Meiju Keinänen

Educating Innovative Professionals

A case study on researching students' innovation competences in one Finnish University of Applied Sciences

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ABSTRACT

This dissertation study focuses on students' innovation competences in higher education. The aim of the research is to present assessment tools to measure students' innovation competences, test and evaluate them in practice, and examine students' innovation competences in innovative learning environments at the course and degree levels. The study has been implemented as a case study at one Finnish university of applied sciences, where innovation competences have been set as learning targets for all students in its pedagogical strategy, which is called innovation pedagogy. The research includes four independent sub-studies using mixed research methods. The first study tests and evaluates the functioning of the earlier developed model measuring students' innovation competences (n=495). The second study supplements the first study, and evaluates and uses a further developed instrument in the innovative courses using students' group interviews (approx. 30 students) and self-assessments (n=69). The third study examines students' perceptions of learning innovation competences during the courses (n=77), and the fourth study (n=236) approaches students' innovation competences and their associations with students' study experiences of learning environments based on innovation pedagogy at the degree level. The dissertation study shows that innovation competence can be assessed, learned and supported already in higher educational environments. There were no differences in the learning of innovation competences by gender, study year, work experience, or course. Instead, certain individual and environmental factors, especially students' motivation, the importance of learning, and the atmosphere of the course, are related to the learning of innovation competences. The results also show that students' study experiences of learning environments based on innovation pedagogy play a significant role in the level of their innovation competences at the degree level. The students who have more experience on studying in different learning environments of innovation pedagogy assessed their innovation competences higher than those students who have less experience. All the six cornerstones of innovation pedagogy: activating learning and teaching methods; multidisciplinary learning environments; working life orientation and RDI integration; flexible curricula; entrepreneurship and internationalization, are associated with the students' innovation competences. However, innovation pedagogy demands plenty of work to be visible in practice. During their 3–4 years of study, the students did

not have many experiences studying in learning environments based on innovation pedagogy. Overall, this dissertation suggests that higher education institutions have a meaningful role in training innovative professionals, but special consideration should be placed on developing innovative learning environments.

Key words: innovation competence, assessment, learning environment, higher education pedagogy

TIIVISTELMÄ

Väitöskirjatutkimuksen aiheena on korkeakouluopiskelijoiden innovaatiokompetenssit. Tutkimuksen tavoitteena on esitellä arviointityökaluja opiskelijoiden innovaatiokompetenssien mittaamiseen, testata ja arvioida niitä käytännössä sekä tutkia opiskelijoiden innovaatiokompetensseja innovatiivisissa oppimisympäristöissä opintojakso- ja tutkintotasolla. Tapaustutkimus on toteutettu eräässä suomalaisessa ammattikorkeakoulussa, jossa innovaatiokompetenssit ovat oppimistavoitteina kaikilla opiskelijoilla osana pedagogista strategiaa, innovaatiopedagogiikkaa. Monimenetelmällinen tutkimus kostuu neljästä itsenäisestä osatutkimuksesta. Ensimmäinen tutkimus testaa ja arvioi aiemmin kehitetyn mallin toimivuutta opiskelijoiden innovaatiokompetenssien mittaamisessa (n=495). Toinen tutkimus täydentää ensimmäistä tutkimusta, arvioimalla ja käyttämällä uudempaa työkalua innovatiivisilla opintojaksoilla hyödyntäen opiskelijoiden ryhmähaastatteluja (n. 30 opiskelijaa) ja itsearviointeja (n=69). Kolmas tutkimus tutkii opiskelijoiden käsityksiä innovaatiokompetenssien oppimisesta opintojaksojen aikana (n=77). Neljäs tutkimus (n=236) tarkastelee innovaatiokompetensseja ja niiden yhteyttä opiskelijoiden opiskelukokemuksiin innovaatiopedagogiikan oppimisympäristöistä tutkinnon aikana. Väitöstutkimus osoittaa, että innovaatiokompetensseja voidaan arvioida, oppia ja tukea korkeakouluympäristöissä. Sukupuoli, opiskeluvuosi, työkokemus tai opintojakso ei ole yhteydessä innovaatiokompetenssien oppimiseen, mutta tietyt yksilölliset ja ympäristölliset tekijät, etenkin opiskelijan motivaatio, oppimisen tärkeys ja ilmapiiri opintojaksolla, näyttävät yhdistyvän oppimiseen. Tulokset myös osoittavat, että opiskelijoiden tutkinnonaikaisella opiskelukokemuksella innovaatiopedagogiikan oppimisympäristöistä on yhteys opiskelijoiden innovaatiokompetensseihin. Opiskelijoilla, joilla oli enemmän kokemusta kyseisistä ympäristöistä arvioivat innovaatiokompetenssinsa korkeammalle kuin ne opiskelijat, joilla kokemusta oli vähemmän. Lisäksi kaikki kuusi innovaatiopedagogiikan oppimisympäristöihin liittyvää kulmakiveä: aktivoivat oppimis- ja opetusmenetelmät; monialaiset oppimisympäristöt; työelämälähtöisyys ja TKI-integraatio; joustava opetussuunnitelma; yrittäjyys ja kansainvälisyys, ovat yhteydessä opiskelijoiden innovaatiokompetensseihin. Innovaatiopedagogiikan näkyväksi tekeminen vaatii kuitenkin paljon työtä. Kolmen-neljän vuoden aikana opiskelijoilla ei ollut

paljonkaan kokemusta innovaatiopedagogiikan mukaisista oppimisympäristöistä. Tutkimuksen mukaan korkeakoululaitoksilla on tärkeä rooli innovatiivisten ammattilaisten kouluttamisessa, mutta erityistä huomiota tulee kiinnittää innovatiivisten oppimisympäristöjen kehittämiseen.

Avainsanat: Innovaatiokompetenssi, arviointi, oppimisympäristö, korkeakoulupedagogiikka

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At this moment – when I am writing the last part, acknowledgements, in my dissertation – it has been almost five years since I started this journey. Five years ago, I set out to find out how to survive such a long, intensive and persistent process, in which I would test my skills, knowledge and mind. The journey has been a memorable one. It is hard to even describe all the various phases, up- and downhills, as well as the intense feelings along the way. This journey has offered not only moments of success, joy, satisfaction, and triumph, but also those of stress, fear, disbelief, and frustration. In all its richness, it has been an extremely rewarding learning experience and lesson in both academic research and myself, as it has also been a journey of personal growth. However, this would not have been possible without the support by a number of people and the cooperation with them. To all these people I would like to express my humblest gratitude for sharing this journey with me.

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List of original publications

Study I

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Study II

Keinänen, M., & Butter, R. (2018) Applying a self-assessment tool to enhance personalized development of students' innovation competences in the context of university-company cooperation. *Journal of University Pedagogy*, 25(2), 18–28. https://yliopistopedagogiikka.files.wordpress.com/2019/03/yliopistopedagogiikka-2018-no2-keinanen-butter.pdf

Study III

Keinänen, M., & Oksanen, A. (2017) Students' perception of learning innovation competences in activity-based learning environment. *Journal of Professional and Vocational Education*, 4, 48–61. https://akakk.fi/wp-content/uploads/AKAKK-4.2017-NET.pdf

Study IV

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Contents

1 INTRODUCTION

In today's society, the importance of innovations is highly emphasized. Innovations are seen as solutions for many global problems; for social and environmental issues, as key elements for organizations and companies to survive in the changing world, boosters for the economy, and as a trendy concept highlighted in many policies. As a result, there seems to be an urgent need for professionals who are capable of participating in innovation processes and who can contribute to the creation of innovations.

Innovative individuals are the resource of all innovations and higher education represents a critical factor in human capital development (e.g., Avvisati, Jacotin, & Vincent-Lancrin, 2013; Finland's national innovation strategy, 2008; Edwards-Schacter et al., 2015; OECD, 2015; Vila, Perez, & Morillas, 2012). The role of higher education is not only to educate undergraduates for future work but also to train employees to perform tasks, which then generate innovations. Educational institutions, regardless of context, are expected to prepare innovative individuals capable of coping with 21st century demands (Avvisati et al., 2013; Bialik & Fadel, 2015; Trilling & Fadel, 2009), such as the fast-changing demands of society, the growing proportion of knowledge-intensive work, the changing nature of work, increasing internationalization and globalization, and the expanding use of information technology and digitalization. The OECD Innovation Strategy (2015) states that broad curricula, updated pedagogical practices and the development of tools to assess innovation-related skills are all important in initial education. Beyond subject-specific expertise, higher education should also develop students' creativity, critical thinking, entrepreneurship and communication skills (OECD, 2015).

However, although education has a central role in developing human innovation skills, several studies suggest that higher education institutions alone cannot fulfil these demands (Badcock, Pattinson, & Harris, 2010; Quintana et al., 2016). Educational practices, especially in higher education, have been criticized for failing to develop these prerequisites of professional expertise. Traditional forms of teaching, like reading, lecturing, and working alone, have even shown to be negatively associated with learning the needed competences or skills (Avvisati et al.,

2013; Vila et al., 2012; Virtanen & Tynjälä, 2016). Michael (2006) also highlights the importance of evidence-based education. According to him, when reforming education there is a growing call to base educational decision-making on high-quality educational research and pedagogical practices generating efficient learning (Michael, 2006). The OECD Innovation Strategy (2015) also states that doing so ultimately depends on pedagogical approaches and the design of curricula. Because rankings of higher education institutions often emphasize research, countries should also ensure that institutions have incentives to improve the quality and relevance of their teaching. (OECD, 2015) Moreover, a renewed EU agenda for higher education institutions (European Commission, 2017) not only highlights the unique role of higher education in contributing to innovation, but also demands effective and efficient higher education systems.

To respond to these claims, the aim of this dissertation study is to research students' innovation competences in higher education. By focusing on students' innovation competences and approaching their learning experiences and study paths in more detail, it could be better understood how to develop more effective education and learning environments, and thus respond to the demands of the changing working life. This dissertation is positioned at the intersection of innovation research and studies on higher education. It is conducted as four independent sub-studies using a case-study approach and mixed research methods. The study has been implemented in one Finnish university of applied science where innovation competences have been set as learning targets for all students in its pedagogical strategy, which is called innovation pedagogy. First, this dissertation provides an overview of the recent literature and discussion on the changing working life and meaning of innovations in that context, and reflects how these changes challenge higher educational institutions to respond to these new requirements. Before dealing with the methodology of research, the pedagogical strategy called innovation pedagogy is described, and current issues relating to previous studies on students' innovation competences are also discussed. Then, the research topic and methodology are treated through the four case studies. Finally, the main findings of the research are described and both theoretical and educational implications and limitations of the study are discussed.

2 THEORETICAL FRAMEWORK AND BASIS OF THE STUDY

Employees who participate in innovative activities at the workplace are expected to have acquired specific skills and competencies already during their studies (Avvisati et al., 2013; Kivunja, 2014; Quintana et al., 2016; Vila et al., 2012). Kivunja (2014) states that the key to teaching creativity and innovation skills lies in creating high-quality learning environments in which learners can solve authentic, real-world problems and be inquisitive and open-minded. Vila et al. (2012) show that collaboration on solutions to new problems improves the acquisition of innovation capabilities in higher education students. Furthermore, it has been shown that an innovative model to conduct courses improves students' innovative performance (Hu, Horng, & Teng, 2016). Consequently, in order to succeed in educating innovative professionals, who are able to participate in different innovation processes and develop own work, traditional higher educational practices, teacher-centred learning environments and content-based curricula should be challenged and approached from more critical points of view (e.g., Kairisto-Mertanen, Penttilä, & Nuotio, 2011; Kairisto-Mertanen et al., 2012; Kettunen, 2011; Kettunen, Kairisto-Mertanen, & Penttilä, 2013; Liebenberg & Mathews, 2010; Strong, 2012).

2.1 Changing working life requires new expertise

In present day, as a result of the growing proportion of knowledge-intensive work, increasing internationalization, a new organization of work-based networks and diverse teams, and the expanding use of information technology, professionals are facing new demands. Employers expect of their employees not only a good command of relevant knowledge but also varied social communication and cooperation skills, the ability to work in different contexts with experts from other fields, and the ability to critically select, acquire, and use knowledge. (Tynjälä, 1999.)

There are plenty of studies, reports and political rhetoric on the fast-changing working life and what it requires from professionals. The topic is in the interest of many actors: scholars, education, economic and many political organizations. For example, in a report of the Confederation of Finnish Industries (2011), representing views of economic interest, randomly selected members of companies were asked about the ways of working now and 5–10 years from now. Many of the respondents estimated that the ways of working will become more modern, varied, autonomous, more creative, bolder in risk-taking and more experimental within the next few years. Work was also characterized as more international than before. The report also stresses that mechanical thinking 'by the book' is ever more seldom an asset. Specific instructions are replaced by guidelines and the level of abstraction of goals increases. Therefore, merely following rules set by others and performing specifically defined tasks is no longer enough. More and more, people themselves need to define the content and the rules of work, or they need to do it together with others. (Confederation of Finnish Industries, 2011.) Similarly, the OECD's paper (2017) related to future work and skills, representing educational policy views, stresses that with the disappearance of routine tasks, growing emphasis will be placed on skills which are more difficult to automate, such as the ability to communicate, work in teams, lead, and self-organize.

Moreover, Tynjälä, Välimaa and Sarja (2003, 158) state that a characteristic of todays' professional expertise is its highly social nature. According to them, experts work in collaborative teams, share their knowledge with other experts in their domain and experts from other domains, and communicate over multi-professional networks. Same kind of views are raised in several publications of other scholars from different disciplines, highlighting that the capacity to work in a new way to achieve new or improved solutions is becoming more crucial (e.g., Alasoini, 2010; Konst & Scheinin, 2018; Paul, 2011; Trilling & Fadel, 2009). For example, Alasoini (2010) stresses that when work duties have changed more and more towards knowledge-work and brainwork, the problem-solving itself is a natural part of working. Additionally, in the time in which finding and producing new information and creating innovations are key elements in the daily operations of companies, the critical qualities of employees producing value for companies are also emphasized in a new way. Alasoini (2010) highlights that especially in a participatory innovation activity at workplaces, initiative, creativity, and passionate commitment are meaningful qualities of employees, and companies should pay more attention how to support these qualities.

Frequently, in the discourse of the changing working life and a new sphere of expertise, innovations and the capacity to foster innovations are included. Innovation is a highly interesting subject, not only for researchers as a wide and versatile research topic, but also as a hot-button issue in political discourse. Pérez-Penalver, Aznar-Mas and Montero-Fleta (2018) state that the evolution of scholarly research publications on innovations has expanded increasingly from the year 2000 up to now.

2.1.1 Innovations and their meaning in today's society

Innovations can be defined and understood in many ways. Today we understand innovation differently than some years ago. Consequently, the concept of innovation itself is constantly evolving. (Verganti, 2016.) Based on the New Dictionary of Modern Finnish, innovation is defined as regeneration, novelty, a new product, an industrial or technical invention (Institute for the Languages of Finland, 2018). However, outlining the concept of innovation to mean just a product or invention is a very narrow way to define it nowadays. Bessant and Tidd (2105) also describe innovation with its various meanings and views. According to the general view, innovations are generated by certain abilities to create and commercialize new information. On the other hand, innovations could be incremental or sustainable, such as remodelling functionality, and radical or disruptive, including breakthrough or paradigm shifts (Bessant & Tidd, 2015). The objects of innovation can be defined as things, products and services, or changes in the way we create and deliver products, services and processes (Assink, 2006, 217). Innovation can be the generation, development, and adoption of an idea or behaviour that is considered new by the people or adopting organization; most innovations are based on the use and combination of existing information (Melkas & Harmaakorpi, 2012). Product ideas that seem irrelevant in one context become relevant in another. Innovation can also take the form of social and organizational change. Ronde and Hussler (2005, 1151) assert that innovation is an evolutionary and social process of collective learning.

Suominen and Jussila (2009) state that organizational innovation capacity constructs of not only organization climate and culture, organization leadership and structure, organization processes, tools for idea and innovation generation, but also of people's competencies. Therefore, both organizational enablers and barriers for innovation and individuals' innovation competences should be taken into account. Similarly, Assink (2006) stresses that, overall, innovation development requires

risk-taking, new methods and ways to act and think, supportive environments, and enthusiastic people. Pérez-Penalver et al. (2018) also state, based on their literature review on indicators associated to innovators, that it has recently been recognized that employees are a crucial driver for innovations. Verganti (2016) adds the concept of meaning in the innovation discourse. According to him, the perspective of innovation of solutions has dominated the discourse on innovation in the last fifteen years. However, today we are more facing the problem of defining a meaningful direction when considering innovation, rather than being worried about the amount of ideas when looking for solutions to problems, which are difficult to solve in the field of a single discipline. He highlights that moving innovation one level higher, to meanings, is nowadays necessary to make a difference. (Verganti, 2016.)

Despite of the varied perspectives to define and approach innovations, overall they seem to have a significant role in todays' societies. Innovation is crucial to the continuing success of any organization (Bessant & Tidd, 2015). For example, according to Alasoini (2010), producing innovations is the key requirement for companies nowadays (see also Bessant & Tidd, 2015; Pérez-Penalver et al., 2018). He describes the changes in companies' ways of operating during the last decades, and states that cost-efficiency, quality and flexibility, the requirements from previous decades, are inadequate in themselves nowadays. Globalization and increasing knowledge challenge companies to constantly prove their abilities to develop their way of operating and creating innovations in different networks, and utilizing different kinds of expertise. In order to succeed in this, new ways to produce innovations are required. Alasoini (2010) describes this with the concept of participatory innovation action. He also adds that not only the way in which innovation is produced is changing, but also the activity of producing innovation is expanding. According to him, the operational environment of innovation is changing, and it cannot be excluded from organizations' other operations anymore. Consequently, producing innovation is spreading out from concentrated and specialized RDI units to whole organizations, and it will also be a part of the operations of small companies. (Alasoini, 2010.)

Similarly, Forsman (2009) brings out the expansion and diversity of innovations. The results of her study showed that innovation development in small enterprises is as common as in larger enterprises. Instead, the nature of innovation development and the quality of innovation capabilities affect more than the size of the enterprise. She highlights that when innovation development expands and diversifies in

enterprises, the requirements for innovation capability become higher regarding all the capability factors. (Forsman, 2009.) Markauskaite and Goodyear (2013) state that it is nowadays widely acknowledged that a range of professional innovations arises from professional practices and problem-focused design activity, rather than developmental work driven by basic research. Additionally, in some bold approaches, spreading or diversification of innovation does not only describe the way in which companies are operating today, but it also demonstrates the whole era in which we are living at the moment. For example, according to Trilling and Fadel (2009, 59), many believe that our current knowledge age is quickly giving way to an innovation age, where the ability to solve problems in new ways, to invent new technologies or create the next killer application of existing technologies, or even to discover new branches of knowledge and invent entirely new industries, will all be highly prized.

On the other hand, innovations are also seen as solutions for many global problems. In these views, innovations are not only the key elements for organizations and companies to grow and survive in the fast-changing world but they are also seen as wider solutions in different fields of society. Innovations are fostering economic competitiveness, increasing well-being, and also solving both social and environmental issues. For example, Wilenius and Kurki (2012), who have studied and analysed different eras from the past to the future, state that slowly but surely, the innovation capacity of the world will focus on the question of how energy and material resources can be utilized ten times more efficiently than at present. They are calling the current time as an era of intelligent technologies, and are seeing these global societal challenges, such as global warming or decreasing of natural resources, as a key platform for innovations. Bessant and Tidd (2015, 6) also note that regarding the platform for innovations, one person's problem is another's opportunity. They highlight that the skill to spot these opportunities and create new ways to exploit them is at the heart of the innovation process.

Similarly, this wider perspective is highlighted in many political approaches, where innovation has been come a trendy concept. For example, the OECD Innovation strategy (2015) emphasizes that the world today faces significant economic, environmental and social challenges, and innovation is the key ingredient of any effort to improve people's quality of life. Today's recovery from the global financial and economic crisis remains fragile. As countries seek to improve their productivity performance and ensure sustained growth, they will need to boost their capacity to innovate. Innovation is also essential for addressing some of society's most pressing

issues, such as climate change, health and poverty. For example, while innovation is often mainly a focus of government policies aimed at strengthening productivity and growth, it is also crucial to support green and inclusive growth and to address global and social challenges more generally. Innovation can help to decouple growth from natural capital depletion and make alternative sources of energy and raw materials cheaper and more sustainable. On the other hand, innovation and the related process of creative destruction lead to novel technologies, entrepreneurs and business models, contributing to the establishment of new markets and eventually to the creation of new jobs. Moreover, as a key driver of productivity growth, innovation leads to value creation that generates the rewards for human, physical and knowledge-based capital. This value creation increases aggregate incomes and has a positive impact on overall living standards. (OECD, 2015.) Overall, it seems that today innovations are appointed with major expectations.

2.1.2 Challenges for higher education

The growing importance of innovation, knowledge production, and evolving perspectives on expertise are challenging higher education, expected to produce experts for working life of the future (Markauskaite & Goodyear, 2013; Tynjälä et al., 2003; Tynjälä, 1999). According to Välimaa and Hoffman (2008), the knowledge society discourse is rooted in the fact that higher education institutions are more important than ever, and they have a crucial role in the development of global knowledge societies. Higher education institutions are integral to the continuous flows of people, knowledge, information, technologies, product and financial capital. (Välimaa & Hoffman, 2008.) Yemini (2012) also claims that the social changes, such as the frequent technological advancements, globalization and increased competition, are sending the employers to look for more skilled and updated workers, and thus in turn are chained for more top-level academic education.

This educational discussion includes often the aspect, in which the role of higher education institutions is not only seen as a producer of competent professionals in working life, but also as a booster empowering innovations in societies. According to Nielsen (2015), earlier the term innovation was often related to economic or high-tech disciplines, but now the trend seems to be that policy makers regard innovation as a potential goal for all educational levels and disciplines. Many countries have started to express innovation policies that stipulate the important role in educational

systems fostering innovation competencies (Nielsen, 2015; see also Neuvonen-Rauhala, 2009). However, although calls for fostering innovation competency have permeated the political discourse for almost 20 years, there is still the need of finding the way to properly transpose the political ambition into the education context (Nielsen, 2015, 318).

Moreover, many other scholars highlight that the urgent need for knowledge workers equipped with the skills required in innovative society challenges education systems around the world to teach and educate in ways that will produce the innovators to be successful in the 21st century (e.g., Avvisati et al., 2013; Bialik & Fadel, 2015; Liebenberg & Mathews, 2010; Trilling & Fadel, 2009). However, despite the fundamental changes in society and world of work in the last few decades (see e.g., Confederation of Finnish Industries, 2011; Davies, Fidler, & Gorbis, 2011; OECD, 2017; Wilenius & Kurki, 2012), many educational practices still seem to be behind time (e.g., Bath et al., 2004; Cobo, 2013; Tynjälä et al., 2003; Tynjälä, 1999) or carrying their old patterns. Thus, educational practices have been criticised for not developing prerequisites of professionals, because they differ from the expertise required in the real environments for which students are supposed to be prepared (Hakkarainen, 2017; Tynjälä, 1999).

For example, historically, one objective of the education system has been to prepare people for the requirements of an industrial society, for jobs that had strictly defined tasks, allocated in advance. In those times, employees worked largely separately from each other and learning one skill was sufficient for a long time (Confederation of Finnish Industries, 2011), while nowadays experts often work in teams and networks, they search for new knowledge, apply it, and transform it for novel uses. However, in contrast, students in their studies work mainly individually, are often disallowed to cooperate and share their knowledge with peers, especially in examinations, and are supported to simply memorize and reproduce the knowledge they have acquired. (Tynjälä, 1999.) Thomas and Brown (2011) also address that memorization, one of the basic staples of education, is not a bad way to learn about things that seldom change. However, in the era when the world's rate of change is excitable, making knowledge stable is an unwinnable game. Today, attempting to memorize the overflowing storerooms of facts and knowledge in any field is clearly impossible. Expertise is less about having a stockpile of information or facts at one's disposal and increasingly about knowing how to find and evaluate information on a given topic (Confederation of Finnish Industries, 2011).

According to Trilling and Fadel (2009), today's education system operates still on not only an agrarian calendar (summers off to allow students to work in the fields), an industrial time clock (fifty-minute classroom periods), but also a list of curriculum subjects invented in the Middle Ages (language, math, science, and the arts). Moreover, they question why students mostly work alone and compete with others for teacher approval, although the world of work is increasingly made of teams working together to solve problems and create something new. Similarly, innovation and creativity are important to the future success of societies, but why do educational institutions spend so little time on developing students' creativity and innovation skills (see also Confederation of Finnish Industries, 2011) or offering diverse social and communal learning experiences for them to create something new (Hakkarainen, 2017)? Wiley and Hilton (2009) also criticize the differences between higher education and the everyday lived experience of individuals. They state that the historic monopoly of higher education is being challenged in each of its major functional areas, including also the structuring and providing access to content. Coiro (2003) asserts that changes in technology have changed the accessibility of knowledge and information for students growing up in the 21st century more than at any other time in history, whereupon the focus on what to teach is reformulated to how to teach. Some scholars are referring to the current situation with the concept of Education 4.0. It is a response to the needs of the industrial revolution (IR4.0), in which the advancement of new technologies blurs the lines between the physical, digital and biological worlds. These new technologies evolve at an exponential pace and are led by the emergence of artificial intelligence, robotics, the internet of things, autonomous vehicles, bio and nanotechnology, 3-D printing, material science, quantum computing and energy storage. (e.g., Hussin, 2018.)

Overall, all these rapid changes have led to increasing pressure for educational institutions not only to re-examine the traditional approaches of teaching and learning, but also to equip their students with needed competences. Many believe that good content-based knowledge on the professional field alone is not enough to prepare students to thrive in the world. For example, according to Bialik and Fadel (2015), employers are speaking out about their newly hired graduates and their lack of skills in the workplace. In order to truly have expertise, students must learn how to use the information they learn. Becoming competent in any subject area means developing both the knowledge and the skills to apply that knowledge to the questions and problems experts in that field would tackle. (Bialik & Fadel,

2015.) Moreover, the role of higher education is not only to educate undergraduates for predetermined work tasks, but also to train employees who are able to manage in uncertain future work (Barnett, 2004; Davies et al., 2011; OECD, 2017), where they continuously need to adapt to new working methods, new technologies and new business models. This requires competences, which are applied and transferred across different jobs and work settings. (Konst & Scheinin, 2018). The processes, where higher education institutions are expected to produce skilled professionals to the needs of global knowledge society, can be described and analysed through multiple views, and by utilizing different theories of learning and expertise. In this study, the current topic is situated and approached from the perspective of competence-based education.

2.2 Targeting at competence-based education

One of the main essential milestones responding to the needs of society and working life in the field of higher education in Europe is called the Bologna Process (Bohlinger, 2012). It has claimed to be the most significant transition in higher education in the last decades, driving towards modernization and standardization of the higher education in Europe and the neighbouring countries. With this cooperation, it was meant to develop high-quality education and strengthen the competitiveness and attractiveness of the European Higher Education Area. Moreover, one of the aims had been to foster student mobility and employability through the introduction of a system based on undergraduate and post-graduate studies with easily readable programmes and degrees. Overall, the establishment of the European Higher Education Area represents an effort to face the changes together in Europe. (Ramos et al. 2012; Yemini, 2012).

The Bologna Process[1] has also provided a strong basis for increasing and guiding educational institutions to draw up and develop their curricula and degree programmes towards a competence-based approach and shift to learning outcomes (Bohlinger, 2012; Laajala, 2016; Mäkinen & Annala, 2010; Ramos et al., 2012). For example,

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1   *The researcher acknowledges that the competence-based approach is only one way and a narrow aspect to approach the Bologna Process and its consequences in European higher education. The aim of this dissertation is not to go deeply in the Bologna process, its history, phases, specific aims and achievements or criticism (e.g. Neuvonen-Rauhala, 2009). In this study, it is used as one contextual example to position the competence-based discourse in European and Finnish higher educational institutions, especially in universities of applied sciences.*

in the beginning of the 21st century, student-centred curriculum development and definitions of generic and field-specific competences were promoted and boosted with several different development projects. Notable approaches in these projects were that the focus of development activities was not only in knowledge- or theory-based competences, but also in other generic competences and skills (Nykänen & Tynjälä, 2012). These projects aimed to offer a concrete approach to implementing the Bologna agreement at the higher education level (Castillo, Caruna, & Wainwright, 2011).

Along with the Bologna Process, European higher educational institutions are today guided by the concept of qualifications frameworks with an emphasis on learning outcomes (European Commission, 2008). In the European Qualifications Framework (EQF), qualifications and competences are allocated on eight reference levels. Each level is provided with a description of the knowledge, understanding and practical capability of a person who has achieved that level. Learning outcomes are defined in terms of knowledge, skills and competences. The EQF provides a tool for defining the interrelations of national qualifications and qualifications systems. The competence-based description of qualifications is designed to support lifelong learning, improve employment prospects, increase mobility, and bridge the gap between education and the world of work. (European Commission, 2008.) In addition to the European level, the curriculum reforms of competence-based approach are currently sweeping across the world, e.g., in Mexico, Australia, and several Asian, South African and Middle Eastern countries (Sturing et al., 2011).

Roughly speaking, the competence-based curriculum is perceived as an implicit transmitter in the processes, where higher educational institutions are expected to produce skilled professionals to the needs of global economy, labour market, and knowledge society. The curricula reform has become a tool to bridge the gap between labour market and education. (Mäkinen & Annala, 2010.) According to Van der Klink (2017), one of the pillars of a competence-based approach to education is the match between the content and the skills demanded by business. A mix of specific professional competences must be sought which ensure usability in the short term, and broader competences that guarantee employability in the longer term. (Van der Klink, 2007.) Sturing et al. (2011) describe that competence-based education better prepares students to become competent professionals, contributes to students' (professional) identity development, braces students for participating in contemporary society and trains students to adapt to changes in work practices

within the same occupation. On the other hand, despite numerous advantages of the aims of competence-based curricula criticism has also been shown. For example, especially in vocational education, the competence-based curriculum has been criticised upon focusing too much on the skills, and over the knowledge, or excessively guided by economic views (Laajala, 2016).

2.2.1 Concept of competence in educational context

Competence is a holistic concept, which describes a person's ability to manage in a specific context (Lester 2014, 2; Mulder, 2012, 36). It is derived from the Latin *competens*, which means capable or qualified (Castillo et al. 2011, 231). The concept has a long and strong history, and definitions of competence vary depending on theorists who have developed them. During the last decades a lot has been written about competence in several knowledge fields, such as linguistic, cognitive psychology, and vocational and professional education, and in various contexts and with diverse aspects, such as in testing, selection and placement performance improvement, management roles and team competence, professional standards and self-assessment, work-process related competence, the development of professional knowledge, critical success factors in organizations, and cross-cultural competence (Bohlinger, 2012; Edwards-Schachter et al., 2015; Lester, 2014; Mulder, 2009.) Roughly speaking, especially in Europe, it first became popular in labour organizations and vocational education. Later it has been expanded to other educational systems and discourses, where the concept refers more to what people are able to do than what they know. (Mäkinen & Annala, 2010; Sturing et al., 2011.) Van der Klink (2007) states that interest in the concept of competence cannot be ascribed to any one development; rather it was a cluster of developments that led higher education institutions to embrace the concept of competence. Recently the concept of competence has achieved a solid position in common language, professional practices and institutional regulations (Mulder, 2009).

Mulder (2009, 13) defines competence as the set of integrated capabilities, which consist of content-related clusters of knowledge, skills, and attitudes, which are conditional for sustainable effective performance (including problem solving, realizing innovation, and creating transformation) in a certain context, profession, organization, job, role and situation. Important characteristics of competence statements are that they are situation-specific and have social meaning, they represent

core responsibilities, are oriented towards performance, but also development-orientated. According him, competence requires a combined set of knowledge, skills and attitudes, which can be applied in this specific situation to make the job a success. All these three elements of competence need to be present, and there needs to be a balance between the elements. The meaning of competence is also social because there are different stakeholders involved who can have different views on what desired performance, and thus related desired competence entails. Competence needs to be related to performance because the use of skills, knowledge and attitudes in professional action expresses the possession of competence. Competence can also be developed, although the extent to and costs at which this can be done is different for competence domains and personal general abilities and talents. (Mulder 2009, 12.)

Instead, Villa and Poblete (2011) define competence as performance in a diverse, authentic, problematic context based on the integration and activation of knowledge, standards, techniques, procedures, abilities, skills, attitudes and values. Instead, Marin-Garcia, Pérez-Peñalver and Watts (2013, 49) highlight the complexity of professional performance. According to them, competences, capacities and skills can be considered as the three categories of complexity in contextualized know-how. A competence is formed by a set of capacities and these, in turn, are formed by several skills, all of which are required for a more complex professional performance. Capacity can be described as a medium complex know-how that integrates skills, which require procedural and conditional knowledge. On the other words, it could be described as complex know-how resulting from the integration and adaptation of capacities and skills to situations having common characteristics, or as complex know-how regarding how to act through the effective mobilization and combination of a variety of internal and external resources within a set of situations. (Marin-Garcia et al. 2013, 49.)

Edwards-Schacter et al. (2015) stress a perspective of learning in competence discourse. According to them, the concept of competence embraces the occupational and personal competences whose acquisition and development occur in a learning process. The competences are defined to four dimensions, including cognitive competences (focuses on knowledge, know what and know why, including tacit knowledge gained experientially), functional competences (such as skills or know-how, things that a person should be able to do and demonstrate), personal competences (meaning behavioural competencies or knowing how to behave) and

meta-competences (an overarching form of competence involving higher order-abilities to cope with uncertainty, learn to learn and self-reflection). They highlight that all these four levels of competence can be learned and taught as part of the process of personal development embedded in educational environments. Van der Klink (2007) states that often there are different views of the concept from the perspective of educational theories and the views from the area of application and practical level. For example, in educational settings, definitions are used in which competences are regarded as developable skills, whereas in selection practice competences are much more often regarded as hard or unvarying personal characteristics.

Moreover, when the concept of competence is included in the education system, it can also refer to authorization, certification or licensure. According to Mulder (2009), educational institutions are authorized to provide graduates with proofs of successful completion of programmes, also referred to as proofs of competence or capability. These official diplomas can imply certain rights or licenses to perform, especially in the occupations and professions with high risks for people, the environment and goods. This approach is also widely popular amongst educational policy experts who want to warrant that the outcomes of education are up to the current standards as defined in national competency-based qualification frameworks. Seen this way, competence is a level of mastery of performance requirements, and in education there is always an assessment of performance, which implies the judgement of the level of mastery of competence. Thus, competence itself is invisible, but it becomes visible and measurable in actual performance. (Mulder, 2009.)

Mäkinen and Annala (2010) use the concept to combine the economic and educational policies of the European Union. Pikkarainen (2014, 623) also states that it is hoped that the concept of competence can offer a common language and understanding between educational authorities and the labour market. According to Mäkinen and Annala (2010), competence is one of the most used concepts with multiple meanings combining thematic discourse of economic, working life, professional development and education alike in the English-speaking area. They refer to that in the colloquial language of labour policy, competence often means performing one's duties or work tasks in the fast changing labour market, but in higher education discourses it refers a problematic relation of working life and education, when it is used to refer to both knowledge, skill, competence and learning outcome. On the other hand, there can be different approaches to the concept in national definitions as well (Castillo et al., 2011; see also Bohlinger, 2012; Van der Klink, 2007). For example, based on the

research of Castillo et al. (2011), in Europe, the various definitions of this concept found in research literature and other educational documents from the UK, France and Germany were used by the Bologna Working Group. Van der Klink (2007) even claims that in educational theories or practices, the number of definitions of this term is probably incalculable.

2.2.2 Closely related concepts of competence

The concept of competence can also be connected to the thematic of generic skills. Edwards-Schacter et al. (2015) state that one of the obstacles to competence-based education is that it embraces an umbrella of terms like competences, competencies, academic competences, transferable skills, soft skills, core skills, key skills, 21st century skills, generic skills, basic skill and cross-curricular skills (see also e.g., Barrie, 2007; Jones, 2009; Kember, Leung, & Ma, 2007; Kivunja, 2014; Tuononen et al., 2017). The characteristic for these competences is that they can be embedded as part of any degree and deployed in a variety of social settings, contexts or fields. They refer to that kind of expertise which education should produce regardless of study fields. (Nykänen & Tynjälä, 2012.) On the other hand, different meanings and emphases can also be found on these concepts (Cobo, 2013; Ursin & Hyytinen, 2010). For example, some views (especially relating to the term of transferable skills) involve the assumption that these skills can be transferable from one discipline to another or one context to the next, while other views criticize this and highlight the context or discipline related aspects (Nykänen & Tynjälä, 2012). Barnett (2004), on the other hand, states that generic skills may seem to offer the basis for learning to an unknown future. The list of the most widely cited generic competences covers, for example, critical thinking, problem solving, interpersonal skills, capacity for logical and independent thought, communication and information management skills, intellectual curiosity and rigor, creativity, ethical awareness and practice, integrity and tolerance (Bath et al., 2004), and knowledge of how to learn through life-long learning (e.g., Chung, 2011; Ursin & Hyytinen, 2010). On the other hand, there is variation in how much detail and to which extent these competences are described in literature, from listing a few areas of competence to detailed lists covering over twenty specific skills (Ursin & Hyytinen, 2010). Bath et al. (2004) summarize that the emerging importance of generic skills, or graduate attributes, in higher education has been influenced by at least three factors: the popular perspective that education is a lifelong process; a greater focus on the relationship between education and the

employment of graduates; and the development of outcome measures as a part of the quality movement.

However, Badcock et al. (2010) state that despite the emerging importance, an evident value of the capacity to transfer skills across domains and adapt to new situations, generic skills and their acquisition raise several complex issues (see also Ursin & Hyytinen, 2010). Barrie (2007) notes that despite the lengthy history of the rhetoric of such policy claims, universities' endeavours to describe generic attributes of graduates continue to lack a clear theoretical or conceptual base and are characterized by a multiplicity of viewpoints. Overall, not only the term competence, but also its near relatives, such as competency, skill, capacity and ability, can be somewhat problematic. Although they are widely used international terms and they have become trendy concepts, there is little consensus on the definition and meaning of the concepts. In many publications of scholars, these concepts lack the detailed definition or consensus in their definitions; the concepts are often used indeterminately or with overlaps (e.g., Bohlinger, 2012; Mäkinen & Annala, 2010; Pikkarainen, 2014).

For example, there is a particular confusion over the distinction between competence and competency[2]. Based on the results of majority dictionaries, competence and competency are synonyms. In research literature, political rhetoric and public commentary concepts are also used as convergent concepts. Instead, in several disciplines concepts are often defined to mean different aspects of know-how. (Castillo et al., 2011; Cowan, Norman, & Coopamah, 2005; Edwards-Schacter et al., 2015; Mäkinen & Annala, 2010.) Roughly speaking it seems that European concepts are mainly stressing on a competence approach and concepts used in documentation from the US, Canada, Australia, and New Zealand are generally highlighting a competency perspective (Castillo et al., 2011; Mäkinen & Annala, 2010). According to Mäkinen and Annala (2010), differences and variations between the definitions are based on miscellaneous claims of professional fields and differences between disciplinary epistemological approaches to use the concept and draw up educational models. Despite the indeterminateness of the concept, overall it has provided a generic and simple approach to achieve the aims of the Bologna Process to modernize higher education curricula towards competence-

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2   *This dissertation study uses the concept of competence in a systematic way. However, when it refers to other authors' texts, the original concepts are used, such as the concept of competency.*

based education. According to Mäkinen and Annala (2010), the concept also reflects a hypothesis that the tradition of higher education institutions all over Europe have been rather focused on increasing students' expertise based on theory and knowledge than emphasizing their performing and action.

2.2.3 Innovation competence

One way to approach the competence-based education and thematic of competence and its varied definitions is innovation competence. In the educational context, innovation competence can be seen included in part of generic skills or competences, like near relatives. For example, according to Nykänen and Tynjälä (2012, 19), characteristic of the generic competences is that they can be embedded as part of any degree and that they needed in a variety of contexts or fields. Thus, from this approach, innovation competence is understood as such competence which every student needs to acquire during their education regardless of the field and which serves as an integrated addition to the competence specific to each field of study. However, when innovation competence is acknowledged not only as a generic competence needed in the changing working life but also as the kind of competence required for being able to participate in and being an active actor in the different phases of innovation processes in professional practices, the concept also involves context-situated and practical-based aspects (Marin-Garcia et al., 2013; see also Hermansen & Nerland, 2014; Messmann & Mulder, 2012; 2011). Moreover, the theoretical basis of innovation competence is on innovation theories and thus, it provides a bounded perspective to approach the thematic of generic skills or competences. The approach also highlights the importance of innovations in today's society, and especially educational institutions' role in fostering innovative professionals.

Innovation competence can be defined in many ways. For example, according to Kairisto-Mertanen et al. (2011) and Kettunen et al. (2013), innovation competence can be divided in individual, interpersonal, and networking competences including different abilities, such as the ability to target-oriented and tenacious action, the ability to co-operate in a diversified team or work community, or the ability to create and maintain working connections. All these competences are characterized by the kind of skills and knowledge that students in all study fields should be acquiring (so called generic skills), in addition to their study specific competences. (Kettunen et al., 2013). Instead, according to Marin-Garcia et al. (2016), innovation

competence is the ability to create, introduce, adapt and/or apply beneficial novelty at any organizational level, which requires a cluster of separate or even overlapping competences, capacities and skills (Pérez-Penalver et al., 2018). They are dividing innovation competence for the five dimensions needed in different phases of innovation processes.

- Creativity: ability to think beyond existing ideas, rules, patterns or relationships, to generate or adapt meaningful alternatives, ideas, products, methods or services regardless of possible practicality and future added value.

- Critical thinking: ability to analyse and evaluate advantages and disadvantages and estimate the risks involved for a purpose.

- Initiative: ability to influence/make decisions that foster positive changes, and to influence creative people and those who have to implement the ideas.

- Teamwork: ability to work effectively with others in a group.

- Networking: ability to involve external/outside stakeholders outside the team. (Marin-Garcia et al., 2016; Pérez-Penalver et al., 2018.)

In this study, innovation competence is understood as part of the context and thematic of generic competences, and thus *generic* in this context refers to innovation competence being needed and useful in all study fields and professions. In other words, the concept refers to such competence which education should produce regardless of study field, as recommended by Kairisto-Mertanen et al. (2011) and Kettunen et al. (2013). Innovation competence can be learned and taught as part of the process of personal development and professional learning (work) activities (such as nursing, construction, or sales) embedded in educational environments. In addition, in this study, innovation competence is formed of a cluster of capacities and skills, which jointly form a complex professional performance needed in creating innovations. However, this study defines the dimensions of innovation competence (compare Marin-Garcia et al., 2016; Pérez-Penalver et al., 2018) as capacities, which can be described as a medium complex know-how in creating of innovation. These capacities integrate skills, which require procedural and conditional knowledge (Marin-Garcia et al. 2013, 49), but can be demonstrated as persons' behaviour or action. Moreover, this study accepts that innovation competence can be approached

from individual, interpersonal, and networking levels (e.g., Kairisto-Mertanen et al., 2011; Kettunen et al., 2013; Penttilä & Kairisto-Mertanen, 2012), but it also agrees that definition and classification of capacities or skills can be constantly evolving (e.g., Keinänen, Ursin, & Nissinen, 2018; Marin-Garcia et al., 2013; Pérez-Peñalver et al., 2012; Watts et al., 2012), as can the concept of innovation. The disposition of innovation competence and its near relatives is described in Figure 1, where a dotted line demonstrates the evolving nature of the concept and its somewhat inaccurate framing for generic skills.
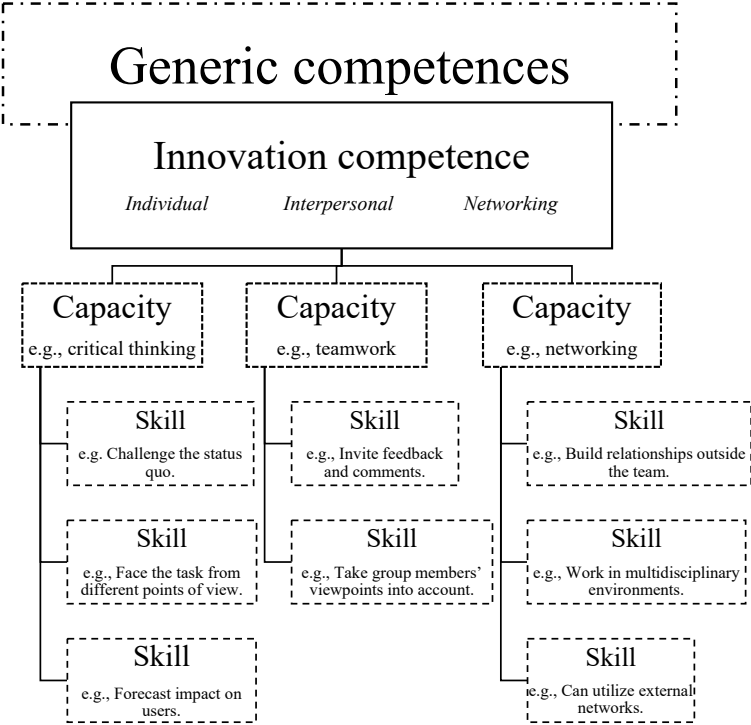
Figure 1. Definition of innovation competence.

2.3 Implementing competence-based education in practice

Versatile theories of teaching and learning can be utilized in the implementation of competence-based education in practice. Generally speaking, these theories identify problems in traditional teacher-centred education and are often based on the principles of constructivist learning. In these theories, learning is achieved by the active construction of knowledge, supported by various perspectives within meaningful contexts. Social interactions are also considered important to the processes of learning and cognition. Additionally, the emphasis is on learning *how*, instead of learning *about*. (Michael, 2006; Thomas & Brown, 2011.) Van der Klink (2007) also reminds that competence-based curricula are not only geared to the competences of the job and training profile, but generally show a number of the following pedagogic characteristics. It gives consideration both to the optimization of the relationship with the labour market and pedagogic innovation. The education focuses on problems from professional practice, integration of the acquisition and application of knowledge and skills, the student's self-responsibility, co-operative learning, new forms of testing. (Van der Klink, 2007.)

Because there is little agreement on the definition of competence, a shared vision on how to introduce competence-based education is often missing in higher education[3]. There is also a considerable lack of clarity about the way how competence-based education must be designed and arranged, and what are the methods to be used (Van der Klink, 2007; see also Sturing et al., 2011; Välimaa & Hoffman, 2008). According to Van der Klink (2007), there are four variants how competence-based is actually used. In the first variant, the term is used by education providers to create a distinct profile on the market without anything actually changing in the education. In the second variant, the term can be used if there is an innovation in the teaching methods, moving towards integration of knowledge and skills, often by the use of authentic problems, projects or cases, but chosen from the pedagogic perspective of identifiability. The third variant can aim at strengthening the relationship with the

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3   *The research and discourse describing competence-based education in practice is highly versatile and somewhat unclarified. It seems to mix more or less several aspects of the current higher educational discourse, including e.g., requirements of knowledge society and working life, curricula reform based on the Bologna Process, concept of competence, changes in the educational paradigm and emergence of the awareness of alternative learning theories, as well as an increasing interest of educational research on the effectiveness of pedagogical models and practices. Therefore, in this study, competence-based education is used as a wide and general term to describe the different processes and applications, which all are aiming to produce skilled professionals to the needs of global knowledge society.*

possibly regional labour market, for instance by setting up consultative committees with representatives from the professional field, staff training or by drawing up job or training profiles in consultation with the professional field. Instead, the fourth variant uses competence-based education as a label for an integrated approach, in which attention is devoted both to pedagogic innovation and optimization of the relationship with the labour market. (Van der Klink, 2007.)

Ramos et al. (2012) highlight a student-centred approach in the competence-based education. This centralization relates to a practice of teaching that is the opposite of more traditional models. Instead of passing ready-made knowledge, supported by large-scale bibliographic sources, the students are encouraged to search for that knowledge on their own, rendering the learners' empowerment and autonomy, emphasizing experiential work and soft-skills acquisition, favouring the development of their creativity and reinforcing their critical thinking. They highlight that student-centred learning represents a cultural mind-set within higher education institutions and derives from constructivist theories of learning. Typical characteristics in this mind-set are innovative teaching methods that pursue learning in interaction with teachers and other students, consequently enabling students to engage active learning through problem solving, critical thinking and reflective thinking. Student-centred learning focuses on learning outcomes, what it is expected that students will be able to do at the end of the subject or programme. (Ramos et al., 2012.)

Trilling and Fadel (2009) also refer to a student-centred approach. According to them, to be an effective teacher in this new paradigm requires a move from teacher-directed to student-centred learning, from direct teacher instruction to interactive exchange with and among students, from teaching content knowledge to equipping students with relevant skills, and from teaching contents to problem solving processes. Effective teaching in this new paradigm requires a shift from teaching basic to applied skills, from teaching facts and principles to investigate questions and problematizing, from mere theory to practice applying the relevant theory or theories, and from working with a fixed or set curriculum to working on authentic real-life projects. It calls for a move away from competitive learning to collaborative learning, from a classroom-tied context to foot-loose global learning networks, from summative to formative assessment of students' performance, and from learning at school to learning throughout life. (Trilling & Fadel, 2009.)

Same approaches are also underlined in the study of Sturing et al. (2011). They list ten current principles of competence-based education, which emerged from various theoretical and empirical studies.

1. The study programme or curriculum is based on core tasks, working processes and competences.

2. Complex vocational core problems are central in curricula development.

3. Learning activities take place in different concrete, meaningful vocational situations.

4. Knowledge, skills and attitudes are integrated around core tasks and learning tasks.

5. Students are regularly assessed with versatile assessment methods (such as authentic, formative and summative assessments).

6. Students are challenged to reflect on their own learning by which they further develop their competence.

7. The study programme or curriculum is structured in a way that the students increasingly self-steer their learning.

8. The study programme or curriculum is flexible.

9. The guidance is adjusted to the learning needs and learning preferences of the students.

10. In the study programme or curriculum, attention is paid to learning, career and citizenship competences. (Sturing et al., 2011.)

2.3.1 Criticism of practices

The principles of competence-based education not only challenge the roles of teacher and student but also the practices and methods of traditional assessment and evaluation. In competence-based curricula, assessment has an important role in many levels. It is not only one individual principle in the list but it also integrates into other pedagogical elements, such as learning activities or learning environments.

Van der Klink (2007) reminds that in competence-based curricula, testing should be integrated into the learning process. Although new methods of testing, such as performance assessment, authentic testing and self and peer assessment, play an important role in the learning process, they are still often missing from competence-based education. He criticises that if students are only evaluated on the knowledge they have acquired, while skills and attitudes are ignored in the assessment, students will only bother to acquire the knowledge needed for the test. Assessment frames what students do; thus, if you want to change student learning, change the assessment. (Boud, 2007; Brown, Bull, & Bendlebury, 1997). Therefore, competence-based testing presupposes the integrated assessment methods of knowledge, skills and attitudes, not only by a recapitulative test at the end of the learning process but also by a formative test to give the learner interim information on their progress and encourage reflection on their own performance. Unfortunately, traditional methods of testing focused on written forms, such as multiple-choice questions, open questions or essays, are regarded as inadequate to say anything about competences because the focus is only too often on knowledge, not in authentic action or behaviour. Consequently, new forms, such as simulations or appraisals in the work or project situation, will have to be added to the test repertoire to be able to assess adequately whether students have acquired the entire competence. (Van der Klink, 2007, 76.) However, the context of assessment in higher education is often taken to be the world of the course, not the world of practice (Boud, 2007).

Correspondingly, Kivunja (2014) supports the above insights, but addresses the importance of changes also in a structural level, in the national examinations. She states that unfortunately, those skills are not yet included in many of the learning outcomes prescribed by most educational jurisdictions or required to be assessed in high-stakes state and national examinations. These skills need to be prescribed among the highly valued learning outcomes that graduate students are expected to achieve as part of their education. Therefore, they should be included in the states and national high-stakes examinations to represent a new approach to teaching, learning and assessment. (see also Trilling & Fadel, 2009.) Boud (2007) states that assessment typically frames how higher education students actually learn because it provides the clearest indication of what the institution gives priority to. It has a powerful backwash effect on all teaching and learning activities. Consequently, there might be a risk that only what can be easily and transparently measured is taught or assessed.

On the other hand, the criticism focused on implementation of competence-based education seems to be more diverse than only the accusations of defective assessment practices. Reichert (2010) praises the visionary goals of using learning outcomes and competences as the structuring principle of all curricula in Europe, but laments that only a few countries and higher education institutions have actually embraced this approach (see also Sturing et al., 2011). Ramos et al. (2012) show that the modernization of higher education has required the implementation of major changes in institutions and in attitudes. They remind that the change in teaching and learning prompts the need for higher education institutions to be aware of several issues, such as how to promote effective cultural change concerning the higher education teaching staff and stressing the centrality of the student's learning process, rather that the knowledge per se. Yemini (2012) brings out, based on the Bologna experts and Higher Education Reform experts' opinions, that student-centred teaching and faculties having to comply with new ways to learn, lifelong learning and the academia-industry cooperation were still the most important future challenges in national higher education systems.

Similarly, several other studies have shown that higher education institutions have not met the demands of working life and they cannot easily respond to these changing needs of competences. Previous studies have demonstrated that graduates have perceived that education has not given sufficient readiness and skills for working life (e.g., Badcock et al., 2010; Knight & Yorke, 2003; Quintana et al., 2016). It has even been shown that teacher performance in the roles of innovating, knowledge society facilitating, collaborating and networking, higher education developing, and entrepreneurship could not be considered as satisfactory (Kasule et al., 2015). Jones (2009) has also revealed that although there has been considerable interest in generic attributes in higher education for decades, and yet while generic skills or attributes are an important aspect of policy, there is often a lack of consistency between beliefs about the importance of these skills and attributes and the degree to which they exist in teaching practice. Kivunja (2014) addresses that it is thus a pedagogical imperative that education providers at all levels of instruction and learning provide effective training in competences so that their graduates will be ready to apply them in the workplaces and occupations that they will enter upon graduation. She underlines that educators and institutions need to educate themselves for change (see also Tynjälä, 1999). This step might require in-service training and professional development to ensure that those charged with the privilege of educating learners for the 21st century

are themselves well skilled in the skills and can in turn teach them effectively to their learners. (Kivunja, 2014.) However, Trilling and Fadel (2009) state that although these combined forces for a 21st century model of learning are powerful and growing, a number of forces are still resisting these changes. According to them, one example of resistances is the fear among some educational organizations that hard-sought improvements in traditional learning outcomes of 21st century skills through a focus on rigorous content will be undermined by a new focus on skills. Additionally, based on the study of Anderson, Boyles and Rainie (2012), experts' opinions on trend of development in the field of higher education are contradictory. According to their study, some of the educational experts still believe strongly that traditional pedagogy of higher education will remain unchanged notwithstanding the current pressures.

Trilling and Fadel (2009) underline that in order to support 21st century learning, understanding, and skills performance, changes are required at four levels of educational support systems. These support systems are standards and assessments, curriculum and instruction, professional development, and learning environments. Often changes have been conducted only in one level of these support systems, such as a new curriculum, without coordinated changes being made in all the other linked systems (like the learning environment, teachers' professional development and aligned assessments or standards). The lack of alignment in development activities in all levels could be one explanation for a wide criticism concerning implementation of competence-based education in practice. If the changes are fixed only in the curricula or instruction level, there could be a risk that objectives of pedagogical vision or strategy and curricula descriptions remain only empty phrases of higher educational institutions.

2.4 Approaching competence-based education with innovation pedagogy

In order to match better with future needs and develop competence-based education and students' working life skills, higher education institutions have started to develop different pedagogical strategies and practices to implement educational reform (Kettunen et al., 2013; Nykänen & Tynjälä, 2012). This is more obvious especially in universities of applied sciences than traditional universities because of their different role and aims (Laajala, 2016, 294; Neuvonen-Rauhala, 2009, 59; Raudaskoski, 2000, 41). In this dual model, used in Finland, both educational

institutions are equal but different, and one of the most central elements which differ universities of applied sciences from traditional universities is their working life orientation[4]. The profile of universities of applied sciences focuses on working life orientation and aiming to educate and develop professionals to working life, while, the profile of traditional universities is more scientific oriented and aiming to provide new research and new information. (Neuvonen-Rauhala, 2009.) In Finnish legislation, missions for universities of applied sciences are described with two aims:

- "to provide higher education for professional expert jobs based on the requirements of working life and its development and on the premises of academic research and academic and artistic education and to support the professional growth of students", and

- "carry out applied research, development and innovation activities and artistic activities that serve education in universities of applied sciences, promote industry, business and regional development and regenerate the industrial structure of the region" (Ministry of Education and Culture, 2014, Section 4.)

Nurmi and Mahlamäki-Kultanen (2015) have studied and analysed the pedagogical strategies and the pedagogical policies of strategies of all universities of applied sciences operating in Finnish and Swedish in Finland. According to them, an institution's pedagogical strategy reveals the desirable ambition of its pedagogical activities. The pedagogical activities are based on the understanding what is higher education pedagogy, development of expertise, and needs of working life concerning key knowledge, skills and attitudes. (Nurmi & Mahlamäki-Kultanen, 2015.) With the pedagogical strategy, an educational institution not only enhances the national and international attraction and quality of education (see also Van der Klink, 2007), but also foresees the future needs of working life and improves learning environments (Kairisto-Mertanen, 2015; Raudaskoski, 2000, 44).

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4   *Higher education systems vary by countries. In addition, the differences in the missions of universities and universities of applied sciences are miscellaneous and these divisions are often undefined in referenced literature. Therefore, this study uses the term higher education.*

2.4.1 Innovation pedagogy as a pedagogical strategy

Although the role of higher education fostering innovations is highlighted on several strategic policy recommendations and discourses (e.g., Finland's national innovation strategy, 2008; European Commission, 2017; OECD, 2015), and previous studies support its role in training innovative professionals (e.g., Avvisati et al., 2013; Edwards-Schacter et al., 2015; Vila et al., 2012), little attention has been paid to students' innovation competences in those Finnish pedagogical strategies (Nurmi & Mahlamäki-Kultanen, 2015). Moreover, Nielsen (2015) criticizes that despite literature is replete with discussions on conceptualizing innovation competency, there is much disagreement about how to put it into operation in teaching and learning. Similarly, Jones (2009) states that several studies point the clear lack of consensus regarding the nature of generic skills and attributes, and their place in the curriculum (see also Mäkinen & Annala, 2010). Avvisati et al. (2013) also highlight that tertiary education institutions should try to foster skills that are important for innovation regardless of the discipline, and these innovation skills should be an integral part on competence-based approaches to curricula.

In innovation pedagogy, an approach to reform pedagogy in higher educational institutions, innovation competences are functionally integrated into learning systems design from the beginning of students' studies. Innovation pedagogy is a strategic choice that permeates through the entire organization and its activities, and supports the development of students' competences to participate in the processes of creating innovations (Penttilä, 2016). It is a pedagogical strategy adopted by one Finnish educational institution. According to the research by Nurmi and Mahlamäki-Kultanen (2015), innovation pedagogy is also one of the few pedagogical strategies in Finland that are also theoretically founded. For example, Kettunen (2011; 2013) and Kairisto-Mertanen (2009) have contributed to the construction of its theoretical bases. According to Kettunen (e.g., 2011; 2013), the roots of innovation pedagogy can be found in many general learning theories, e.g., in constructivism, collaborative learning, pragmatism, and learning from experience, which will next be described shortly.

An overview of learning theories that form the basis of innovation pedagogy

Generally speaking, according to the theories behind innovation pedagogy, learning is reached when the active construction of knowledge is supported by various perspectives within meaningful contexts. Moreover, social interactions are also considered to be an important part of the processes of learning and cognition. These views emphasize on learning how, instead of learning about. According to *constructivism*, learning is not passive reception of information but learners' active and continuous process of constructing and reconstructing their conceptions of phenomena. Thus, it means that learners construct their own individual knowledge and understanding of things. Then again, *social constructivism* emphasizes the collaborative aspect of the construction of knowledge. It underlines understanding instead of memorizing and reproducing information, and it relies on social interaction and collaboration in meaning making. (Tynjälä, 1999.) As one of the sociocultural theories, social constructivism views that learning occurs always at a certain time and in a certain culture, and thus learning cannot be separated from the surrounding world. The cultural operating models always steer learners and their activities. Social learning has been conceptualized as societal learning in general, as processes of interaction that lead to concerted action for change, as group learning, and as the learning of individuals within a social context (Buckingham & Ferguson, 2012).

The concept of *collaborative learning* is closely linked to the concept of social learning. The theoretical basis of collaborative learning can be traced back to two main concepts (Helle, Tynjälä, & Olkinuora, 2006), namely the concepts of socio-cognitive conflict (Piaget, 2001) and the zone of proximal development (Vygotsky, 1978). Piaget (2001) refers to the mechanism through which individuals realize that their thoughts or ideas are inconsistent with other people's views or with new information. This internal conflict leads the individual to reflect on their thinking and may serve to initiate a conceptual change. Instead, Vygotsky (1978) underlines the social nature of learning and states that the role of social interaction is fundamental in the development of cognition. The concept of the zone of proximal development refers to the distance between what learners can achieve independently and what they can reach through the guidance and encouragement of adults or collaboration with peers. The tutor may model behaviors and/or provide verbal instructions for the learner. According to Vygotski, community plays a central role in the process of "making meaning" and social learning tends to precede development.

Similarly, Hakkarainen (2000) approaches learning from sociocultural perspectives, but he also adds an aspect of practice in the discussion and uses terms of community of practice and boundary crossing to describe it. He underlines that a progressively deeper association with different authentic expert communities enables learners to adopt tacit knowledge, practices, and the culture of the community, and thus deepen their growth of expertise. However, association in a new or unfamiliar community typically requires crossing the existing boundaries. These boundaries can either hinder or support learning. Boundaries function as potential platforms to show learners' own boundaries of their understanding, knowledge and competences. Learning in these boundaries can work not only for the newcomer but also for the community. Through social communities, high-level competences and new ideas can be conveyed, and thus, they can also be seen as an action to foster innovations. (Hakkarainen, 2000.)

In addition to the social learning theories, *pragmatism* is also a key part of the theoretical basis of innovation pedagogy. Indeed, the very mission of a university of applied sciences is pragmatic, i.e. to merge theory and practice. Pragmatism emphasizes the significance of action and practice-oriented approach in learning. It is based on the assumption that all human thinking, scientific knowledge creation, truth, learning, and social interaction should be approached from the perspective of practice and action (Siljander, 2016, 176). The aim of pragmatism is to convert practicable knowledge arising from real-life problems into action. Thus, the learner constantly acquires new knowledge and skills while learning focuses on action. According to Taatila and Raij (2012), pragmatism views that every learning situation should improve the learner's capacity for practical work. However, Messmann and Mulder (2011) highlight that learning environments must be related not only to actual work experience but also to students' needs, interests, and personal context, because personally relevant and optimally challenging learning environments will make the learning process meaningful and motivating to students. Therefore, experiential learning theories are also closely integrated to the views of pragmatism and they have been often used to describe the development of expertise. In the model of *learning from experiences* (Kolb, 1984), learning is an ongoing process where experience is generated through ongoing engagement with the world. This model suggests that learning and experience cannot be separated. According to Kolb (1984), "ideas are not fixed and immutable elements of thought but are formed and re-formed through experience." Thus, "students transform abstract theories and formal

knowledge for use in practical situations and, accordingly, employ their practical knowledge to construct principles and conceptual models" (Kolb, 1984). However, Kettunen (2013, 53) writes that "effective learning does not follow from positive experience but from effective reflection", and this kind of reflection, in which long-held and socially constructed assumptions, beliefs and values about the experience can be examined, can also lead to transformative learning. Kolb (1984) also states when learning is conceived adaptive process, it provides conceptual bridges across life situations, such as education and work, portraying learning as a continuous, lifelong process. Additionally, Messmann and Mulder (2011) have also showed that reflection is not only important for professional development but also for innovation development.

Thus, based on these pedagogical foundations, innovation pedagogy supports the argument that "through social interaction, students may reach a higher state of development than they would achieve by working and studying on their own" (Helle et al., 2006). When different actors (e.g., teachers, students, working-life representatives) are able to work together in dialogue in such manner that their own expertise can be efficiently shared and combined in fresh ways, it results in something more than the sum of its parts. This process also enables novel knowledge creation and understanding based on the thought and ideas presented by others. Moreover, according to innovation pedagogy, when the purpose of universities of applied sciences of supporting regional development is integrated into the learning process, achieving intuitive learning and tacit knowledge from practices and culture of community is possible by facilitation. (e.g., Kettunen, 2011; Kettunen, 2013; Kettunen et al., 2013.) In other words, according to innovation pedagogy, learning takes place by applying knowledge by doing and experimenting in a problem-based manner in the working life context. Learning also occurs through collaborative learning, not only from and with others but also from different sources of information in a multidisciplinary-manner, by creatively combining different competences and experiences. From educators, this requires support, encouragement, and guidance in order to facilitate life-long learning, collaborative working methods, combination of different expertise, and utilization of reflection and feedback. In addition to competence in activating teaching and learning methods as well as in planning and implementing successful teaching and the learning processes, it also involves competence in cooperation and networking with working life organizations, in

flexible study paths, and in internationalization and entrepreneurship (Konst & Scheinin, 2018).

Therefore, drawing understanding and inspiration from these pedagogical foundations (Figure 2), innovation pedagogy also develops and uses different tools and methods not only for teaching and learning, but also in different structural educational operations and facilities that support that kind of learning (more in subsection 2.4.2). Thus, as a holistic pedagogical strategy, innovation pedagogy can be implemented in practice through different pedagogical models appropriate for specific context, such as progressive inquiry (e.g., Hakkarainen, 2005) or trialogical learning (e.g., Paavola, 2012), and by using different learning and teaching methods and tools. However, the concept of *innovative pedagogy* refers to innovative teaching and learning solutions, while *innovation pedagogy* as a pedagogical strategy additionally has an impact on all educational solutions pertaining to organizational issues, decisions related to RDI activities, curriculum development, or cooperation with external interest groups. (Konst & Kairisto-Mertanen, 2018, 36.)
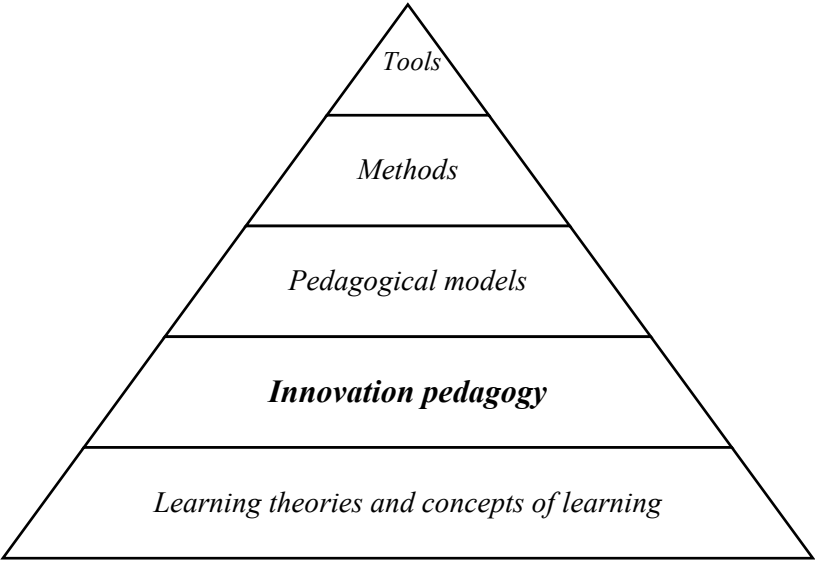
Figure 2. Hierarchy of pedagogical concepts and innovation pedagogy (Konst & Kairisto-Mertanen, 2018).

Implementation of the pedagogical strategy as part of the development process

The first steps in the development process of innovation pedagogy took place in the early 21st century. During those years, e.g. curricula were renewed to comply with the Bologna process (Kairisto-Mertanen, 2005) and societal drivers were challenging the institution to develop its own educational approaches to respond better to the duties of universities of applied sciences and demands of working life (Kettunen et al., 2013; see also Raudaskoski, 2000, 40–41). For these reasons, the institution was also reorganized in a totally new way, into multidisciplinary faculties. In order to succeed in this new direction a novel but common vision was crucial (Kairisto-Mertanen, 2005; Raudaskoski, 2000, 45, 49). Moreover, soon after these changes, Finland' national innovation strategy (2008) was also launched, and this strategy inspired the institution to take an active role in implementing the national innovation strategy in practice and fostering innovation and regional development (Kettunen et al., 2013). Consequently, these key drivers together generated a shared pedagogical strategy, called innovation pedagogy.

Furthermore, in the meanwhile, European (EQF) as well as national guidelines (NQF) and Arene's (Rectors' Conference of Finnish Universities of Applied Sciences) recommendation for generic competences, guiding higher education institutions to define their learning outcomes of competence-based curricula, supported to concretize and profile the pedagogical strategy further. Whereupon, the process of defining innovation competences as goals for the students' learning, regardless of study field, was started. (Kettunen et al., 2013.) Overall, reforming the education has taken many years and it is still progressing and developing. Naturally, it also takes time to truly cover the whole institution with almost 10 000 students and 700 staff members. Although it has been supported by several succeeding arrangements, activities and versatile methods (such as mentoring, trainings and discussion forums), mistakes have been part of the process. It is also clear that many kinds of feelings are involved when a whole culture has been put under consideration and a new start into a totally new direction has been obligatory. Especially, in the beginning of the process it has caused lot of anxiety and insecurity. (Kairisto-Mertanen, 2005; Kairisto-Mertanen, 2015; Konst & Scheinin, 2018.) However, during the last few years innovation pedagogy has been strongly brought up in the operation of the organization. For example, innovation pedagogy has been raced to the institution's strategy (2015–2025) as one of the four lines of action. Furthermore, in 2015, systematic internal staff training on innovation pedagogy was started. The aim is to

train the whole organization, including administrative staff, teachers, RDI project workers, and managerial personnel alike. (Konst & Scheinin, 2018.) At the moment, approximately half of the entire staff has been trained.

2.4.2 Innovation competences as learning outcomes

Vila et al. (2012) highlight that individuals taking part in innovative activities at the workplace require for them to have already developed a set of specific competencies during their studies. Bath et al. (2004) state that this kind of skills are best developed when embedded in curricula as objects for learning. Learning outcomes are statements used to describe what a learner is expected to know, understand and do at the end of a period of learning. These statements describe what is achieved and assessed at the end of the course. Guidelines for learning outcomes recommend that they be clearly observable and measurable (Buss, 2008; Harden, 2002). Learning outcomes can also be seen in the context in which knowledge, skills and attitudes are all integrated (Harden, 2002). Knowledge and skills of knowledge application play a crucial role in the creation of innovations, as well (Bessant, Caffyn, & Gallagher, 2001), which also demands innovation competence. In innovation pedagogy, the definition of innovation is grounded on the definition of Finland's national innovation strategy (Innovation Strategy 2008), where an innovation is understood as a competitive advantage based on knowledge. According to this definition, innovation can also be understood as a process that can be already existing but new in the circumstances where it is being applied (e.g., Kairisto-Mertanen et al., 2011; Kettunen et al., 2013; Kettunen, 2011).

In innovation pedagogy, both study programme specific competences and innovation competences represent a new sphere of expertise (Penttilä, 2016). To achieve this desired expertise, students must gain necessary study field specific competences and innovation competences during their learning process to help them to be active in different innovation processes and ultimately create innovations (Kairisto-Mertanen et al., 2012; Kettunen et al., 2013). Thus, based on the above described theoretical premises, learning innovation competences requires that the pedagogical practices in higher education enable the application of theory to practice and emulate working life and innovation activities in social interaction. In innovation pedagogy, these practises are called cornerstones. According to Kairisto-Mertanen et al. (2011), the cornerstones could be defined to include the

six elements of learning environments: 1) activating learning and teaching methods; 2) multidisciplinary learning environments; 3) working life orientation and RDI integration (research, development and innovation activities); 4) flexible curricula; 5) entrepreneurship; and 6) internationalization. These six elements have emerged on the one hand from the Finnish legislation regarding the mission of universities of applied sciences and from the characteristics of pedagogy in higher professional competence-based education, and on the other hand, as a result from a systematic and proactive internal education development.

As demonstrated in Figure 3, these elements are essential for learning when the aim is training future professionals who are capable of participating in innovation processes and who can contribute to the creation of innovations. The cornerstones are narrowing the gap between the demand for professional skills and the skills that students acquired in the classroom (Kairisto-Mertanen et al., 2011; Kairisto-Mertanen et al., 2012).
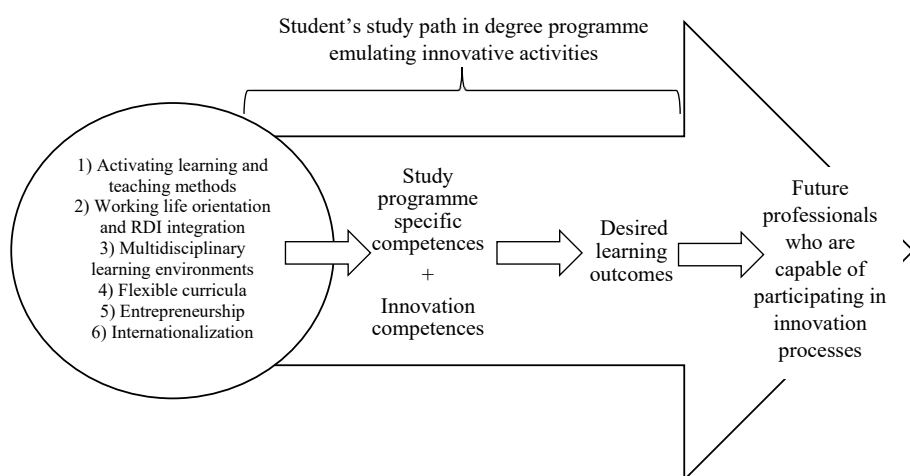
Figure 3. The outcomes, competences and cornerstones of innovation pedagogy (adapting e.g., Kairisto-Mertanen et al., 2011).

Enhancing students' learning through cornerstones of innovation pedagogy

The six cornerstones are essential requirements for innovation pedagogy to succeed and produce the desired learning outcomes. They form the basis of the everyday application of innovation pedagogy, as they are enabled in the learning environments. (Kairisto-Mertanen et al., 2011; Kairisto-Mertanen et al., 2012; Keinänen & Kairisto-Mertanen, 2019.) First of all, the aim of the learning and teaching methods used in innovation pedagogy is to activate students. Activity-based learning consists of different processes of keeping students mentally and often physically engaged in their learning (Michael, 2006). According to Henrico (2012), activity-based learning methods not only enrich the contact sessions, but also improve students' chances to excel in the workplace. For example, based on previous literature, presented by Henrico (2012), Levine and Guy (2007), and Michael (2006), these methods have been shown to improve, for example, critical thinking, communication skills, argumentative, responsibility, and innovative abilities. Jeno (2015) also adds that the introduction of active learning in class not only leads to retaining and understanding knowledge but also increases engagement with learning (Jeno, 2015). In innovation pedagogy, learners are expected to actively construct knowledge and meaning from the situations they meet. According to Konst and Scheinin (2018), when students take responsibility for their learning and actively aim for reaching their learning goals, they will also become innovative and oriented towards various kinds of development tasks after their graduation.

However, traditional learning environments, such as classrooms, do not necessarily encourage engaged learning; finding answers and memorizing facts do little to inspire a passion to learn (Thomas & Brown, 2011). To achieve meaningful and deep learning, the focus should be on the learning from effortful practice and lived experience where students can revisit ideas, ponder them, try them out, play with them, and use them (Kettunen, 2011; Levine & Guy, 2007). Kivunja (2014) states that the key to teaching creativity and innovation skills lies in creating high-quality learning environments in which learners can solve authentic, real-world problems and be inquisitive and open-minded. Furthermore, Paul (2011) and Avvisati et al. (2013) have shown that participating in, for example, research projects as well as in project and problem-based learning during tertiary education has an effect on the ability to perform innovative activities later in working life. Therefore, in addition to the activating learning and teaching methods, working life orientation and integration of studies and RDI activities are also needed. These elements help ensure

that learning takes place in authentic, dynamic and changing learning environments through real-life situations, assignments and projects, together with working life partners, meeting the demands of working life. This way, it becomes possible to emphasize that the task of education is also to develop, renew and question the models of operation in working life.

To succeed in versatile RDI activities and working life operations, multidisciplinary faculties and operations crossing the faculty boundaries are also needed. Typically, customer needs are development tasks which cannot be solved by using the knowledge of a single discipline or degree programme. (Kettunen, 2013.) Similarly, in an innovation process, different types of knowledge and expertise are needed and used. Moreover, the modern globalized world faces issues and challenges which are becoming more and more difficult to address within the framework of a single method, discipline, or a profession. Therefore, the learning environments should also be multidisciplinary (Chung, 2011). In addition to a physical space, a learning environment is also virtual and social, enabling people with different talents and competences to interact with each other. This kind of "transdisciplinary collaboration can push knowledge development beyond the limits of conventional disciplinary borders" (Wall & Shankar, 2008; see also Hakkarainen, 2001). The participants' attitudes are significant for the effectiveness of boundary crossing collaboration. According to Wall and Shankar (2008), one of the crucial aspects of transdisciplinary training is the involvement of participants who are ready and willing to learn from other disciplines. This requires practising and facing complex multidisciplinary learning situation already during the studies. However, the possibility to study in multidisciplinary real-life projects requires flexibility from the curriculum. Thus, flexible curricula are one of the key elements in the implementation of innovation pedagogy. A flexible curriculum enables students to take various alternative learning paths. Flexibility in this context means that the curriculum can be reformulated and developed during the years of study and according to both the needs and motivation of each individual learner. When students' needs, interests and personal situation are taken into account in their individual study paths, curricula will become personally relevant and optimally challenging for students. This will not only make the learning process meaningful and motivating (Messman & Mulder, 2011) but also supports students' sense of ownership which is needed for successful learning (Hakkarainen, 2000). Sturing et al. (2011) also highlight that flexibility in curricula is essential if the aim is to fully realize competence-based education.

Promotion of entrepreneurship has been one of the aims of the Finnish higher education policy for a decade (Ministry of Education and Culture, Finland, 2015). Therefore, according to innovation pedagogy, education should also offer studies that promote entrepreneurial thinking or mind-set, as this is needed in working life regardless of the tasks or study field (see also Chung, 2011; Edwards-Schachter et al., 2015; OECD, 2015). Taatila and Down (2012) guide teachers to focus on developing skills related to innovation, risk-taking, pro-activeness, confrontation tolerance and networking when the aim is to improve students' entrepreneurial skills. Chang et al. (2018) also present, based on previous studies, that entrepreneurial learning environments fostering students' entrepreneurial traits and entrepreneurial mind-set are examples of how to produce more young successful entrepreneurs in future. Similarly, Bjornali and Støren (2012) recommend making general education programmes (not only those specialized in entrepreneurship education) more action-oriented, with greater emphasis on the development of entrepreneurial skills among students through project and problem-based learning in order to train entrepreneurial and competent innovation workers. In innovation pedagogy, entrepreneurship is supported by flexible curricula and integration with RDI activities (Kettunen, 2011). Additionally, influenced by globalization, education is moving towards greater mobility (Chung, 2011). The increased globalization and multiculturalization of the world and working life (Confederation of Finnish Industries, 2019) require students to acquire the ability to work in an international team with people from different disciplines and/or nationalities (Chung, 2011). This demands not only good language skills and but also cultural competence. In innovation pedagogy, the aim of internationalization in teaching and different pedagogical contexts is that students develop both professional and working life skills needed for acting and working in the global context.

However, implementing these kinds of pedagogical student-centred practices, as a result of which students are expected to achieve desired expertise and learn study field specific competences and innovation competences (Kairisto-Mertanen et al., 2012; Kettunen et al., 2013), requires changes not only at institutional level and in teaching culture but also in student's role as an active learner. Thus, learning in innovation pedagogy requires students to develop renewing study skills, which emphasizes students' self-regulatory skills and an active motivational set. According to Jeno (2015), autonomous and intrinsically motivated students are guided by interest, seeking optimal challenges, enjoyment, and importantly, choice. When behavior is regulated by the self, the student has internalized the behavior and made

it a part of their own value system, and consequently, regulation from teachers is not needed. This is an important point especially when creative, critical, and outside the box thinking is needed (Jeno, 2015). Previous innovation studies have also shown that from the individual factors, the person's motivation is one of the key elements in promoting innovation (Hero, et al., 2017; Quintana et al., 2016, 13).

However, Jeno (2015) also highlights that learning in higher education is not solely determined by students' personal motivation, but also by the extent to which teachers are able to support or hinder learning and motivation. He suggests that students who perceived their instructor as informative and autonomy-supportive not only became more flexibly adaptable to the course in question and performed at a higher level, but they also became more autonomously motivated throughout the course (Jeno, 2015). According to Hakkarainen (2000), in a successful learning process, students have ownership of their own learning. Practices that support and encourage learners to share their experiences will support the development of this sense of ownership. Therefore, instructors should pay special attention to facilitating not only inspiring but also positive and open learning atmospheres in their courses. For example, Bollinger (2014) shows that in order to be able to productively handle uncertainty and accompanying feelings during the research process of the bachelor thesis, students must feel safe enough. Virtanen and Tynjälä (2016) have also shown that a positive learning atmosphere during the course is one of the key factors in learning of generic skills. However, Alexander (2016) states that although individuals' motivations and affects are significant contributions to the development of expertise and important influencers in learning results, students' interest is an element often underestimated by educational planners.

2.4.3 Researching innovation competences

Although there are many theoretical articles and practical cases on how to implement innovation pedagogy in practice (e.g., Kairisto-Mertanen et al., 2012; Kettunen et al., 2013; Konst & Scheinin, 2018; Penttilä, 2016), less empirical studies or statistical analyses are published on how students are learning innovation competences and how these varied elements of learning environments or certain individual and environmental factors can be associated with the students' innovation competences. Moreover, in the light of previous studies, there still seems to be a lot to improve as regards research into the competences that can be taught and learnt to prepare

students for innovation-oriented action. This deficiency has been pointed out by many scholars saying, for instance, that such research is hard to find (Bjornali & Støren, 2012), it is scattered and poor in terms of the theoretical background (Edwards-Schachter et al., 2015, 28) or it is based only on a retrospective assessment of graduates (e.g., Avvisati et al., 2013; Bjornali & Støren, 2012; Paul, 2011; Vila et al., 2012).

Naturally, a number of attributes similar to those apt for innovation competences can be found in many generic skills or work roles. Many studies of students' generic or "soft" skills, e.g. critical thinking, problem-solving, and interaction and collaboration skills (e.g., Ballantine & MCour Larres, 2007; Virtanen & Tynjälä, 2016), and professional competences, such as competences of project managers (e.g. Kantola, Karwowski & Vanharanta, 2005; Bikfalvi et al., 2007; Chang, Kantola & Vaharanta, 2007; Chang et al., 2009; Makatsoris, 2009) and entrepreneurs (e.g. Achcaoucaou et al., 2012; Taatila & Down, 2012), have been conducted, but there are fewer and narrower approaches focusing only on innovation competences in the context of higher education (e.g. Chang, 2014; Edwards-Schachter et al., 2015; Hero, 2017; Hero, Lindfors & Taatila, 2017; Hu et al., 2016; Kasule et al., 2015; Konst & Jagiello-Rusilowski, 2017). In these previous studies, innovation competences have been defined narrowly and with inadequate variables, such as focusing only on creativity skills (Hu et al., 2016), measuring a competence of teachers (Kasule et al., 2015), researching the development of students' innovation competences from the perspective of teachers (Hero, 2017), or dealing with students' self-perceptions, not with their action or behaviour (Edwards-Schachter et al., 2015). Moreover, in these previous studies, approaches to learning environments are also limited; they focus only on specific learning activities, such as innovation tournaments (Hero, 2017; Konst & Jagiello-Rusilowski, 2017), examining only teaching techniques or innovative course implementation (Hu et al., 2016; Chang, 2014), or general perceptions of training or education (Edwards-Schachter et al., 2015).

Although there are some encouraging case studies on comprehensive competence models of student action or behaviour – including also innovation competences – in pedagogical contexts (such as Kantola et al., 2005; Bikfalvi et al., 2007; Chang et al., 2007; Chang et al., 2009; Makatsoris, 2009; Achcaoucaou et al., 2012), many of these studies are focused only on university students and based on limited samples. Moreover, a wide range of studies on other subjects of innovation already exist, dealing with e.g. innovation-based competence models, but focusing on organizations and

their employees (e.g. Bikfalvi et al., 2010; Suominen & Jussila, 2009). Therefore, valid comprehensive research frameworks are still scarce when it comes to student behaviour or action needed in different phases of innovation processes developed especially in educational contexts and based on innovation theories. Marin-Garcia et al. (2013, 6) have also shown that there is a research gap in academic literature related to a person's innovation competences, and how to measure and develop it. Moreover, Nielsen (2015) states that although understanding innovation competency is the first step in fostering innovative students as conceptualizations can both enhance and inhibit innovative behaviours, there still seems to be a niche for finding an operational list of assessment criteria concerning students' innovation skills that is highly contextualized in the teaching of the existing disciplines. He also adds that there is still disagreement over how to put into operation the concept in teaching and learning. Consequently, the purpose of this dissertation is to respond to the lack of research on the topic and bring a new insight to the field of higher education and innovation.

3 RESEARCH METHODOLOGIES

This chapter first presents the research aims and study process. Then it discusses the methodological considerations in the four studies presented in this dissertation, particularly the choices made concerning the research subject, methods, data collection and analyses, and discussion of reliability and validity of the research and ethical considerations.

3.1 Research aims and questions

The dissertation aims to respond to the lack of research on the topic of innovation competence and bring a new insight to the field of higher education and innovation. The purpose of the research is to present the valid operational lists of assessment criteria to measure students' innovation competences, test and evaluate them in practice, and examine how students learn these competences and what kind of learning environments support and associate with students' innovation competences in innovative learning environments at the course and degree levels. By focusing on students' innovation competences and researching innovative learning environments, it could be better understood how to develop more effective pedagogical practises, and thus respond to the demands of working life. Through studying these approaches, important information concerning how the chosen pedagogical strategy, innovation pedagogy, is revealed from students' perspectives is also gained. Overall, the study not only combines two considerable topics: studies on learning environments and innovation competences, but also approaches both themes from a more versatile perspective. Consequently, the study positions itself as an expansion of our knowledge of the phenomenon in a new context.

Moreover, the study also links into the long-term educational development work through three different RDI projects funded by the European Union (described in the section 3.3.). Thus, these RDI projects bring an interesting nuance of practical and applied aspects on the scientific research and also indicates the importance of

the current research interest in the European policy level of higher education. The research process is described in Figure 4.

CASE-STUDY CONTEXT
FEATURES FROM PRACTICE-ORIENTED, EVALUATION AND ACTION RESEARCHES

STUDY 1: Testing and developing the instrument to measure innovation competences

STUDY 2: Testing and evaluating the further developed instrument to measure innovation competences

STUDY 2 & 3: Pilot studies

STUDY 4:

GROUP 1: More study experience from learning environments based on innovation pedagogy

GROUP 2: Less study experience from learning environments based on innovation pedagogy

Researching students' innovation competences in the context of higher education

Figure 4. The research aims as a study process.

The main research questions of the study are the following:

1. What are innovation competences and how can they be measured in higher education?

2. How does the developed instrument to measure students' innovation competences function in authentic pedagogical practices from the perspective of students?

3. Do innovative learning environments with university–company cooperation support the development of students' innovation competences?

4. What kind of individual and environmental factors are related to the learning of innovation competences?

5. Is there a difference in students' innovation competences and in their study experience of varied elements of learning environments built according to innovation pedagogy?

The more specific questions related to the individual case studies can be found in Figure 5.

3.2 Methodology

This dissertation is positioned at the intersection of innovation research, higher educational studies and research on learning environments. Consequently, it could be considered as a cross-thematic research, which is grounded on case-study methodology and conducted with mixed methods utilizing theory triangulation. The study also applies some features around the assumptions of practice-oriented, evaluation and action research strategies, albeit it is not purely grounded on these theories. On the other hand, based on some classifications, these strategies can also be considered under the case-study approach, or even the other way around. Therefore, a case-study approach is not a clear, constant or unchanged research strategy (Eriksson & Koistinen, 2005). From the wider perspective, the study approach is settled on epistemology of pragmatism, which stresses the practical nature of knowledge. Pragmatism shows not only in the research strategies but also in the study context and in the three RDI projects related to this dissertation and its basis. Additionally, pragmatism has a strong basis in innovation pedagogy from theoretical, developmental, and practical aspects.

Pragmatism includes various orientations, but common for all these orientations is that they all emphasize the meaning of action and practice-oriented approach when doing research, solving problems, and producing knowledge. Pragmatism is based on the assumption that all human thinking, scientific knowledge formation, truth, learning and social interaction, should be approached from the perspectives of practice and action. Because action in the practices and every day experiences

form the entire basis for knowledge formation, they are also the ultimate and main principles for scientific research. (Siljander, 2016, 176.) Pragmatism highlights that thinking has to be put in the part of action, and ideas and concepts have to be set on work including human experiences, in order to receive their real pragmatic meaning (Pihlström, 2007, 158). Thus, there is a cycle of interaction between the actor and its social, cultural and natural environment. It could be seen as a common unity, in which different elements are constantly in active and adaptive interaction, finding balance there. In this process, an individual not only adapts to the environment but also adjusts the environment for its own purposes. The actor is always inseparable from its operational environment. Consequently, in the research, the research subject should not be seen separately from the researcher, or the researcher is unable to get "objective" information on the research subject. Similarly, the validity of research or produced knowledge links to the action. Validity has always to be evaluated with its relation to the action. Thus, scientific theories are just instruments or tools to structure experiences or solve problems, and their validity ("truth") is based on how functional and profitable they finally are. (Siljander, 2016, 176–180.) Nooteboom (2012, 19) states that "questions of truth lead always to questions of workability". Moreover, in pragmatism, knowledge and understanding are accepted to be cultural and contextual, but also imperfect, uncertain and fluid. The pragmatic theory of research is essentially centred on emphasizing human fallibility (fallibilism). According to it, we never have unmistakable, infallible information available; any of our beliefs may turn out to be ineffective and require the correction of new research. Knowledge itself is constantly evolving and uncompleted. (Pihlström, 2007, 151.) Thus, some views state that pragmatism has been seen as a kind of philosophy of creativity and innovation (Nooteboom, 2012; Paavola & Hakkarainen, 2008, Pihlström, 2007, 158–159). Furthermore, many pedagogical development projects and applications are based on it (Siljander, 2016, 181), such as innovation pedagogy and the three RDI projects in this study.

Some concrete examples demonstrating pragmatism in research practices are the strategies or orientations called case-study research, practice-oriented research, evaluation research and action research. The case-study research design is especially useful for trying to test theoretical models by using them in real-world situations. Consequently, the data is collected in a natural setting and context. It is also described as a method used to narrow down a very broad field of research into one easily researchable topic. In that case, it will not answer a question completely, but

it will give some indications and allow further elaboration and hypothesis creation on a subject. In order to draw an obvious picture of case studies, qualitative or quantitative evidences can be used, which all end by their perspectives of cases. Moreover, it is recommended that when one needs to research the effectiveness of a programme, a case study is one of the most appropriate methods to explore it in depth. (Alnaim, 2015; Eriksson & Koistinen, 2005.) In this dissertation study, a case-study research functions as a bounded context, in which the selected university of applied sciences and its pedagogical strategy create a specific framework for its actors in their natural environment (in this case for higher educational students). Instead, practice-oriented, evaluation and action research strategies provide versatile but narrower aspects or views to approach the research case.

Hermans and Schoeman (2015) state that the strength of the practice-oriented research strategy is to develop knowledge about the improvement of practices. Practice-oriented research is a research strategy in which the goal of study is coming from the professional practice and in which the knowledge created in the study contributes directly to this professional practice (Hermans & Schoeman, 2015). Equally, in the core of the evaluation study, the aim is also to provide means to judge actions and activities in terms of values, criteria and standards for a given situation. Evaluation research judges the impact of social interventions, such as new treatment methods or innovations in services. In that case, it (its evaluation criteria) is always value-bound and distinguishes the evaluation from other research. Moreover, the difference compared to research in general, is that the aim of evaluation is to examine how effectively existing knowledge is used in practice rather than to provide new knowledge. When research seeks to prove, evaluation seeks to improve. (Anttila, 2007, 15–16; Dahlberg & McCaig, 2010, 16.) Consequently, at the same time, evaluation is also a practice that is intended to have some real-world effect by seeking to enhance effectiveness in the public sphere and policymaking. It aims to produce for the drawing up of justifiable conclusions and developing recommendations a sufficient amount of information which is high-quality enough to support management and decision-making. Thus, it also forms a mirror of practices to concrete actors. (Anttila, 2007; Jokinen, 2017.) Similarly, the main purpose of action research is also to develop and improve practices. It not only focuses on studying the action but also tries to change prevailing practices.

Furthermore, other similarities with the key features of these research approaches are engagement to the context, intensive cooperation and active action together with

the research objects. For example, according to Hermans and Schoeman (2015), in the expert model of practice-oriented research, the researcher also has the role of expert, for example someone with a great deal of knowledge on the subject related to the problem and problem solution. The researcher needs to have not only knowledge of the research methodology, but also knowledge of the practice and process as a change agent in organizations. The special role of a researcher is also highlighted in action research, where a researcher is actively involved in the actions of the research subject in the whole study process (McNiff & Whitehead, 2001; Taylor, Baser & Wilkie, 2006). On the other hand, the key elements of action research can also be seen as a framework to describe the whole dissertation study as a learning process for a researcher. McNiff and Whitehead (2001, 203–214) present that the key elements of action research are: 1. the researcher is central to the process; 2. the researcher is learning first about him/herself in order to change a social situation; 3. the researcher is not aiming for closure but ongoing development; 4. the process is participative; and 5. the process is educational. They highlight that action researchers show the process of the growth of their own understanding, and how this has a potential beneficial influence in the lives of others, in this case especially the researched organization.

Overall, all these research approaches can be seen as intertwined, and thus supplement to the wholeness of the dissertation research. For example, the action research approach gives support for approaching a researcher's role and participation in the dissertation, the organization being studied, and the integrated RDI projects. On the other hand, it can also be used to approach the dissertation as a learning process. Practice-oriented research, instead, can be applied to solving problems of pedagogical practices, such as, in this study, the need for a valid assessment tool to measure students' innovative behaviour in educational contexts. The evaluation research approach, in its turn, can help in judging the impact of social interventions, e.g., effectiveness of innovative learning environments or revealing of pedagogical strategy, innovation pedagogy. Furthermore, the methodology of these research approaches also typically frames different kinds of RDI projects or activities (e.g., Anttila, 2007). Hence, it has naturally mirrored in this dissertation through the integration of the three RDI projects. Despite the fact that here the research approaches are described quite modestly, the researcher is aware of that inside of these methodologies there is a long history and traditions, which include versatile trends and research strategies (e.g., Pihlström, 2007; Anttila, 2007; Eriksson & Koistinen, 2005; Jokinen, 2017; McNiff & Whitehead, 2001).

3.3 Research context, data and methods

In order to research students' innovation competences in higher education with a case-study approach, one higher education institution was selected as the research subject. This certain institution was chosen, because there innovation competences have been set as intended learning outcomes for all students, notwithstanding their study fields, but based on their pedagogical strategy. Moreover, the said university of applied sciences has actively and crucially been part of several national and international research and development projects, and diverse pedagogical activities concerning students' innovation competence development during several years. In addition, focusing only on one university of applied sciences is a reasonable choice because in Finland every university of applied sciences prepares their own pedagogical strategy as an autonomous player and from their own basis. Therefore, pedagogical models and choices can be varying, and thus comparing is difficult (Raudaskoski, 2000, 43–44). Neuvonen-Rauhanen (2016, 59) also notes that because Finnish universities of applied sciences seem to differ from each other, studies related to them have mainly been implemented as case studies.

Although the selected research context stayed the same during the whole study process, the four independent studies approached the subject from different perspectives, whereupon the target groups, data and methods of studies differed (Figure 5). All the data of the studies have been collected during the years 2013–2017. The first study relies on quantitative data of students' self-assessments. In addition to the selected research institution, it also covers a wider sampling from three other Finnish universities of applied sciences. In the three following studies the data has instead been collected from the selected research institution. The second study uses data of students' group interviews and self-assessment inquiries collected from one faculty and from three specific innovative courses based on innovation pedagogy. In here, the quantitative data is divided in two parts, and the third study concentrates on analysing the other part of the self-assessment inquiries. The final, fourth study approaches the topic from a wider perspective, focusing on individual study paths in the degree level. The data is based on students' self-assessment inquiries, but it is collected from different faculties from the selected institution. The research data and four independent studies can also be seen as a cumulative process, where a previous study gives support and evidence to continue to the next phases and studies. In

subsections 3.3.1–3.3.4, the study objects, data and used methods in each study are presented in more detail.

Researching students' innovation competences in higher education

STUDY I

Large data set (n 495) – institutional level

Focusing on research question 1

Aim:

To develop an instrument measuring students' innovation competences in Finnish higher education context

Specific research question:

1. How the tool measuring students' innovation competences functions in the authentic learning environments of Finnish higher education institutions?

2. How to develop the tool further?

Questionnaire,

Quantitative methods

STUDY II

Pilot study (n 69 + approx. n 30) – course level

Focusing on research questions 2 and 3

Aim:

To test and evaluate the further developed instrument to research students' innovation competences in authentic learning environments and examine whether these kinds of environments support the development of students' innovation competences

Specific research question:

1. How the novel innovation competence assessment tool functions in authentic pedagogical practices from the perspective of students?

2. Whether the innovative learning environments of university–company cooperation support the development of students' innovation competences?

Questionnaire & Semi-structured interviews,

Quantitative methods & Thematic analysis

STUDY III

Pilot study (n 77) – course level

Focusing on research question 4

Aim:

To research students' learning of innovation competences from a deeper perspective concerning certain individual and environmental factors

Specific research question:

1. What kinds of innovation competences do students learn during their courses?

2. Are there different groups of students based on their learning of innovation competences?

3. Are gender, study year, work experience, course, motivation, importance of learning, atmosphere of the course, learning of field-specific contents, project-based learning preference, and support and guidance related to the learning of innovation competences in different groups?

Questionnaire,

Quantitative methods

STUDY IV

Large data set (n 236) – degree level

Focusing on research question 5

Aim:

To research different student profiles concerning their level of innovation competences and on their study experience of learning environments in the degree level

Specific research question:

1. What is the level of innovation competences of third and fourth-year bachelor students? Are there different groups of students based on their level of innovation competences?

2. Are there differences between different groups of students concerning their study experience of all the six elements of learning environments built according to innovation pedagogy?

3. How is innovation pedagogy revealed from students' perspectives during their studies based on the six elements of learning environments?

Questionnaire,

Quantitative methods

INCODE (2011–2013)

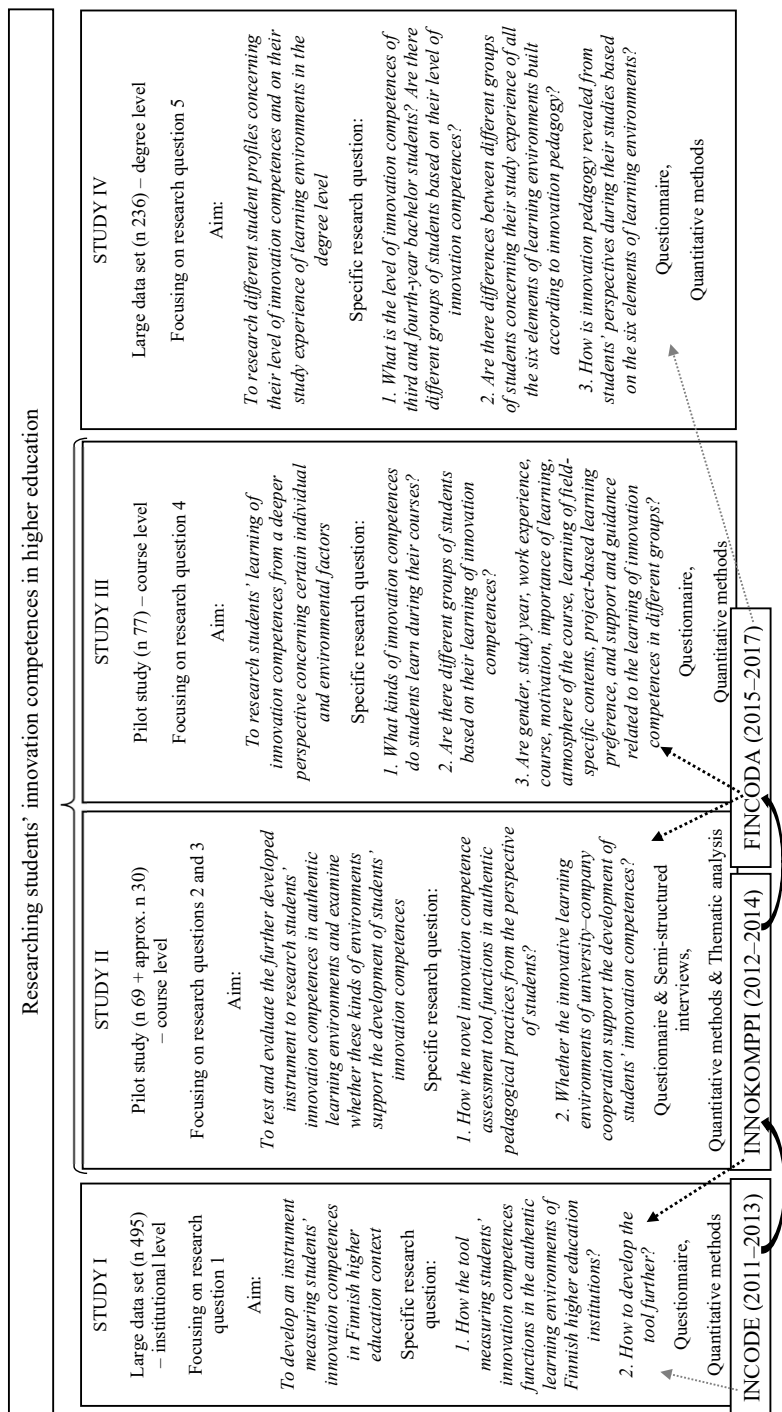INNOKOMPPI (2012–2014)

FINCODA (2015–2017)

Figure 5. Overview of the independent empirical studies

Moreover, some part of the data has been part of three international and national RDI projects, funded by the European Union.

INCODE: Innovation Competencies Development 2011–2013

The goal of the INCODE project was to embed pedagogical knowledge in innovation activities to offer a long-desired theoretical basis for developing knowledge-based competitiveness in the co-operation between working life and education. INCODE aimed to get valid information about different research and design related competencies and how these innovation competencies can be reached. For these reasons, the project developed and implemented a special higher education tool, the ICB (Innovation Competencies Barometer) and a special kind of learning method, the REHA (Research Hatchery). The project consortium was formed of four higher education institutions from four European countries. The project was funded by the Lifelong Learning Programme of the European Union. More information can be found at: http://www.incode-eu.eu/en/

INNOKOMPPI: Innovaatiokompetenssien mittaaminen 2012–2014 (Measuring innovation competences, translated by author)

The INNOKOMPPI project was based on the results of the INCODE project and continued the testing and redevelopment of an assessment tool to measure students' innovation competences, but now only in the Finnish higher education context. In this project, four different kinds of universities of applied sciences from various locations in Finland and one Finnish university worked together. The project was funded by the European Social Fund. More information can be found at: http://innokomppi.turkuamk.fi/

FINCODA: Framework for Innovation Competencies Development and Assessment 2014–2017

The FINCODA project was aimed at developing a novel innovation competences assessment tool by utilizing the existing innovation competences barometers that have been researched and developed since 2011. The project expanded the use of this barometer into companies and increased the knowledge of behaviour-based assessment in universities and enterprises. In this project, five universities of applied sciences and nine innovation-intensive companies from five countries from various locations in Europe engaged in university–company cooperation. The project

aimed at cooperating for innovation and the exchange of good practices, improving the quality and efficiency of education, and training and enhancing creativity and innovation. The project also suggested ways to create a solid path for future innovators from higher education institutions to companies. The project was funded by the Erasmus + Programme of the European Union. More information can be found at: https://www.fincoda.eu/

3.3.1 Study I

The aim of the first study was to test and evaluate the functioning of the earlier developed three-dimension model instrument to measure students' innovation competences (Marin-Garcia et al., 2013; Pérez-Peñalver, Aznar-Mas & Watts, 2012; Watts et al., 2012) in the authentic learning environments of four Finnish universities of applied sciences. Because the study linked to the larger RDI project, called INNOKOMPPI, certain choices had to be made concerning the data collection and selection. Thus, in this study, the data were collected from higher-education students of courses that applied constructivist and student-centred approaches to learning with activity-based teaching methods. As such, it was presupposed that these students, based on their pedagogical understanding and experience, can also assess their innovation competences at the end of the courses. Consequently, the electronic self-assessment questionnaire was distributed to students (n=495) from four Finnish universities of applied sciences at the end of the semester in 2013. The students came from different study fields and study years. The questionnaire consisted of 25 statements, in which the respondents could assess their own innovation competence on a 5-point scale: 1= none, 2 = poor, 3 = moderate, 4 = good, 5 = excellent, based on the earlier developed instrument (Marin-Garcia et al., 2013; Pérez-Peñalver et al., 2012; Watts et al., 2012). In addition, there was the option, 'I can't say'. Because this option does not lend itself to determining the reliability of the instrument, such answers were excluded from the reliability value calculations and factor analyses. The questionnaire also included some background questions on the respondents' gender, study year, study field, and work experience.

A confirmatory factor model was used in order to test how the three dimensional-model is fitting to the data. In this method, the questionnaire statements with their respective loadings were forced into three predefined factors (individual, interpersonal, and networking) according to the earlier construction validation

study. After that, the performance of the instrument was evaluated by *factor-analytic methods*. Although the confirmatory factor analysis was the principal approach, some *exploratory analyses* were also conducted, especially when looking for hints on how to improve the fit of the originally postulated factor model. The statistical calculations were carried out using *the CALIS and FACTOR procedures of the SAS® 9.4 software*. The goodness of fit of the confirmatory factor models were assessed by several well-known measures: *goodness-of-fit index GFI* (Jöreskog & Sörbom, 1989); *adjusted goodness-of-fit index AGFI* (Mulaik et al., 1989); and particularly, *comparative fit index CFI* (Bentler, 1995), *standardized root mean square residual SRMR* and *root mean square error approximation RMSEA* (Steiger & Lind, 1980).

3.3.2 Study II

The aim of the second study was to respond to the lacks of the first study, and test and evaluate the further developed instrument (Pérez-Penalver et al. 2018; Butter & van Beest, 2017; Marin-Garcia et al., 2016) to research students' innovation competences in authentic learning environments. The used instrument in this study covers the lacks and limitations of earlier studies of innovation competence assessment (e.g. Marin-Garcia et al., 2013; Keinänen et al., 2018; Pérez-Peñalver et al., 2012; Watts et al., 2012) which were only based on the higher educational context and data of students´ self-assessments. The psychometric properties of the assessments were not explicitly addressed, either. Instead, the novel instrument is based on a literature review and a psychometric validation with mixed-method design including construct validity and criterion validity studies (Pérez-Penalver et al. 2018; Butter & van Beest, 2017; Marin-Garcia et al., 2016).

Before students' innovation competences can be addressed, first students' understandings of these concepts must be considered, and determine how these competences are contextualized in authentic educational environments. Therefore, the specific aim of the second study was to test the novel instrument in a specific pedagogical context in university–company cooperation and demonstrate how it functions in authentic learning environments from the perspectives of students. This study approaches the topic from a qualitative side in order to deepen the understanding of the topic and better reflect the quantitative results of students' self-assessments. Moreover, this study applied the instrument in the new innovative pedagogical context and studies whether these kinds of learning environments in

university–company cooperation support the development of students' innovation competences in the course level. The second study also acted as a pilot study in order to confirm the preliminary hypothesis related to the further studies.

In this second study, students of one Finnish university of applied sciences were selected from three mandatory undergraduate courses (15 ECTS). The students (n=69) were from different engineering degree programmes and study years. Most of the respondents were second-year students, 53.60% (n=37), and third-year students, 31.90% (n=22); the rest, 14.40% (n=10), were first- and fourth-year students. Most of the respondents were male, 82.60% (n=57), and 17.40% (n=12) were female. The criteria for the selected courses were that all the courses are mirroring elements of an authentic innovation process, similar in extension, carried out in university–company cooperation during the autumn semester of 2016, and implemented by different lecturers. The framework for all courses was innovation pedagogy. Although the courses differed in their content, the studying was based on activity-based learning methods, where students worked with authentic problem-based assignments, and innovated solutions for the companies. The contact lessons combined e.g. theory, working with the assignments, learning in teams and different active learning methods that supported the performing of the development assignment.

The study was conducted with mixed methods, where quantitative data was based on inquiries and qualitative data on interviews. The quantitative data was collected in two phases: at the beginning (N=87) of the course and at the end (N=77) of it. In the pre-assessment, the students assessed their level of innovation competences and in the final assessment, the students assessed their learning of innovation competences during the course. Although there were differences in the instructions (and it was acknowledged that it might set certain conditions for the results), the instrument, its items, and the scale were the same in the both assessment times. This supported, with the consistent results of the interview data, the final decision to compare the assessments in the two conditions. In the inquiries, students assessed their innovation competences with 34 items on a 5-point scale: 1 = Very poor, 2 = Need to improve, 3 = Pass, 4 = Good and 5 = Excellent. In the final assessment, in addition to the 34 items of the instrument, there were also some background questions in the inquiry (for example, gender, study year, and work experience). In the quantitative analysis, only those students who completed both the pre- and final assessments were taken along (n=69). Based on the previous psychometric validation work of the FINCODA project (Butter & van Beest, 2017), the five *sum*

scales were created of the 34 items on innovation competence (creativity, initiative, critical thinking, teamwork, and networking). The FINCODA scales were ensured to be reliable based on their values of the *Cronbach's alphas*. However, because of the small size of collected data, a confirmatory factor model cannot be fitted to the data to test the statistical validation of the instrument. Instead, in order to research the difference between the pre- and final assessments, *paired samples t-tests* were used to compare two dependent samples with five scales.

In addition to quantitative self-assessment data, qualitative data was collected. At the halfway point of the course, one of the student groups (in total, 12 teams) was chosen for an interview. The sample was chosen through purposive sampling. Approximately 30 students from nine teams (three teams were absent) were divided in three interview groups. One interviewer had students from at least two teams and approximately eight to ten interviewees in a group. A *group interview* was selected as the method because it is a practical and effective method to collect information, and it supports the interviewees to be more natural and unconstrained when there are more persons present (Hirsjärvi & Hurme, 2008, 61–63). The aim of the interviews was to gather qualitative information about the function of the instrument, the development of students' innovation competences in order to complement the picture arising from the quantitative score differences, and to enhance understanding of the learning process of innovation competence. The questions and items were sent to the students before the interviews. The interviewers discussed chosen items of innovation competences with the students (three to four items per student team). In the interviews, students were asked how they understand these competences, if these competences have been brought up in their development assignments with companies, what kind of importance competences such as these would have in their future profession or working life in general, what kind of meaning these competences have at the moment concerning students' studies, and if they see any connections between these competences and innovations. Items 19–21 and 28–30 were not discussed in as much detail as the other chosen items, because three of the teams were absent from the group interviews. Although there were items chosen as focuses in the discussions, in some parts of the interviews the students also discussed all innovation competences in general, not only the chosen items. The students were also able to see the whole list of items during the discussions. All the interviews were recorded, transcribed and analysed with a *thematic analysis method*.

3.3.3 Study III

Similarly, the third study can also be considered as a so-called pilot study. It was aimed to focus on examining students' perceptions of learning innovation competences in innovative learning environments in university–company cooperation in the course level, and to study whether there are differences in students' learning and what kind of factors are associated with the acquisition of innovation competences. The third study used a part of the data from the second study, but it focused on analysing the data which was collected at the end of the courses (n=77). In this study, at the end of the innovative courses in university–company cooperation, students completed a self-assessment questionnaire with 34 items of innovation competence (creativity, initiative, critical thinking, teamwork, and networking). Respondents assessed their learning of innovation competences during the course on a 5-point scale: 1 = Very poor, 2 = Need to improve, 3 = Pass, 4 = Good, and 5 = Excellent. Additionally, the questionnaire includes categorical variables of gender, study year, work experience and course. Moreover, it comprises single variables of motivation, importance of learning, atmosphere of the course, learning of field-specific contents, project-based learning preference, and support and guidance. The single variables were scored along a 5-point Likert scale, where 1 = Completely disagree and 5 = Completely agree.

Because of the small size of the collected data, a confirmatory factor model cannot be fitted to the data to test the statistical validation of the instrument. However, based on the previous psychometric validation work of the FINCODA project (Butter & van Beest, 2017), the five *sum scales* were created of the 34 items on innovation competences to show sufficient reliability of the assessment tool. The FINCODA scales were ensured to be reliable based on their values of the *Cronbach's alphas*. After that, *K-means cluster analysis* was conducted to explore different groups of students based on their learning of the five innovation competences. The aim of cluster analysis is grouping a set of objects in such a way that objects in the same group, called a cluster, are more similar to each other than to those in other groups, or clusters (Nummenmaa, 2006). In order to examine these groups in more detail, *Independent samples t-tests* and *Chi-Square analysis* were used to explore different variables' association to students' perception of learning innovation competences.

3.3.4 Study IV

The results and evidence based on the previous studies strengthen the hypotheses that innovation competences can be learnt during courses in the learning environments based on innovation pedagogy, and students are able to understand and recognize these competences in parts of their studies. Consequently, the aim of the final study was to examine whether learning environments built according to innovation pedagogy can be associated with students' innovation competences in the degree level. This study focused on examining whether there are different student profiles concerning their level of innovation competences and how these students differ based on their study experience of varying learning environments. Through studying these approaches, important information was also gained about how the chosen pedagogical strategy is revealed from students' perspectives during their studies.

In this fourth study, the data were collected from different faculties from the selected Finnish university of applied sciences by inquiring only third- and fourth-year bachelor students who are expected to be close to graduation. It was presupposed that these students, based on their pedagogical understanding and experience, can widely approach their study experiences and also assess their innovation competences. Consequently, the electronic self-assessment questionnaire was distributed to students (n=236) at the end of the spring semester in 2017. Students came from four different study fields: 11.4% (n=27) from culture; 14% (n=33) social sciences, business and administration; 35.2% (n=83) from social services, health and sports; and 39.4% (n=93) from technology, communications and transport; and represented 17 different degree programmes. Most of the respondents were female, 61.4% (n=145), and 37.7% (n=89) were male. Third-year students composed 67.8% (n=160) of the respondents and fourth year students 32.2% (n=76). The quantitative data was collected with the same instrument as in the second and third studies. In addition to the 34 operationalized items of innovation competence, the questionnaire also included some background questions, e.g., on the respondents' gender, study field, and work experience, and several questions of students' studying, motivation and learning environments concerning their 3–4 study years. These questions were scored along a 5-point scale, where 1 = Not at all and 5 =Very much. There was also the option 'I can't say', which was excluded from the final analyses.

Before statistical analysis, a *confirmatory factor model* was used to test the validation of the assessment tool for the collected data. The test showed that the data forms a functional model (demonstrated in Figure 6) based on the earlier validation study (Butter & van Beest, 2017), and only one item (item number 27) from the teamwork dimension was removed from the model. After that, five sum scales were created of the 33 variables on innovation competence. The *sum scales* were ensured to be reliable based on their values of the *Cronbach's alphas*. Moreover, on the basis of the theoretical premises of Kairisto-Mertanen et al. (2011), variables describing learning environments were selected, and created either as sum scales or were used as a single variable to measure the six cornerstones of innovation pedagogy. In order to explore different profiles of students based on their level of the five innovation competences, *K-means cluster analysis* was conducted. In the follow-up phase of the study, nonparametric *Mann-Whitney's U-tests* were used to compare these student groups concerning their study experience of innovation pedagogy based on the six elements of learning environments (cornerstones). In addition, the *effect size* of student groups' means were calculated in order to ascertain the intensity of associations, based on Cohen's (1988) standards.

Figure 6. Validation results of innovation competence instrument based a confirmatory factor model.

3.4 Reliability and validity

The previous section described the data and methods used in the four independent sub-studies, but more important questions regarding reliability and validity are: whether the data and methods measured what was intended, how well they measured what was intended, and whether the conclusions drawn from the results were valid. This section focuses on reflection on these questions. First, it evaluates the study design and then moves to consider questions regarding quantitative and qualitative data and the used methods.

Overall, the research design varied from the original plan and it took shape during the process. The room left for this enabled a fluid process and cooperation with the varying RDI projects, instead of a systematic or exact study plan. In this way, it renders a process-driven approach in the research design and with the four independent studies. Hence, the study design progressed study by study, and article by article, in which all the studies can be seen as a cumulative process, where a previous study not only gave support and evidence to continue further but also clarified for the next phases and research questions. According to Lempinen (2018, 45–46), this kind of process-driven approach can be seen increasing the validity of research because it is not locked on a straight approach and it allows for innovation. In this approach, one builds on one's knowledge, rather than from the knowledge that was at the beginning of the plan. However, there are certain issues in the process-driven study approach. For example, Lempinen (2018, 45–46) reminds that this type of working method could lead to chaos with no linkage between the articles. On the other hand, Eriksson and Koistinen (2005, 28) highlight that especially in an intensive case-study approach, that kind of disorder and unpredestination can be a natural part of the research process. In this dissertation research, following consistently the themes of students' perceptions of innovation competences, applicability of results and practical-oriented research supported to construct a coherent unity and facilitated to avoid chaos and inconsistence. Naturally, instead of using process-driven and cumulative process as a frame for study design, there could have been several alternative designs, but they would have required a more systematic strategy. For example, the students could have been followed throughout their four- or three-year study period, and thus deepen their development of innovation competences and study path in more detail. Moreover, with a longitudinal study, the students could have been followed throughout their study path, graduation and occupation.

However, it is part of researching that the researcher has to make choices constantly in the process, and these optional designs are important views for further studies.

The instruments used to measure students' innovation competences have an essential role concerning the reliability and validity issues of this dissertation. Here, both instruments were based on a long-term research and development work conducted in multi-expert consortiums, where reliability and validity have been taken into account in several validation studies (e.g., Marin-Garcia et al., 2013; Pérez-Peñalver et al., 2012; Watts et al., 2012; Pérez-Penalver et al., 2018; Butter & van Beest, 2017; Marin-Garcia et al., 2016) and they have also been supported in different project activities (such as in different pilots and workshops). Thus, in both instruments not only the scientific validity but also the practical validity were considered. These both aspects are also the key elements in methodologies of case study, practice-oriented, evaluation, and action researches. Moreover, in this dissertation study, the reliability and validity of instruments were also readdressed in both qualitative and quantitative data. For example, before statistical analysis, confirmatory factor models were used to test the validation of the assessment tool for the collected data, or with smaller data the Cronbach's alpha were established to be sufficient. In qualitative data, the function of instrument was part of the research design.

Reliability and validity of the studies were considered also in the instructions or questions of inquiries and interviews. Here, for example with the qualitative data, the interview questions were planned together with one of the responsible instructors of students, who verified the appropriateness of the questions for this specific population. The questions were sent to the students before the interviews and at the end of the interviews, students had possibilities to complete their answers. In the data collection, researcher triangulation was used. Although three different persons implemented the interviews, the results were consistent which, thus, supports the objectivity of data collection (Eriksson & Koistinen, 2005, 51). Researcher triangulation was also used when preparing the quantitative data collection. There, the questionnaires were designed in cooperation with educational experts or their work was utilized in the planning of the questions or operationalization of the research subjects. Furthermore, in the exhaustive questionnaire used in study 4, some terms that could have required further explanation (such as RDI integration, flexible curriculum and multidisciplinary learning environments) were opened in the text, and the whole inquiry was pretested with students from different study fields before the particular study. All these procedures helped to identify difficult

terminologies and correct other misunderstandings in the questionnaires. However, in study 2, there were some differences in the instructions and the researcher fully acknowledges that this might have set certain issues for the analysis and especially the conclusion from the perspective of validity. Furthermore, the problematic nature of the concepts used in the dissertation and the challenges and risks surrounding them (e.g., concepts can be lost in translations) were also understood.

Equally, the credibility of the study could be referred to how well the data and the chosen analysis methods addressed the research focus. In here, triangulation of data and methods were used to secure that the results of the studies are constant or parallel and not dependent on one methodology (Eriksson & Koistinen, 2005, 51). With quantitative methods, in particular, statistically significant numbers had to be considered. As mentioned in the previous section, different kind of statistical analyses were used. All these analyses were conducted by the requirements related to them and the results were interpreted at a significance level of certain method (such as, the p-value or the effect size). Moreover, the data was saved, cleaned and analysed with care in order to avoid mistakes. The same procedure was also used with the interview data. To show the significance of thematic analysis method the authentic quotations were used. With these quotations the authentic voices of informants were also preserved.

As a whole, researcher is aware that these data and methods reflect students' perceptions of their innovation competences, and do not purely indicate participants' innovative behaviour itself. Albeit, the previous validation study (Butter & van Beest, 2017) shows that there are hints of reasonable correlations between the self-assessment scores, assessment by third person (supervisor-assessments), and qualitative stories on innovation evaluated by the STAR method. However, the possibility that some uncontrolled-for events during research were responsible for its outcome (the so called Hawthorne effect) also exists. For example, the special attention subjects receive from their observers and lectures or the novelty or the unique features of the experimental activity may effect subjects' behavior, or individuals may modify an aspect of their behavior as a response to their awareness of being observed or studied (Adair, Sharpe, & Huynh, 1989). In this study, the innovative study modules in cooperation with companies or the new assessment criteria in those modules may have led to a defective assessment regarding students' behaviour, such as seeking of social desirability, and thus, the sustainability or authenticity of their competences remains unexplained. Similarly, students' assessments of their innovation competences may be biased because of their awareness of the institution's pedagogical strategy and

its aims. Although this dissertation is based on various data sets, it cannot provide evidence of the existence of these possible underlying mechanisms for students' assessments. On the other hand, this kind of dilemma is always connected to the discussion of validity, especially in human sciences. Therefore, overall, it is important that the researcher is aware of the possible hinders of this kind and will also take them into account especially when drawing conclusions and considerations of the study. However, even though the validity of self-assessment is contested, numerous advantages also support the use of self-reports; for instance, people have more accurate or higher quality information about themselves (e.g., Paulhus & Vazire, 2007, 226–229).

Similarly, reliability and validity play an important role when drawing conclusion from the analysed results. The reliability of the results can be discussed from the perspective of who answered the questions and how they did so. Because of the case-study settings and mainly used a purposeful sampling, there should be cautiously with the results, especially related to their generalization or transferability. On the other hand, these choices are appropriate when aiming to contact participants who possess the needed information (Tuomi & Sarajärvi, 2018, 99), which they did, especially when the data was collected from part of certain courses, in particularly, in the pilot studies, study 2 and 3. However, some data collected via email, where instructors were also used to help contact the students from the selected study fields. In these cases, an issue concerning who answered the questionnaire should be considered, because it is known that only some people tend to answer questionnaires. Yin (2014) encourages case-study researchers to use multiple sources rather than using individual sources of evidence or cases in order to provide stronger results, and avoid some fears of having suspect causes of choosing that specific cases. Hermans and Schoeman (2015) remind that in action research there can be a biased, selective observation of the situation or action. They also state that the blur roles of researcher, research objects, and problem owner in practice-oriented research can be a challenge. Jokinen (2017) calls issues of causality of the factors, interaction between mechanism of action and the context, and the role of researcher, as wicked problems in evaluation research. According to him, these issues cannot necessarily be solved completely, but we can deal with them, when we are accepting their existence in this kind of social research context. (Jokinen, 2017). Despite of possible biases of researcher's role, overall in this study the researcher's role in the researched organization as a trainer, developer and researcher, secures the needed

"in-depth understanding of the case" and renders to receive many different types of information. Thus, the researcher's expertise on research subject could be seen as an essential resource to conduct not only reliable and valid research but also improve effectiveness of research on practices (see also Hermans & Schoeman, 2015).

3.5 Ethical considerations

Research ethic is a crucial part of the whole research process and it continuously guides every action and choices of researcher, from the research idea, to the planning and conducting and finally publishing the results. Naturally, ethical demands go also hand in hand with the credibility of the research, which is already described above. In generally speaking, research ethic can be defined as a good scientific practice which is used in the whole study process. That means general agreed rules according to colleagues, object of the study, funding or clients and big audience. For example, the Finnish Advisory Board on Research Integrity (2012) defines that a responsible research should follow the principles that are endorsed by the research community, that is integrity, meticulousness, and accuracy in conducting research, and recording, presenting, and evaluating the research results. This requires that research is planned, implemented, and reported qualitatively. It also requires that a researcher uses data collection and research methods, which are ethically sustainable and accepted by researcher community. Researcher presenting the results with honesty, generic carefulness and exactness. There is no inaccuracy in refereeing or references, plagiarizing, or deceptions in outputs. Moreover, the research objects are protected, and their privacy has been respected. (American Psychological Association, 2017.) Consequently, researchers face an array of ethical requirements (Smith, 2003), especially in cases when research object are humans, such as in many education studies. This section reflects some main ethical demands related to the dissertation.

According to the American Psychological Association's (2017) ethical principles, researchers strive to benefit those with whom they work and take care to do no harm. Although in this dissertation research topics (such, as perception of own innovation competences, experiences from courses, questions about studying, motivation and working life) were quite neutral than sensitive ones and all the participants were of age, demand of beneficence and nonmaleficence from the perspective of participants is still relevant. There can be always a risk that some research questions could arouse

undesirable feelings with some participants. On the other hand, filling survey can also be a good learning situation where student has an opportunity to reflect own experiences and competence. Smith (2003) also recommend that, if the data collection is part of class syllabus, there has to be an educative value for students. Like in this dissertation, in most of the cases, filling survey and self-assessments have been part of the course requirements or they have been conducted during the lessons or courses, whereupon a responsible instructor has evaluated that students' participation is a pedagogically meaningful choice. Moreover, the researcher has also acknowledged that there is special ethical issues when data is collected during the courses (such as, is student's participation genuinely voluntary or is it based on a social pressure or belief in authority) or part of course requirement. However, in the carefully ethical consideration the researcher has taken into account that collecting data in that way supports more the validity of the research because authentic and relevant information is gained from real learning situations. Instead, some students, mainly in the pilot studies 2 and 3, and study 4, were contacted by email. Answering to the questionnaire was considered to indicate voluntariness and consent to use the answers. In emails, students have been informed the basic information on the research e.g., the aim of the study, how data is managed and used and the researcher' contact information, and when the data was collected during the courses the responsible instructors have also been informed about the research. In addition, in order to increase participants' dignity in the interviews (study 2), there were options where students had an opportunity to add something own to the discussion. Although it is a good way to collect unexpected information, it is also an essential gesture to show respecting for them.

To follow ethical principles, the research data was also handled and stored with care. In analysing and publishing the results, participants' confidentiality was maintained and their anonymity was protected. For example, from the data the names and identifying information were removed and individual participants cannot be identified from the analyses or final results. Moreover, all the data was preserved and archived with care, and it has only been seen by the researcher(s). Research ethics also mean that researcher has to master the selected and used research methods (such as, in this case, different statistical analyses and semi-structured interview). In addition, the researcher has a duty to report the results for public and professional audience and secure that the results are equitable and respect the professional field, research community, and the participants. However, in this study, the researcher was

also aware of her position in relation to the phenomenon studied and multiple roles (researcher, instructor, developer, and expert of the organization) in the research process (e.g., Hermans & Schoeman, 2015; McNiff & Whitehead, 2001; Smith, 2003; Taylor et al., 2006). The researcher was aware that her background could affect how she constructed the research and made meaning. This requires that extra care was necessary when e.g., conducting research, analysing results or drawing conclusions.

Furthermore, the researcher has been aware that meanwhile promoting, maintaining and developing the discourse of the research theme in the professional community, a researcher uses his/her own power to maintain certain public discourses and affect a certain educational policy and action. This is noteworthy especially when some part of this dissertation's studies have been conducted in the part of national and international RDI projects funded by the European Union. Jokinen (2017) reminds that methods, concepts and facts used in evaluation research always construct a social reality and therefore they are not neutral. Anttila (2007) also states that in evaluation research the evaluation criteria are always value-bound. Moreover, it is crucial to take into account in the whole research process that the funding cannot affect the research's sincerity and control, especially when publishing research results, although they might not be in line with the aim of the funding. (e.g., TEKO 2001, 10–11). Overall, in order to be a competent researcher, you also have to be ethically conscious. This dissertation has taught the researcher that research ethic is more like a mind-set which guides the researcher's every choice through the whole research process. It is also continuous balancing between the practical demands, scientific requirements and ethical choices.

4 RESULTS OF THE EMPIRICAL STUDIES

This section presents the main results of the dissertation through the four independent studies. These sub-studies form a cumulative process for the whole research (Figure 7). The results of these four studies are published through four peer-reviewed articles. In all the articles, researcher triangulation was used, although the dissertation researcher had the main responsibility of the articles. The first article focuses on research question 1 and the second article concentrates on research questions 2 and 3. Based on the supportive results of the second article (such as the instrument is practicable and specific courses are supporting students' development of innovation competences), the third article finds answers to research question 4 by approaching students' learning of innovation competences more deeply. Finally, when the second and third articles indicated that there is an evidence that innovation competences can be learnt during courses in the learning environments based on innovation pedagogy and students are able to understand and recognize these competences in part of their studies, the fourth and final article approaches the topic from a broader perspective through research question 5. This section offers only the short summaries of the main outcomes, but detailed results and discussions can be found in the articles (Appendixes 1–4), and a bonding conclusion of them is presented in section 5.

Developing the assessment tool | Testing the further developed tool in an authentic pedagogical context | Researching students' learning of IC in the course level | Researching students' IC and their study path in the degree level
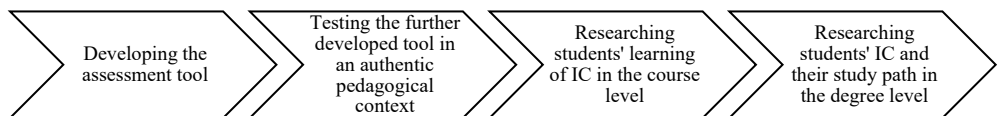
Figure 7. The study process and research aims of the dissertation.

4.1 Article I: Developing an assessment tool to measure students' innovation competences

Keinänen, M., Ursin, J., & Nissinen, K. (2018). How to measure students' innovation competences in higher education: Evaluation of an assessment tool in authentic learning environments. *Studies in Educational Evaluation,* **58, 30–36.**

For individuals to take part in innovative activities at the workplace requires that they develop a set of specific skills and competencies during their studies (Vila et al., 2012). Bath et al. (2004) state that these kinds of skills are best developed when embedded in curricula as objects for the learning process. This requires tools to assess that the objectives are achieved. Thus, there is a need to update assessment practices and develop new tools to measure and support a person's innovation competence development. The aim of this study is to continue the earlier validation studies (Marin-Garcia et al., 2013; Pérez-Peñalver et al., 2012; Watts et al., 2012), and test and evaluate the functioning of the earlier developed three-dimension model instrument measuring students' innovation competences in authentic learning environments of Finnish higher education institutions. The electronic self-assessment questionnaire was distributed to students (n=495) from four Finnish universities of applied sciences. The questionnaire consisted of 25 statements, in which the respondents could assess their own innovation competences related to individual, interpersonal and networking factors.

The results of this article showed that the questionnaire statements formed a functional innovation competence barometer for self-assessment. However, the result of the reliability and factor analyses showed that the five-factor solution appeared as a better option than the three-factor model. Accordingly, the original three-dimensional innovation competence barometer was divided into five sublevels, including *creative problem-solving, systems thinking, goal orientation, teamwork,* and *networking competences.* In the new model, creative problem-solving, systems thinking, and goal orientation are part of *the individual scale of the innovation competences,* and teamwork and networking skills are connected to *the interpersonal* and *networking scale of innovation competences.* Consequently, by suggesting a five-dimensional model, this article revised and elaborated the previous studies which have highlighted the three-dimensional nature of innovation competence (Kairisto-Mertanen et al., 2011; Kettunen et al., 2013; Marin-Garcia et al., 2013; Penttilä

& Kairisto-Mertanen, 2012; Pérez-Peñalver et al., 2012; Watts et al., 2012), and thus offers a more specific and concrete version than the previous ones. Moreover, the items of the new model are built up in a new order compared to the original model. Therefore, the result of the five-dimension model strengthens the approach that innovation competence is not simply an individual feature but a combination of individual and social factors. The assessment tool offers one example to facilitate the development of teaching, assessing, and curriculum design in higher education.

4.2 Article II: Testing and evaluating the further developed assessment tool in the authentic pedagogical context

Keinänen, M. & Butter, R. 2018. Applying a self-assessment tool to enhance personalized development of students' innovation competences in the context of university-company cooperation. *Journal of University Pedagogy,* **2(1), 18–28.**

Previous studies have shown that skills needed in the participation in innovation activities are hardly part of actual teaching or assessment. Therefore, there is an urgent need to update the learning outcomes and re-design both assessment structures and methods to include specific key skills (Edwards-Schacter et al., 2015; Kivunja, 2014). In addition to the higher education institutions, companies are also struggling with the same challenge. Companies are requiring tools and methods to assess their employees' innovation skills as part of their knowledge management activities, in recruitment processes, internal development activities and when subcontracting service training for their staff (Butter & van Beest, 2017). Thus, this second article presents a further developed assessment tool to measure innovation competences in the context of higher education and business. Furthermore, the specific aim of this article is to test a novel innovation competence assessment tool in a specific pedagogical context in university–company cooperation, demonstrate how it functions in authentic learning environments from the perspectives of students, and study whether that kind of learning environments support the development of students' innovation competences.

In this study, conducted with mixed-methods, students of one Finnish university of applied sciences were selected from three mandatory undergraduate courses (15 ECTS) based on innovation pedagogy and implemented in university–company

cooperation. The data of students' innovation competences was collected in two phases: at the beginning (N=87) of the course and at the end (N=77) of it. Only those students who completed both pre- and final assessments were taken along in the final analysis (n=69). In the inquiry, the students assessed their five innovation competences (creativity, critical thinking, initiative, teamwork and networking). In addition to quantitative self-assessment data, the qualitative data was collected based on students' interviews. The aim of the group interviews was to gather qualitative information about the function of the instrument, and the development of students' innovation competences in order to complement the picture arising from the quantitative data and to enhance understanding of the learning process of innovation competences.

The results from the interviews show that the instrument is usable and understandable from the students' perspective. The results of different group interviews were entirely consistent. Students understood what the items of innovation competences mean and they could show several concrete examples from the course how the innovation competences were demonstrated therein. They also experienced that competences have an important meaning concerning the success of their development project for the company, but also in their future professions or working life in general. This study shows that innovation competences can be made familiar for students already during their studies. With the assessment tool, students were able to describe and reflect not only own innovation competences but also their learning from versatile perspectives. The results of the study also showed that the assessment tool raises students' awareness of the innovation process. Moreover, based on those interviews and the results of pre- and final assessments analysed with the paired samples t-test, the study shows that the learning environments of university–company cooperation contribute significantly to the development of students' innovation competences. Students developed their creativity, critical thinking, initiative, teamwork, and networking capacities during the courses.

4.3 Article III: Researching students' learning of innovation competences in the course level

Despite the fact that higher education has a central role in the development of innovation skills, previous studies have shown that these institutions have not met the demand. Educational practices have been criticized for not developing these prerequisites of professional expertise (e.g., Badcock et al., 2010; Quintana et al., 2016). Traditional forms of teaching, like reading, lecturing, and working alone, have even shown to be negatively associated with learning of the needed competencies or skills (Vila et al., 2012; Virtanen & Tynjälä, 2016). Although many studies highlight the benefits of university–company cooperation, emphasizing the prevalence of proactive teaching and learning styles and instilling capacities required to lead innovation, insufficient research has addressed the effects of such cooperation on education and learning from the students' perspective (Rossano et al., 2016, 40). Moreover, research on students' learning of innovation competences has received less attention (e.g. Bjornali & Støren, 2012; Kasule et al., 2015; Vila et al., 2012). Therefore, this article responds to the lack of research on the topic, offers an example of educational practice supporting students' professional expertise, and studies whether that kind of learning environment supports students' learning of innovation competences. The article also discovers whether there are differences in learning and what kind of certain individual and environmental factors are associated with the acquisition of innovation competences. The selected factors e.g. motivation, atmosphere and guidance are highlighted in theoretical bases of innovation pedagogy and activity-based learning, and previous studies suggest that these factors are related to the learning of similar attributes to innovation competence (e.g., Rossano et al., 2016; Virtanen, Tynjälä, & Eteläpelto, 2014; Virtanen & Tynjälä, 2016).

In this study based on data from one Finnish university of applied sciences, students (N=90) were selected from three mandatory undergraduate courses (15 ECTS) implemented according to the innovation pedagogy in university–company cooperation. At the end of the courses, students (n=77) completed a self-assessment questionnaire, where they assessed their learning of innovation competences (creativity, critical thinking, initiative, teamwork and networking) during the

course. According to the results of the self-assessment questionnaire, the study showed that university–company cooperation with activity-based learning methods seems to develop students' innovation competences. The students assessed that they have learnt innovation competences during the courses, especially creativity, critical thinking, and teamwork. However, K-cluster analyses revealed two groups of learners: those who learnt less innovation competences and those who learnt more. Chi square tests showed that all students are able to learn innovation competences. Gender, study year, work experience or course were not associated with the learning outcomes of innovation competences in these two student groups. Instead, certain individual and environmental factors distinguished these two groups from each other. T-tests showed that students' motivation, importance of learning, atmosphere of the course, learning of field-specific contents and project-based learning preference are associated to learning of innovation competences. The group that reported having learnt more innovation competences score higher in motivation and consider the learning more important during the course than those who reported having learnt less. Similarly, those who assessed they learnt more innovation competences, described the atmosphere in the course as more supportive and safer, and that it encouraged discussions. These students were also more likely to report having learnt field-specific contents in the course. Furthermore, the group that reported having learnt more innovation competences, also preferred project-based courses to traditional lectures slightly more than the group that had learnt less. Instead, learning of innovation competences was not related to the support and guidance students reported having received during the course.

4.4 Article IV: Researching students' innovation competences and learning environments in the degree level

Keinänen, M., & Kairisto-Mertanen, L. (2019). Researching learning environments and students' innovation competences. *Education+Training, 61(1),* 17–30.

Working life is continuously looking for innovative employees. Companies need innovations to survive and create competitiveness and the public sector needs innovations to produce high-quality, cost-efficient, and sustainable services. As a result, there is an urgent need for professionals who are capable of participating in innovation processes and who can contribute to the creation of innovations.

Innovative individuals are the resource of all innovations and higher education represents a critical factor in human capital development (Avvisati et al., 2013; Edwards-Schacter et al., 2015; Vila et al., 2012). The role of higher education is not only to educate undergraduates for future work but also to train employees to perform work tasks, which then generate innovations. Meanwhile, the importance of evidence-based education is highlighted. When reforming education there is a growing call to base educational decision-making on high-quality educational research and pedagogical practices generating efficient learning (Michael, 2006). To respond to these claims, the aim of this article is to present an example of pedagogical strategy, called innovation pedagogy, and study whether learning environments built according to it can be associated with students' innovation competences. This article focuses on examining whether there are different student profiles concerning their level of innovation competences and how these students differ based on their study experience of varying learning environments. By focusing on different levels of innovation competences of students and approaching their study path in more detail, it could be better understood how to develop more effective education and learning environments, and thus respond to the demands of working life. Through studying these approaches, important information about how the chosen pedagogical strategy is revealed from students' perspectives during their studies is also gained.

In this study, the data were collected by inquiring third- and fourth-year bachelor students from four different study fields from one Finnish university of applied sciences. The research focused only on third- and fourth-year bachelor students because it was presupposed that these students, based on their pedagogical understanding and experience, can widely approach their study experiences and also assess their innovation competences. The results of K-mean cluster analysis showed that two different groups of students with different profiles could be identified. The first cluster consists of students who report the level of their innovation competences being higher, and the second cluster comprises students who report the level of their innovation competences being lower. The further analyses, with Mann-Whitney's, showed that students' study experiences based on learning environments of innovation pedagogy play a significant role regarding the level of their innovation competences. The students who assessed their level of innovation competences higher, report having studied more in learning environments including all the six elements of innovation pedagogy, than those students who assessed their innovation competence levels lower. In addition, the effect sizes of variables, based on Cohen's

standards (1988), confirm the result that there are clear associations between the elements of learning environments and students' innovation competences in the two student groups, albeit at different intensities. From these six factors, especially activating learning and teaching methods and internationalisation, seem to have the strongest relations to the competences. However, surprisingly, during the 3–4 years, the students did not have many experiences studying in learning environments based on innovation pedagogy. For example, students in both groups perceived that their studies have not, or have only slightly, supported entrepreneurship, and the students' experiences from multidisciplinary learning environments were minor. Instead, activating learning and teaching methods were revealed most in students' studies.

5 CONCLUSION AND DISCUSSION

The aim of this dissertation research was not only to present the valid assessment tools to measure students' innovation competences, test and evaluate them in the authentic pedagogical contexts, but also examine students' innovation competences in innovative pedagogical practices and learning environments in the course and degree levels in the context of higher education. Moreover, the dissertation also concentrated on researching whether there are different student profiles concerning their innovation competences and how these different students differ based on their perception and experiences of studying. Focusing on different levels of innovation competences of students and examining their learning, perceptions and study paths in more detail, it could be better understood how to develop more effective pedagogical practices, and thus respond to the demands of working life. Through studying these approaches, important information concerning how the chosen pedagogical strategy, innovation pedagogy, is revealed from students' perspectives in their studies was also gained.

5.1 Main findings of the studies

This dissertation suggested that higher education institutions have an important and responsible role in training innovative individuals, which finally are the source of all innovations. In order to assess innovative behaviour and increase students' innovation competences, new and valid self-assessment tools are required. However, assessing the complex cognitive behaviour needed in the creation of innovations can be challenging, but if we are just focusing on teaching and assessing learning outcomes, which can be easily and transparently measured, we cannot support the development of students' innovation competences. This study presents two assessment tools to measure students' innovation competences, and thus, offers not only concrete pedagogical methods for assessments, but also theoretical perspectives to approach the problematic discussion of generic skills or competences and

innovation competence research, and instruments to research the effectiveness of pedagogical practices.

In this study, innovation competence is formed of a cluster of capacities and skills, which jointly form a complex professional performance needed in creating innovations. It refers to the kind of competence which education should produce regardless of study field. This dissertation study shows that innovation competence can be assessed, learned and supported already in higher educational environments. The study showed that students are capable to identify and assess their innovation competences during their studies. The used instrument functions in a natural manner and it is understandable and usable from students' perspectives. The assessment tool supports students' reflection and observation of their learning. For example, with the assessment tool, students were also able to recognize different kind of learning situations, and describe and reflect not only their innovation competences but also their learning and expertise from versatile perspectives. Similar kind of results have been showed also in the previous studies. For example, Chang, Kantola and Vanharanta (2007) highlight that student self-evaluation can be considered as an efficient tool for learning. Butter (2013) has also shown that, self-assessment tool, such as the innovation competence assessment tool, supports the self-reflections and choices of students at a distance, but in a sound and rigorous manner. In addition, Sturing et al. (2011) present that especially in competence-based education, students are challenged to reflect on their own learning by which they further develop their competence.

This dissertation research suggests that by using the developed assessment tool, innovation competence and innovative behaviour can be made familiar to students already during their studies. The results of this study showed that students could show several concrete examples from the course how the innovation competences were demonstrated therein. The tool also raises students' awareness of the innovation process. To participate effectively in innovation projects, it is important that a student in higher education has a clear picture of the innovation competence, capacities and skills that are needed in a specific project, and the extent to which he or she possesses these. Moreover, this might be one way to improve an employee-driven innovation action at workplaces later. According to Alasoini (2010), in this kind of innovation action it is believed that in every level of organization, employees can have a large amount of so-called hidden creativeness, which can lead to creation of new kinds of products, services or producing methods, if it has been supported and guided

in an appropriate way. Similarly, Hakkarainen (2017) notes that every person has potential to develop and achieve a high-level intellectual competence if he or she has opportunities to work and interact with experts and with innovative practices. When students are aware of their personal innovation competences, and can identify and develop them already during the studies, it might be easier to reach this kind of hidden innovativeness at workplaces in their future professions.

Furthermore, in this study, the students experienced that competences have an important meaning concerning the success of their development project for the company but also in their future professions or working life in general. They were also able to describe their innovation competences in a rich way and recognize them also in another learning contexts. These features might foresee versatile long-term values for students and support the development of their metacognitive skills needed in 21st century learning. For example, students' ability to identify, reflect and be confident in these kinds of competences has showed to be associated to metacognition skills and ability to transfer the competences in another context (Tuononen et al., 2017), and even employability (Knight & Yorke, 2003). Tuononen et al. (2017) show that graduates who were able to describe various demanding competences and provide detailed analyses of them, and had high confidence in success in working life, were also able to transfer those competences in another context and had better metacognitive skills and self-efficacy beliefs, compared to graduates who had limited description on those competences and low confidence. Therefore, they state that without ability to reflect one's competences, graduates remain unaware of the competences they may have. Tuononen et al. (2017) suggest that emphasizing the importance of acquiring these competences during studies and stressing students the usefulness of these competences in future working life could help them to develop and recognise competences better.

On the other hand, the dissertation not only showed that innovation competences can be identified and can be made familiar but they can also be learned during the courses. The research presented that students can learn and develop their innovation competences in the courses, especially in the courses which were conducted in university–company cooperation and based on active learning methods under the concept of innovation pedagogy. The study showed that all students are able to learn innovation competences. There were no differences in learning outcomes by gender, study year, work experience, or course. Instead, certain individual and environmental factors support the learning of innovation competences. The results

showed that especially students' motivation, importance of learning, and atmosphere of the course are related to the learning of innovation competences. Similar factors have also been found from previous studies of students' approaches to learning (e.g., Hailikari & Parpala, 2014), or learning of generic skills (e.g., Virtanen & Tynjälä, 2016). Moreover, Tuononen et al. (2017) have showed that especially a deep approach to learning seems to have a positive association with reflection ability of academic competences. Thus, this raises a question of whether students who assessed having learnt less innovation competences may have a surface approach to learning or they may have fewer skills to reflect their learning and abilities to recognize these competences.

In addition, interest and motivational factors are shown to be crucial elements in the development of expertise in the educational context (Alexander, 2016), and a safe atmosphere to be essential in the students' research studies (Bollinger, 2014). Bollinger (2014) shows that in order to be able to productively handle uncertainty and accompanying feelings during the research process of the bachelor thesis, students must feel safe enough. Previous innovation studies have also shown that from the individual factors, the person's motivation is one of the key elements in promoting innovation (Hero et al., 2017; Quintana et al., 2016, 13). However, surprisingly, students' experience of received support and guidance during the course was not related to the learning of innovation competences, as previous studies of different learning contexts have suggested (Hailikari & Parpala, 2014; Virtanen et al., 2014). Although creating supportive, encouraging, and motivating learning environments requires a lot of guidance and guidance skills from instructors, it is not necessarily always explicit to students.

Instead, project-based learning preference seems to be linked to the learning of innovation competences. One explanation for this could be that some prefer active learning methods more than others do. Students who assessed that they learnt less could be described more like passive players in the classroom according to their behaviour or action related to innovation competences. Therefore, these students might prefer more traditional teacher-centred methods where students' role is more passive. In addition, this dissertation showed that learning innovation competences in the courses is not excluding the learning of subject-specific competences simultaneously. With the active learning methods in university–company cooperation, students are able to learn both innovation competences and programme-specific contents. These outcomes are not mutually exclusive. Bath et al. (2004) highlight that these

kinds of competences need to be taught within the discipline, integrated and embedded in the curriculum, although some teachers may not perceive competence development as their teaching responsibility and may believe that such things are best taught in additional courses. Henrico (2012) has also shown that activity-based teaching will not only enrich contact sessions, but also improve the skills needed in business today: e.g., problem-solving, responsibility, communication, and critical thinking. Rossano et al. (2016) found similar results researching students' learning in university–business cooperation based on problem-based learning. Heinis, Goller and Meboldt (2016) state that the future of professional education needs broader and more competency-based schooling. The purpose of engineering education is to train students to become successful engineers who possess technical expertise, social awareness, and bias toward innovation. Higher education has therefore two challenges: to teach technical knowledge that students are able to apply in their future work, and to teach the social and individual competencies needed to use the acquired technical knowledge and expertise. This dissertation showed that students do not always have to be in the workplace to learn needed competences.

Although the two pilot studies already showed that innovation competences can be identified, assessed and developed in the course level, this dissertation wanted to examine the phenomenon during the degree level. In order to create more comprehensive picture of the role of higher education institution in training innovative graduates and evaluating function of its pedagogical strategy, the dissertation studied the level of innovation competences of third- and fourth-year bachelor students, who are close to graduation, and approached their study paths in more detail. The results from this study were in line with the two previous pilot studies of learning innovation competences in the course level. The research showed that students' study experiences based on learning environments of innovation pedagogy play a significant role regarding the level of their innovation competences. The students who have more experience studying in different learning environments of innovation pedagogy assessed their innovation competences higher than those students who have had less experience. This could be explained that innovative students may be attracted to innovative learning opportunities (such as project-based learning preference), and they may also have utilized more different kinds of learning opportunities during their studies because of their, e.g., initiative or networking capacities. Virtanen et al. (2012) have also shown that students who had

the energy to act and try things in their workplace learning period also seemed to be the ones who were most likely to learn and to develop themselves professionally.

Moreover, these results are also supported by previous studies. These studies suggest that specific pedagogical practices, e.g., activating teaching methods, cooperative learning, and opportunity to integrate theories with practice, are developing students' attributes that resemble innovation competence (Ballantine & MCourt Larres, 2007; Chang, 2014; Henrico, 2012; Hu et al., 2016; Levine & Guy, 2007; Michael, 2006; Quintana et al., 2016; Rossano et al., 2016; Tynjälä, 1999; Vila et al., 2012; Virtanen & Tynjälä, 2016). However, it is also possible that those students who have studied more in the courses based on elements of innovation pedagogy have also better adopted the rhetoric related to innovation pedagogy, and thus, they can recognize and assess their innovation competences differently, or they may aim for social desirability either unconsciously or consciously. On the other hand, from a pedagogical point of view, consciously paying attention to innovation competences may have many positive effects on students' future (see also Tuononen et al., 2017), e.g., in job interviews, because of their increased awareness of the importance of these kinds of competences and their ability to verbalize their own skills.

The study also strengthens the understanding that learning environments and opportunities should be versatile and include many-sided elements. All the six cornerstones of innovation pedagogy: 1) activating learning and teaching methods; 2) multidisciplinary learning environments; 3) working life orientation and RDI integration; 4) flexible curricula; 5) entrepreneurship, and 6) internationalization, are more or less associated with the level of students' innovation competences. Avvisati et al. (2013) also highlight that a diverse offering of pedagogies is the most effective way to foster all skills for innovation in the working population. In this study, especially, the dimension of activating learning and teaching methods has the most and strongest association with the students' innovation competences. This dimension was also the most visible element in learning environments of innovation pedagogy, although, surprisingly, during the 3–4 years, the students did not have many experiences studying in learning environments based on innovation pedagogy.

5.2 Scientific and practical implications

As a cross-thematic research, this dissertation combines two considerable topics: educational sciences and innovation research, and thus, it gets close to both themes not only from the theoretical and methodological perspectives but also from pedagogical aspects. Thus, it also provides several implications to both scientific community and practitioners.

5.2.1 Theoretical and methodological implications

Although researching innovation competence is an urgent issue when one wants to produce innovations, research on the competence that can be taught and learnt in order to prepare students for innovation-oriented action is still defective in the educational context. Thus, this study brings new insights for the limited research topic by adding new knowledge as well as versatile and wider perspectives to the current literature and research of education and innovation. The theoretical and methodological contributions can be approached as three topics: innovation competence as a concept, learning of innovation competence, and learning environments that support innovation competence.

First, this study offers theoretical clarification and extension to the concept of innovation competence in the educational context by presenting two structured theoretical frameworks. As described previously, not only the term competence but also its near relatives, such as competency, skill, capacity, and ability, raise several complex issues in educational discourse (Badcock et al., 2010; Ursin & Hyytinen, 2010). For example, although they are widely used international terms and they have become trendy concepts, there is little consensus on the definition and meaning of the concepts and their accuracy remains limited (e.g., Bohlinger, 2012; Mäkinen & Annala, 2010; Pikkarainen, 2014). Moreover, universities' endeavours to describe these attributes of graduates seem to lack a clear theoretical or conceptual base despite the lengthy history of the rhetoric of such policy claims (Barrie, 2007). Correspondingly, Marin-Garcia et al. (2013, 6) have also shown that there is a research gap in academic literature related to a person's innovation competence, and how to measure and develop it. Nevertheless, even though a range of studies on dealing with innovation-based competence models of organizations and their employees exist (e.g., Bikfalvi et al., 2010; Suominen & Jussila, 2009), valid comprehensive

research frameworks are still scarce when it comes to student behaviour or action needed in innovation processes but developed in educational contexts. Thus, as one of the theoretical contributions, this study offers structured frameworks for approaching the problematic discourse of competence in higher education, with clear theoretical bases of innovation theories, which also complement and extend the existing innovation competence models found in the literature related to innovation research (Pérez-Penalver et al., 2018).

Second, this study also contributes to the versatile empirical evidence for deepening the understanding of students' learning of innovation competences and the elements of learning environments associated with students' innovation competences. To date, the literature lacks studies that investigate all these aspects in an adequate way. For example, in the light of previous studies, there generally seems to be a lot to improve in terms of research on the competences that can be taught and learnt to prepare students for innovation-oriented action (Bjornali & Støren, 2012; Edwards-Schachter et al., 2015, 28). In those few promising approaches that focus on innovation competence in the context of higher education (e.g., Chang, 2014; Edwards-Schachter et al., 2015; Hero, 2017; Hero, Lindfors, & Taatila, 2017; Hu et al., 2016; Kasule et al., 2015; Konst & Jagiello-Rusilowski, 2017), innovation competence has been defined narrowly and with inadequate variables (Hu et al., 2016), the research has focused on measuring the competence of teachers (Kasule et al., 2015), the development of students' innovation competences has been studied from the perspective of teachers (Hero, 2017), the research has dealt with students' self-perceptions instead of their action or behaviour (Edwards-Schachter et al., 2015), or the studies are based on a retrospective assessment of innovative behaviour or promoting of innovations of graduates after their graduation (e.g., Avvisati et al., 2013; Bjornali & Støren, 2012; Paul, 2011; Vila et al., 2012). Additionally, in these previous studies, approaches to learning environments are also limited although their study designs are varied. For example, they only focus on specific learning activities, such as innovation tournaments (Hero, 2017; Konst & Jagiello-Rusilowski, 2017), or examine teaching techniques or innovative course implementations alone (Chang, 2014; Hu et al., 2016), or with general and narrow perceptions of training or education (Avvisati et al., 2013; Bjornali & Støren, 2012; Edwards-Schachter et al., 2015; Paul, 2011). Therefore, this dissertation extends and diversifies the previous research on innovation competence by using a structured and extended theoretical framework of innovation competence in the new contexts (course and degree levels

in different degree programmes), with new factors (personal and environmental), mixed methods (questionnaires and interviews), and study designs (pre- and post-assessments).

With these studies, this dissertation offers not only a deeper understanding of the complex phenomena but also contributes by providing implications for how to develop more effective pedagogical practices that enhance these competences. Thus, it also provides crucial information on how this specific pedagogical strategy, namely innovation pedagogy, is perceived by students and shows to them during their studies. So far, there have been few empirical studies, especially statistical analyses, on innovation pedagogy, although several theoretical and practical cases on how to implement innovation pedagogy in practice are published (e.g., Kairisto-Mertanen et al., 2012; Kettunen et al., 2013; Konst & Scheinin, 2018; Penttilä, 2016). Therefore, this work also contributes to the important empirical evidence concerning innovation pedagogy and supports its further implementation.

However, although the dissertation includes different study designs and data sets, it still leaves room for further questions and investigations (more also in the section 5.3). Thus, as third, it also provides methodological suggestions in order to further deepen the understanding of the complex phenomenon Although using self-assessments in educational context is a justified choice and produces consistent data to approach the phenomenon in one view, it is clear that external assessments (e.g., peers, teachers, tutors, or internship supervisors), carefully designed norm or control group studies, (e.g., Chang, 2014; Messmann & Mulder, 2012; Ward, Gruppen, & Regehr, 2002), and longitudinal or retrospective studies later in professional workplace settings (e.g., Avvisati et al., 2013; Bjornali & Støren, 2012; Paul, 2011) are also recommended for acquiring evidence of students' actual enacted innovation competences. Additionally, the results of this study encourage to research further the application of innovation competence in different context-situational professional settings (e.g., Mulder, 2009; Messmann & Mulder, 2011) in order to better understand the relation, connection, and application of interweaved innovation and discipline specific competences in the authentic learning process and innovative behaviour, especially in different concrete professional practices (e.g., Nykänen & Tynjää, 2012, 19). Similarly, a methodological suggestion is to acquire more demonstration of the transferability of innovation competence in working life (e.g., Tuononen et al., 2017). From the viewpoint of these recommendations, qualitative methodologies such as interviews, observations, or reflective documentations (e.g.,

Messmann & Mulder, 2012; Messmann & Mulder, 2011) should be also considered. Naturally, the presented frameworks can be also used to further investigate other cases in other contexts.

5.2.2 Pedagogical implications

From the practical view, the findings of this study have several important implications for future practice when it comes to developing effective pedagogical practices and responding to the demands of innovation-driven working life. The pedagogical implications of this work can be divided into four wider themes, which offer implications for students, educators (such as teachers, planners, tutors), educational organizations, and society: 1) As a whole, this study contributes to societal understanding of the role of education in training innovative professionals, and thus, 2) it encourages and supports further the implementation of innovation pedagogy as a pedagogical strategy. For that, 3) the work offers practical tools to students, educators, and organizations for curriculum development and teaching and learning practices that support innovative behaviour, and 4) provides empirical evidence and information to organizations and educators for designing higher quality learning environments that enhance students' innovation competences.

In terms of the first theme, this dissertation suggests that education has an important and responsible role in training innovative individuals. Students' innovation competences can be supported with suitable, systematic and continuous educational strategies and choices, versatile and active learning environments, and specific assessment tools. Overall, this requires changes in educators' mind-set, as they must realize how important the role of higher education institutions is in producing innovative individuals. For example, Paul (2011) shows that graduates are crucial actors in the innovation process. His study indicates that more than half of graduates reported that they play a role in introducing innovation in their organizations. Certainly, it would be unwise to think that higher education can create fully formed professional innovators, but it is reasonable to expect higher education institutions to train their students to be competent to start participating in innovation processes and capable of becoming professional innovators (see also Markauskaite & Goodyear, 2013). Therefore, this study suggests from a societal point of view that supporting the skills related to innovative behaviour could be taken into account also in the other educational levels (considering context-suitable methods)

in order to ensure a long-term and comprehensive competence, albeit this study only focused on the context of higher education, particularly universities of applied sciences. To supporting other educational organizations, this dissertation offers one example of a pedagogical strategy, models of innovative learning environments, and concrete tools to assess and boost innovation competence.

However, making an educational change can be demanding. This study shows that a pedagogical strategy demands plenty of work in order to be visible in practice for all the students. Strategic management of higher education requires that strategies are also realized in practice. In other words, strategies must be in line not only with the curriculum but also with implementing it, like suggested in the theory of constructive alignment (Biggs & Tang, 2011). This requires that educators and institutions need to train themselves for the change (Kivunja, 2014; Tynjälä, 1999). Changes are required on all levels of educational support systems: standards and assessments, curricula and instruction, professional development, and learning environments. However, often the changes have only been conducted at one level of the support system, such as producing a new curriculum, without coordinated changes being made in all the other linked systems. (Trilling & Fadel, 2009.) Moreover, Ramos et al. (2012) emphasize training for teachers but remind how difficult it is to change the old habits of teaching staff (see also Hermansen & Nerland, 2014). Tynjälä (1999) also states that designing constructive learning environments requires of the teacher much more than traditional ones because the main emphasis shifts from the presentation of information to guiding students' learning process. On the other hand, it has also been shown that staff members in higher education differ in their orientation towards change (Aldahdouh, Nokelainen, & Korhonen, 2018). Therefore, addressing the second larger theme mentioned in the beginning of this subsection, this dissertation encourages educational institutions not only to systematic and long-term development work and goal-oriented staff training but also to research the orientations and attitudes of their staff in order to put a pedagogical strategy into practice. To support this and make a reform, evaluation and practice-oriented research strategies could be used more to indicate the organization's present state in their practices and attitudes, and thus, also offer framework for sharing good practices. If not, there is a no action problem and people and organizations simply continue to do what they are doing (Hermans & Schoeman, 2015).

To foster these changes, as a third practical contribution, this work presents concrete tools for practices. These instruments provide a new perspective and support for

curriculum design, pedagogical practices and teaching, and assessment culture in higher education in several ways. This dissertation shows that assessment tools may present a method in scientific research and be applied to hands-on work. For example, educational organizations can use the instruments (when knowing their limitations) to measure the development of students' innovation competences throughout the degree programmes as well as to measure the effectiveness of their own organization and their pedagogical practices to produce innovative professionals. Educators, such as teachers or tutors, can use the tools to help recognize the special capacities and skills that emerge during their pedagogical practices, and thus, to support in evaluating their own course designs or implementations. Using the instruments can also help to demonstrate and become familiar with the strategical aims of innovation pedagogy in a very concrete way. The study also recommends using the instruments as developmental tools to increase awareness of important aspects of innovative behaviour not only among the staff but also among students. Messmann and Mulder (2011) argue that work contexts provide many opportunities for innovation development, but individuals must first recognize these opportunities in order to become active innovators. Thus, the tools also help to understand the importance of the application of innovation competences in the innovation processes and in work practices. Moreover, the assessment tools require students to actively monitor and regulate their own learning as they reflect on their achievements and demonstrate that they have met or exceeded the standards of their programme and institution (see Postareff, 2017). Understanding their own level of innovation competences supports students' metacognitive skills and prepares students better for a more complex life and work environment. A stronger consideration for reflective activities may be useful in integrating innovation development and professional development into innovative work behaviour (Messmann & Mulder, 2011).

However, identifying, assessing, and developing innovation competence also requires that learning environments are designed so that students must use innovation competence in their academic activities. Thus, as the fourth and final wider theme, this dissertation also offers suggestions for careful learning environment design. Based on the results of this work, learning environments should be versatile and include many-sided elements. In addition, they should be safe, supportive and motivating for different types of students. Therefore, designers of learning environments and courses, such as instructors, should be mindful of not only creating a safe and supportive atmosphere but also including elements and

practices which motivate and interest students. According to Jeno (2015), students with an initial disinterest in a subject may become highly autonomously motivated under the right conditions. Therefore, this study recommends that it is extremely important that higher education institutions ascertain the right methods to support different kinds of students in their study paths to be more active, encourage them and offer them several learning opportunities to be utilized. Moreover, it is one of the instructor's or tutor's responsibilities to make students understand what will be needed and necessary in their professional lives (Henrico, 2012). Therefore, in order to maximize powerful learning, it is important to have the discussion of individual learning preferences and how to develop them, as well as to explain why specific learning methods are used in the courses and what is expected from students by education and innovation-driven working life. Jeno (2015) states that students who perceived their instructor as informative and autonomy-supportive not only became more adjusted in that course and performed at a higher level, but also became more autonomously motivated during the course (Jeno, 2015). This also requires students to take a more active and responsible role as a learner.

Similarly, to be an effective teacher in this new paradigm requires a move from teacher-directed to student-centred learning and also renewing teachers' skills (Konst & Scheinin, 2018; Trilling & Fadel, 2009). Kasule et al. (2015) state that teachers' innovation competence in the contemporary education system is paramount for the realization of better student learning achievement and outcomes. Kivunja (2014) also reminds that new requirements of professional development are needed to ensure that those charged with the privilege of educating learners for the 21st century are themselves well skilled and can in turn teach the skills effectively to their learners. Alexander (2018) urges those committed to improved teaching and assessment in higher education to act as role models in the face of change. For the management of education institutions, this means showing the right direction and encouraging the faculty to update their education to be able to implement new ways of delivering education. This could involve, for example, supporting staff to share their own experiences and good practices or emphasizing the evidence of the significance of small development steps, such as the development and promotion of activating learning and teaching methods in the courses. Comfortingly, the result of this work indicates that students' innovation competences could also be supported effectively in quite simple ways. Moreover, from the perspective of an individual teacher, it might also be easier to start the change with small steps, such as teaching techniques

or methods, than with wider structural changes, like curricula or multidisciplinary and international learning environments.

5.3 Considerations, limitations and future studies

Although the dissertation research shows promising results, brings new knowledge on the research topic, and gives several implications, certain weaknesses with the methodology are also worth consideration. For one, the reliance on students' perceptions of their innovation competences may be seen somewhat as a methodological weakness. Undoubtedly, there is always a risk of possible bias with self-assessments. However, despite that the validity of self-assessment is contested, e.g., people often respond in such a way that presents them in a more favourable light, numerous advantages support the use of self-report, e.g. people possess better quality of information about themselves (e.g. Paulhus & Vazire, 2007, 226–229). On the other hand, based on previous studies, the validity of expert assessment is also conflicting. It has shown to be elusive and uncertain (Ward, et al., 2002). Furthermore, the validation study (Butter & van Beest, 2017) of the innovation competence assessment tool used in this research shows that there are reasonable correlations between the self-assessment scores and external indicators of innovation competences. However, the possible Hawthorne effect should also be taken into account in conclusions, although this study cannot provide evidence of the existence of these possible underlying mechanisms for students' assessments of their innovation competences. Therefore, in future studies control group arrangements, for example, should be considered, albeit there seem to be little knowledge about the real mechanism of the influences of the Hawthorne effect and their magnitude (Chiesa & Hobbs, 2008), and thus, the appropriate control procedure also remains unclear (Adair et al., 1989).

In addition, because of the case-study setting and a limited sample, there are limitations to the generalizability of the findings. Although some results of case studies can be applied and generalized to theories, which represent the scope or context of that theory of the cases, it is important to acknowledge that it is not the purpose of case-study research approach (Eriksson & Koistinen, 2005). On the other hand, those limitations serve points of consideration for future research. Thus, this dissertation research suggests that further research should use more extensive data and mixed research methods to increase especially the credibility and

transferability of the results. In the next studies, different perspectives of key players, such as instructors or peers, and a larger and versatile number of respondents are also needed. Moreover, a further study could assess long-term effects, for example, how this pedagogical strategy is revealed for new students after extensive staff-training or other strategical activities or how these different students are succeeding and using their innovation competences in their future working careers.

Although causal interpretations of students' level of innovation competences and association to be innovative at work is not granted with this research, it could be cautiously assumed, supported by previous studies of Avvisati et al. (2013), Bjornali and Støren (2012) and Paul (2011). They have studied graduates five years after graduation and showed that when graduates' study programmes had emphasized, e.g., group assignments, participation in research projects, internships, work placement, project- and/or problem-based learning (Avvisati et al, 2013; Paul, 2011) and entrepreneurial skills (Bjornali & Støren, 2012), the probability of having introduced innovations or participated in innovation processes at work increased. Thus, these evidences encourage and inspire to research this possibility further to understand higher education's role in educating innovative employees more comprehensively, like suggested in several policy recommendations (e.g., European Commission, 2017). Moreover, this dissertation cannot give causal interpretations of innovation competences and students' learning approach or personal affection, but it can serve hints of consideration for future research to study students' innovation competences more in terms of a psychological and personal approach. This dissertation left room for discussion whether innovative students may be attracted to innovative learning opportunities and preferred active learning methods. Thus, they may have also utilized more different kinds of learning opportunities during their studies because of their, e.g., initiative or networking competences. It seems that there might be students who prefer more traditional teacher-centred methods where the students' role is more passive, and it also shows in their level of innovation competences and learning those. Thus, further research is needed to understand these different student profiles deeper and thus find supportive solutions for them. Moreover, learning environments, motivation, atmosphere, support, and guidance are complex and extensive phenomena as well, and in this study, the variables related to these elements were rather narrowly covered. To remedy this limitation, future research should also focus on examining the personal and environmental factors that support students' innovation competences by using the existing valid instruments.

Overall, as this discussion suggests, there is much left unanswered about researching students' innovation competences from different perspectives. This dissertation hopefully inspires for further pursuits and encourages researchers to undertake this subject. Moreover, in the spirit of evaluation and action research in case-setting, hopefully the results and conclusions of this dissertation can be a push for further strategical evaluations, practice-oriented interventions and pedagogical development projects, or provide results for management level for decision-making or strategical development in educational institutions in general. With all these aspects of further investigation, we can better guarantee that higher education institutions can prepare innovative individuals capable of coping with the constantly fast-changing working life.

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7 APPENDIX

APPENDIX A: Research instrument I - Innovation competence assessment tool

This appendix presents English translation of the Finnish version of innovation competence statements used in the study 1. The Finnish original version of the full questionnaire (including introduction and background questions) is available from the author.

1. I suggest ideas for others to approve how the job should be done.
2. I suggest new ideas for solving problems.
3. I suggest new practical solutions to reach a goal
4. I make justified evaluations on what lies behind the activities.
5. I understand causal relationships between matters.
6. I am capable of looking at a task from different actors' perspectives.
7. I use existing resources in an imaginative way.
8. I anticipate upcoming developments.
9. I indicate by my behaviour that I am interested in the matter.
10. I work persistently to achieve the goals.
11. I make daring but justified decisions.
12. I concentrate on relevant points to achieve a goal.
13. I relay information I have received to the target group.
14. I take group members' viewpoints into account.
15. I create a confidential atmosphere through conversation.
16. I am capable of collaborating.
17. With my competence I help achieve the goals of the group.
18. I bring forth new ideas openly available to others.
19. I can steer the group towards the goal.
20. I can resolve conflicts to achieve a common goal.
21. I act in line with the values of my professional field.
22. I can use external networks.

23. I am capable of productive cooperation with professionals from different fields.
24. I am capable of productive cooperation with people from different cultural backgrounds.
25. I am capable of networking.

APPENDIX B: Research instrument II - Innovation competence assessment tool

This appendix presents English translation of the Finnish version of innovation competence statements used in the studies 2, 3 and 4. The Finnish/English versions of the full questionnaires (including background questions and variables) are available from the author.

1. I think differently and adopt different perspectives.
2. I´m attentive when others are speaking, and respond effectively to others' comments during the conversation.
3. I use intuition and own knowledge to start actions.
4. I invite feedback and comments.
5. I foster improvements in work organization.
6. I obtain constructive comments from colleagues.
7. I find new ways to implement ideas.
8. I identify sources of conflict between oneself and others, or among other people, and to take steps to overcome disharmony.
9. I take an acceptable level of risk to support new ideas.
10. I go beyond expectations in the assignment, task, or job description without being asked.
11. I meet people with different kinds of ideas and perspectives to extend your own knowledge domains.
12. I convince people to support an innovative idea.
13. I systematically introduce new ideas into work practices.
14. I act quickly and energetically.
15. I generate original solutions for problems or to opportunities.
16. I use trial and error for problem solving.
17. I develop and experiment with new ways of problem solving.
18. I acquire, assimilate, transform and exploit external knowledge to establish, manage and learn from informal organisational ties.
19. I challenge the status quo.
20. I face the task from different points of view.
21. I make suggestions to improve current process products or services.
22. I present novel ideas.
23. I forecast impact on users.

24. I show inventiveness in using resources.
25. I search out new working methods, techniques or instruments.
26. I provide constructive feedback, cooperation, coaching or help to team colleagues.
27. I work well with others, understanding their needs and being sympathetic with them.
28. I share timely information with the appropriate stakeholders.
29. I consult about essential changes.
30. I build relationships outside the team/organization.
31. I refine ideas into a useful form.
32. I engage outsiders of the core work group from the beginning.
33. I ask "Why?" and "Why not?" and "What if?" with a purpose.
34. I work in multidisciplinary environments.

In today's society, innovations are seen as solutions for many global problems; for social and environmental issues, as key elements for organizations and companies to survive in the changing world, boosters for the economy, and as a trendy concept highlighted in many policies. As a result, there seems to be an urgent need for professionals who are capable of participating in innovation processes and who can contribute to the creation of innovations. Educational institutions, regardless of context, are expected to prepare innovative individuals capable of coping with demands of innovation-driven society.

To respond to these claims, the aim of this study is to research students' innovation competences in higher education. This study presents and evaluates assessment tools to measure students' innovation competences, test them in practice, and examine students' innovation competences in innovative learning environments based on innovation pedagogy at the course and degree levels. The study has been implemented at one Finnish university of applied sciences, where innovation competences have been set as learning targets for all students in its pedagogical strategy, which is called innovation pedagogy. The research includes four independent case studies using mixed research methods.

The dissertation study shows that innovation competence can be assessed, learned and supported already in higher educational environments. The study suggests that higher education institutions have a meaningful role in training innovative professionals, but special consideration should be placed on developing innovative learning environments. With specific learning environments and tools, we can support the development of students' innovation competences.

This study not only presents some examples of innovative learning environments based on innovation pedagogy but also concrete tools to assess and boost students' innovation competences. The tested instruments bring a new perspective and support for curriculum design, pedagogical practices and teaching, and assessment in higher education.