role in boundary transition, findings of this dissertation give basis for justifying teacher education for these learning environments. As teachers act as role models, the ability to coach students to cross boundaries inside and outward from the learning environment is essential. In addition, as first proposed by Oonk (2016), the assessment of student boundary crossing competence development could be the one of the practical implications. By the assessment practices, the recognition and importance of the knowledge workers boundary crossing competence is highlighted.

The results also indicate that the more we can get the students to work on actual projects, the better it is for knowledge creation. In LSM, as students seek solutions to real needs from the focus industry, they learn both industry-specific knowledge and knowledge related to their own field of study. This is important as the students get to practise previously acquired skills and knowledge in a multidisciplinary environment more similar to work-life. This might raise the question whether studio-based learning might not be optimal to learn completely new skills or knowledge from their own field of study, for which the traditional way of learning might be more suitable. In LSM, learning is supported by both theory and practice. A pedagogical environment with a strong focus on instilling empathy and ways of doing, feeling, seeing, communicating, organising and learning things which in turn enables students to create and internalise new knowledge.

The university structures can mitigate against experimental teaching and learning, and against the 'unpredictability' of authentic, community-engaged projects. Although the LSM is relatively new, its design seems to enthuse a broad range of participants, collaborators and teachers (Seppänen *et al.*, 2016) who show openness for experiments and effective implementation. The Oamk LABs and its now proven boundary crossing activity may function as an effective interface organisation (Whitmer *et al.*, 2010), and bridging needs of university

and society (e.g. Brandt *et al.*, 2013; Bull & Whittle, 2014; Flynn, Pillay & Watters, 2016), thus supporting higher educational transitions towards out-of-school readiness. The results of this dissertation should also encourage the establishment of new studios and the studio model of education to be used more across disciplines, as well as within entrepreneurial study programs.

4.3 Reliability and validity

This dissertation research was done through the exploratory research approach with design research and case studies selected as the methodologies. Among a large variety of options for qualitative research, these selections were made due to the pioneering purpose of the research and close collaboration with practitioners. The purpose of the research was to approach the complex phenomena from selected directions with variety in methods. This research was conducted in a particular setting of a studio model education, the LAB studio model, and was carried out in a Finnish University of Applied Sciences. The studied topics arise from the needs of understanding the knowledge workers' higher education, and the research was designed and conducted in collaboration within the Oamk LABs research group and particular LAB studios.

The nature of qualitative research requires specific criteria for evaluating reliability and validity. Ability to repeat the results of the research is part of research reliability (e.g. Creswell, 2013). As exploratory research is a useful methodology to obtain a better understanding of a less clear phenomenon and to establish guiding principles for further research, the results cannot be generalised in another context (Stebbins, 2012). On the other hand, design research should aim for ecological validity, meaning that the results should provide a basis for adaptation to other situations. The premise is that an empirically grounded theory of how the intervention works accommodates this requirement (van den Akker *et al.*, 2006). In other words, the design research study process can be repeated in a somewhat similar environment, but the information cannot be generalised (Kananen, 2013). In contrast to traditional experimental research, the challenge when conducting design experiments is not that of replicating instructional innovations by ensuring that they are realised in precisely the same way in different classrooms (van den Akker *et al.*, 2006). The conception of teachers as professionals in fact suggests that complete ability to replicate is neither desirable nor possible (cf. Ball & Cohen, 1996; Simon, 1996), as one of the primary aims of this type of research is not to develop the instructional sequence as such, but to

support the constitution of an empirically grounded local instruction theory that underpins that instructional sequence (van den Akker, 2006). Instead design research produces practical information that can be transferred to practises of the education setting. The solutions are developed in a specific context, and are therefore effective and useful (Edelson, 2002). Ketokivi and Choi (2014) point out the case research duality of being situationally grounded while also seeking a sense of generality as situationally grounded case research implies an empirical disposition and addressing contextual issues already in the data collection phase.

During the research process of this dissertation, concerns have been addressed and actions have been taken to increase and ensure the reliability and validity. Table 11 summarises the actions taken to ensure the reliability and validity of each article.

Table 11. Actions taken to ensure the reliability and validity of each article.

Article	Reliability	Validity
I	Transparent data collection from professional literature	The research approach and the results were discussed with other researchers
	The other researcher reviewed and commented the data, data analysis and the research report	Double blind review process was used for the article
II	Transparent data collection from professional literature	The research approach and the results were discussed with other researchers
	The other researchers reviewed and commented the data, data analysis and the research report	Double blind review process was used for the article
III	Standardised data collection method: survey	Data triangulation was used
	The data was recorded and stored	The data was handled with confidentiality and anonymity
	The other researchers reviewed data, data analysis and the research report	The research approach and results were discussed with other researchers
		Double blind review process was used for the article
IV	Standardised data collection method: semi-structured interview	Data triangulation was used
	The data was recorded and stored	The data was handled with confidentiality and anonymity
	The other researchers reviewed the data, data analysis and the research report	The research approach and results were discussed with other researchers
		Double blind review process was used for the article

For its credibility evaluation, design research uses the criteria of qualitative and quantitative research. Quantitative research uses two concepts to ensure

credibility; reliability and validity (Kananen, 2013). No single agreed upon criteria for judging qualitative research exists, and in the end, every researcher should choose their own criteria (Lichtman, 2013). Reliability means the consistency of the research results, which is the degree to which scores obtained with an instrument are consistent measures of whatever the instrument measures (Fraenkel, Wallen, & Hyun, 1993). Reliability is addressed in multiple ways during the research process. The reliability is ensured by utilising standardised methods for collecting data, by recording and transcribing the interviews, by using fellow researchers as reviewers for the data reliability and analysis, and by ensuring anonymous data handling (Yin, 2013). Each original study in articles I–IV can be repeated in other contexts but the result are likely to be somewhat different, which is due to the nature of the socially constructed reality of qualitative research. Validity means that the correct issues are researched. In design research, validity concerns are typically divided to two main types, internal validity and external validity. (Kananen, 2013.)

The *internal validity* aspect is divided into three subcategories: content validity, structural validity and criteria validity. *Contents validity* considers that correct measures are used, as a measurement measures exactly the very thing that is subject to measurement (Kananen, 2013). Before starting the research, the methods for each study were discussed and argued by the researchers participating in the writing of each article. During the research process of studies in articles I and II, the validity of the contents was ensured by several research design iterations and by analysing the data with feedback from other researchers. During the research and individual studies of articles III and IV, data triangulation was addressed by using multiple data sources including interviews, internal documents, surveys, and observation and data analysing together with other researchers. *Structural validity* refers to the degree to which a test measures what it claims to be measuring; it measures how well the concepts of the research have been derived from the theories (Kananen, 2013). For this purpose, the overall research was designed as a joint effort and feedback from other researchers was utilised along the research process. During the research the students were encouraged to honestly answer the surveys and during the interview, and all collected research data was handled as confidential and anonymous. The informants were given a chance to check the analysis that was based on the data they had provided as well as the written reports. This was done during the interview already, where the data collected was drawn on big sheets of paper, so that everybody could see and make corrections to possible misunderstandings of

the data. In addition, all the interview discussions were recorded and typed into notes. *Criteria validity* is based on using research by other researchers to support one's own research results (Kananen, 2013). In practice, criteria validity measures if other researchers have obtained similar results through the previous studies. This research indicated similarities in results on the effect of an interdisciplinary environment to boundary crossing competence development (Oonk, 2016).

External validity refers to the extent that the results of a study can be generalised, and whether the results are applicable in other contexts (Kananen, 2013). The ability to generalise the results of qualitative research is challenging and very restricted. Educational design research as a research approach is always situated in a particular educational context in practice. This means that the researcher bias cannot be totally avoided, not even preferred to avoid. Objectivity in qualitative research means the degree to which the researchers' own values have influenced the results. In other words, there's a question whether another researcher would reach the same findings. This would require that another researcher would be able to repeat the research procedures exactly, conduct the same case study again, and arrive at the same findings and conclusions (Yin, 2013). Due to the exploratory nature of this dissertation research and constantly changing LAB studio environment, it is unlikely that another researcher could be provided with the same research setting. Even though the collected data has been stored, it is also unlikely that another researcher would gain exactly the same findings and conclusions. For this reason, the perspectives of several researchers were utilised in the data analysis to increase the objectivity of this dissertation research.

4.4 Recommendations for future research

The nature of the research topic and the chosen explorative research approach of this dissertation caused several identified topics for further study. First of all, this study focused on boundary crossing competence within a special educational configuration utilising the studio model for its pedagogical model. As there's a growing interest towards studio-based educations in higher education, study of boundary crossing enabling conditions within other studio model configurations is a potential future research topic that would enable comparisons between different configurations. Recommended future study topics include how well do the findings of this dissertation apply to different types of new education configurations, for example, by the categorisation by Savander-Ranne *et al.* (2013)

and how do the different characteristics of the other models affect the conditions of boundary crossing. As the LSM has been utilised in LAB studios established in other countries and different contexts (Stevenson *et al.*, 2017), the similar study in those countries is recommended. In addition to above, the effect of a LAB studio's focus industry, for instance, health or educational technology, should be included.

Another research topic, which is related to the T-shaped professional, includes the learning of disciplinary skills (I-shaped skills) within the LSM. So far, the model has been studied focusing on the metaskills. However, the importance of a student's I-shaped skills cannot be ignored. Therefore, future research should address the studio model's effect on I-shaped skills; for instance, study how the disciplinary knowledge and skills are developed during the studies in a LAB studio. In addition, research of students' perception of themselves as new professionals and their professional growth (Ruohotie, 2006) during their studies in a LAB studio should be included.

Finally, during the research, it became evident that studies during the LAB studio model affect many aspects of the knowledge workers skills. Based on the participants' feedback, one of the most referred is the leadership skill, also discussed by McIntosh & Taylor (2013). Recommended future study for the leadership skills development within the LAB studio model topic includes how the LSM support the development of a project team's leadership skills and attitude against the leadership within a team and a larger organisation.

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