

# AN INNOVATION PROCESS – COMPETENCES NEEDED TO MAKE IT SUCCEED

Meiju Räsänen<sup>1</sup> Ari Putkonen<sup>21</sup> and Liisa Kairisto-Mertanen<sup>3</sup>

<sup>1</sup>Turku University of Applied Sciences, Finland,

Sepänkatu 1 20700 Turku, Finland, tel. +358403550938, meiju.rasanen@turkuamk.fi

<sup>2</sup> Turku University of Applied Sciences, Finland

Sepänkatu 1 20700 Turku, Finland, tel. +358505985815, ari.putkonen@turkuamk.fi

<sup>3</sup> Turku University of Applied Sciences, Finland

Sepänkatu 1 20700 Turku, Finland, tel. +358503854118, liisa.kairisto-mertanen@turkuamk.fi

Meiju.Rasanen@turkuamk.fi

## ABSTRACT

*Higher education represents a critical factor in innovation and human capital development on society, curricula and individual levels. As a learning outcome individual competence consists of knowledge, skills and attitudes. However, we have limited or even mysterious ideas how creative individuals utilize their competences during innovation processes and what kind of demands they meet. The aim of this exploratory study is to demonstrate how the different phases of an innovation process call for different kinds of innovation competences to produce successful results. The exploratory study considers the theories of innovation processes and innovation competences together and builds linkages between them. In the final contribution the integrated model of innovation process and competences will be introduced. This model helps education planners and teachers to develop higher education and pedagogical practices and students to understand the importance of innovation competences when they participate real development activities and innovation processes in working life.*

**Keywords:** *Innovation competence, innovation process, product and service development, higher education, exploratory study*

## 1. CHALLENGES FOR HIGHER EDUCATION

Rapid changes in working life are challenging higher education institutions to respond to new demands and to focus on the competences they produce. Working life requires from graduates more than just excellent knowledge of the substance. The role of higher education is not only to educate undergraduates to future work but to train future employees who are capable to develop working life and their own work tasks which generate innovations.

Smart, sustainable and inclusive growth is set as the targets in the communication from the European Commission “Europe 2020”, the strategy leads to the creation of an “Innovation Union” which aims to improve the framework conditions for research and innovation and this way to ensure that the transfer from innovative ideas into innovative products and services succeeds (European Commission 2010). This initiative underlines the importance of innovations in all sectors of economy. There is an urgent need for future professionals who can contribute to the creation of the “Innovation Union”. Innovations

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<sup>1</sup> Both authors, Räsänen and Putkonen, have contributed this article in similar amount.

can be related to products and services but also to the ways of working and thinking (Khalaf Alhartley et al. 2013).

Higher education represents a critical factor in innovation and human capital development and plays a central role in the success and sustainability of the knowledge economy (Välimaa & Hoffman 2008). Although, it has a very central role in the development of human innovation skills, several studies have shown that higher education institutions are not able to respond to these changing demands of skills (Badcock et al. 2010). According to the report (Tremblay et al. 2012) of Assessment of higher education learning outcomes (AHELO), 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 few countries and higher education institutions have embraced this approach. This has led to increasing pressure for education to equip their students with skills beyond disciplinary content knowledge that can be broadly applied across different contexts. (Badcock et al. 2010; Chung 2011).

Learning outcomes, competences, can be seen in the context where knowledge, skills and attitudes are all integrated and combined together (Harden 2002). Innovation research emphasises the similar elements when creating innovations. The well-known context where innovation competences are needed and applied is the new product development (NPD) process. In the past, a highly competent group of designers performed new product development based on their individual knowledge and skills only. The traditional movement of NPD studies has emphasised the importance of understanding a wide variety of product related requirements in order to be successful. Cooper (1996) argued that an efficient project management supported by a systematic NPD process is a very important success factor of NPD. By contrast, the creation of innovation is nowadays global and designers have to work in challenging distributed design environments (Putkonen 2013). In NPD, overlapping and interdependencies between tasks are normal and collaboration and team working are therefore fundamental elements of the design work.

We argue that the success of an innovation process is not related to the knowledge of a subject specific team only, i.e. a design team, but to the other type of skills and attitudes as well. We call these skills and attitudes innovation competences. The aim of this study is to demonstrate how the different phases of an innovation process call for different kinds of innovation competences to produce successful results. This is an exploratory study which considers the theories of innovation processes and innovation competences together and builds linkages between them. In the final contribution the integrated model of innovation process and innovation competences will be introduced and discussed.

## **2. INNOVATION COMPETENCES AS LEARNING OUTCOMES**

Traditionally, the role of education has been to give knowledge-based readiness, which later would be applied in practice to various innovation processes in working life (Chung 2011; Tynjälä et al. 2003). Innovation pedagogy contributes to the development of new generation of professionals whose conceptions of producing, adopting and utilizing knowledge make innovative thinking and creating added value possible. Innovation pedagogy introduces how the development of students' innovation skills from the very beginning of their studies can become possible in emphasizing interactive dialogue between the educational organization, students, and surrounding working life and society. (Kairisto-Mertanen et al. 2011; Kairisto-Mertanen et al. 2012.)

Innovation competence as a learning outcome consists of knowledge, skills and attitudes. They enable students to participate in innovation activities and contribute to creating

innovations. Kairisto-Mertanen et al. (2011) have defined these generic skills, the capacities and skills that make innovation competence, in individual, interpersonal and networking dimensions. Räsänen et al. (2015) have researched innovation competences in higher education and redefined competences further. According to them innovation competences include five sub dimensions: creative problem-solving skills, systems thinking, goal orientation, team working and networking skills. Student's contribution for an innovation process can be observed through these dimensions. Innovation competences are generic by nature and expected in all study fields in higher education as well as in all fields in businesses and organizations.

### ***2.1 INDIVIDUAL DIMENSION OF INNOVATION COMPETENCE***

The individual dimension of innovation competences identify an individual person's capabilities of being involved in the different innovation processes of the organization. Organizations are made up by people so it is essential that the people are capable of being innovative and producing something new, the learning of the organization is related to the learning of its employees (Sinkula et al. 1997). Innovation calls for the members of the organization to continuously question their beliefs and behavior (Assink 2006). A capability of solving problems and an ability to think independently are also needed in order to participate in innovation work (van Kleef & Roome 2007). The process of generating new ideas is not the same as applying these ideas in practice, and calls for dealing with different critical incidents, problems and tasks that require innovative thinking and responses so as to overcome any difficulties that might arise (Berdrow & Evers 2010). The individual scale of innovation competences focuses on target-oriented and tenacious actions, independent thinking and decision-making, creative problem-solving and development of working methods, persistence, risk taking and personal outlook.

### ***2.2 INTERPERSONAL DIMENSION OF INNOVATION COMPETENCE***

In order to innovations and new ideas not to stop on the individual level the dimension of social competences has also been taken into account in the definition of innovation competences. A characteristic of today's professional expertise is its highly social nature. Organizations are based on ideas of team work and network. Communication skills are needed to transmit the knowledge and the information and at the same time to build networks between human beings. Nowadays, also innovation is most often considered to be a result of cooperation in normal social and economic activities (Melkas & Harnaakorpi 2012). An employee has to be able to learn from the others and has to be able to utilize others expertise and thoughts (Alberts 2007). According to Sáenz et al. (2009) the concept of innovation has been closely related to that of "knowledge creation". The process of innovation consists of an ongoing pursuit of harnessing new and unique knowledge. To create new knowledge and produce innovation involves a continuous process by interacting and sharing tacit and explicit knowledge with others. It is vitally important that an organization also makes sure that the conditions for organizational learning exist. Sharing information and building trust and the best possible atmosphere for innovation work are crucial parts of enhancing the innovation capability of organizations (Khalaf Alharthey 2013; Sáenz et al. 2009). Collaboration and interpersonal skills are becoming important when considering the innovation skills of employees. These skills are effected on workers' innovation performance (Tsai et al. 2010). The interpersonal dimension of innovation competences is based on communication, teamwork, and team leadership.

### **2.3 NETWORKING DIMENSION OF INNOVATION COMPETENCES**

Networking competences form the third level of innovation competences. Networking plays a central role in the process of innovation (Hillier & Figgis 2011; Ronde & Hussler 2005, 1151). By Melkas & Harmaakorpi (2012), innovativeness depends in such cases rather on the innovation network's ability to interact than on an individual actors' progress in a particular scientific field. Multidiscipline understanding is one of the factors in knowledge-creating organizations (Alberts 2007). People who innovate not as simply lone thinkers but as members of a community, experts working in collaborative teams, share their knowledge with others in their own discipline and with experts from other disciplines by communicating over multiprofessional networks. (Tynjälä et al. 2003, 158). Customers' participation, interaction and networking with external environment such as universities and suppliers seems to have a positive effect on innovativeness. Also deliberate actions are important for improving regional innovativeness. (Rondé & Hussler 2005.) An organization's ability to network in a transparent way is shown to contribute to its innovation success. The most valuable advantage derived from networking is acquisition of new customers, improving special competences and mental wellbeing. (Ritter & Gemünden 2004.) Innovation must go hand in hand also with ethical values and social responsibility (Mulder et al. 2007), which includes sustainability (Hamzah & Abdullah 2009). The network dimension of innovation competences covers an ability to create and maintain working connections, an ability to work in networks, an ability to cooperate in a multidisciplinary and multicultural environment and an ability to communicate and interact in an international environment.

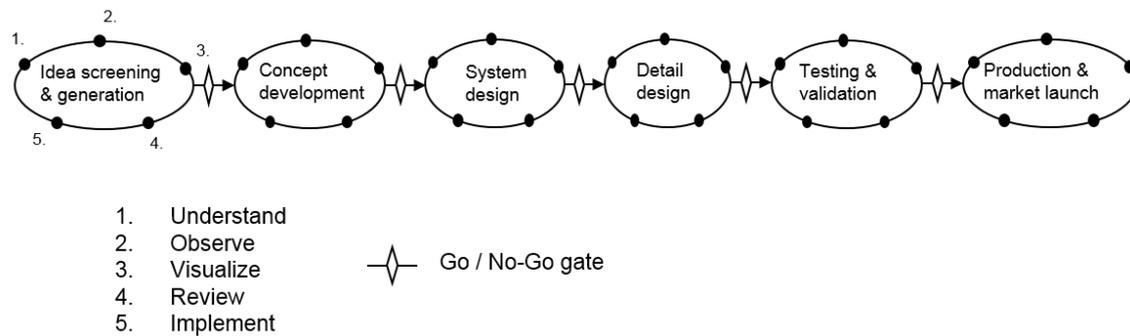
## **3. PRODUCT DEVELOPMENT - ILLUSTRIOUS INNOVATION PROCESS**

The context where innovation competences are often required and applied is the new product development (NPD) process. In the product development the knowledge is used for creating new artefacts or for improving the existing ones. This kind of innovation process can be seen as a knowledge transformation process from an idea to a system, and the system is formed within the limits of the designers' (all people involved) cognitive and information capacities (Nevala 2005). The problem is always unique and specific, and thus design knowledge and skills must be translated to support the specific case. We can examine product development activities as a typical innovation process.

### **3.1 LINEAR AND ITERATIVE NPD PROCESS MODELS**

Various strategies, approaches and methodologies have been developed for enhancing the NPD process. Among these are: structured, hierarchical design techniques (Pahl et al. 2007), methodologies emphasising user needs (Maguire 2001), methods mapping user requirements to design attributes (Suh 1997) and gate reviews of project management (Cooper 1996). The purpose of all these different approaches is to finger the direction towards the efficient and successful innovation process.

Typically, the NPD process has been divided into phases in a timeline from the product idea to the market launch (Figure 1). Each stage is designed to gather information and perform all the tasks necessary to progress in the project. (e.g., Ulrich & Eppinger 2004; Cooper 2004.) These processes depict the phases of development for the project management purposes, but they do not address the required knowledge, skills or attitudes i.e. innovation competence.



**Figure 1. Typical description of linear NPD process.**

According to Pahl et al. (2007) the product development consists of the following stages: problem definition, concept planning, rough planning and planning of details. Cooper's (1996) Stage-Gate-Model consists of five stages; preliminary investigation, detailed investigation, development, testing and validation, full production and market launch. Each stage is designed to gather information and perform all the tasks necessary to progress in the project. Between the stages there are entry gates or decision points where the results of the actions of the previous stages are reviewed and the quality of deliverables is checked.

Above depicted NPD process supports the design and development of new products by offering systematic phases to gather information and perform all the tasks necessary. Often the front end of the process is focused, exploring the needs and requirements of users and other stakeholders. However, designers are increasingly considering a product's entire life cycle, from investigating the environmental, social and economic impacts of a new product to its final disposal and recycling (Milton & Rodgers 2013). Usually, it is not possible to master all the needed knowledge in the front end of the process, thus instead of a linear NPD model an iterative design strategy is useful to employ. This approach is especially valuable when completely new ideas and clients are addressed and type of innovation is radical.

Milton and Rodgers (2013) divided the iterative design process in seven phases; opportunity identification, brief and specification, concept design, design development, detail design and production. Process begins with the identification of needs, desires and problems needed to be solved. All this information forms the briefing of the design and acts as basis for the product design specification. The aim of the concept design phase is to create a number of alternative preliminary designs having solution potential. The chosen concept is developed further to satisfy the requirements of the product specification during the phases of design development and detail design. The final phase focuses on determining what processes and production technologies should be employed. Even if the above described design process is sequential on the higher level, according to Milton and Rodgers (2013) every phase undertakes an iterative set of five step cycles; understand, observe, visualize, review and implement. Every individual phase of the design process begins with the discussion about the design status, users' needs and which design specifications are being met or not so far in order to truly understand what design activities are required next. This is followed by a series of observations by users to determine what is required in the context of real use. The visualization phase produces concept communication means for all design stakeholders to critically analyse and review the design outputs. If the feedback is satisfactory the design team can proceed to the next phase of the design process or conversely, the design team has to undertake an other iteration cycle priors to continuing to the next phase.

#### 4. RESEARCH OBJECTIVE AND METHODOLOGY

The aim of this paper is to combine specific areas from innovation research, higher education strategies and design science and to create an illustrative model how the different phases and tasks in the innovation process are calling and benefiting from distinct innovation competences. Later this model will be tested empirically and utilised as a base on the formation of the theory. This exploratory study is part of a larger doctoral dissertation research.

The identification of the research question is based on the strategy of the European Union which aims to improve the framework conditions for research and innovation and this way to ensure that the transfer from innovative ideas into innovative products and services succeeds (European Commission 2010). Theoretical framework of the paper is based on the earlier studies of innovation pedagogy (Kairisto-Mertanen et al. 2011; Kettunen et al. 2013; Räsänen et al. 2015) and on the research of design science concerning new product development processes (Cooper 2004; Ulrich & Eppinger 2004). These studies are used to better understand the relationship between innovation competence and the phases of the innovation processes and consequently also to understand the role of the different innovation competences for successful design.

The integrated model of innovation process and innovation competences is constructed by using the above studies as theoretical framework. Key variables and characteristics of an innovation process are described on a spreadsheet format where the typical steps, demands and resources of design work are compared with the innovation competences of designers. Validation of the constructed linkages is made by comparing the results with the earlier studies and by logical reasoning discussed at the end of the exploratory study.

#### 5. INTEGRATED MODEL OF INNOVATION PROCESS AND COMPETENCES

Above mentioned product development activities are designed to gather information and perform all the tasks necessary to progress in the different innovation processes. Between the stages there are entry gates or decision points where the results of the actions of the previous stages are reviewed and the quality is checked.

Table 1 describes how the different types of knowledge and innovation competences are used and assimilated during the phases of an innovation process to make it succeed. When completely new ideas and clients are addressed and the type of innovation is radical, an iterative NPD model is useful to employ by repeating distinct stages until the results are satisfactory.

<b>Stage of innovation process</b>	<b>Targets of design</b>	<b>Specific innovation competences required</b>	<b>Description of competence</b>
Idea screening and generation	Present service or product improvements, new technical solutions, cost reductions or process improvements	Creative problem-solving, Systems thinking, Team working, Networking	Ability to see new possibilities everywhere and holistic comprehension about the relations between subjects. Ability to spread new ideas widely in cooperation with other people.

Develop a concept	Holistic and common understanding of a problem and its potential solutions.	Creative problem-solving, Team working, Networking	Ability to think independently but same time willingness to listening others and utilize their expertise for problem solving. Ability to communicate to transmit and share the knowledge and new ideas in team.
System design	Defining the elements of a product or service that it meets the requirements.	Systems thinking, Goal orientation, Team working	Ability to analyze the relationships between the system's parts in order to understand a situation for better design. Ability to work persistently to achieve the goals. Ability to interact and share knowledge with others, understand principles.
Detail design	Design information in a form of plans, drawings, calculations, diagrams, models, or prototypes	Goal orientation, Team working	Ability to concentrate on relevant points to achieve a goal. Ability to interact and share knowledge with others, understand details.
Building the system	Realisation of design, sharing of practical experiences, social context and team collaboration	Team working	Ability to take group members' viewpoints into account and productive cooperation with people coming from different cultural backgrounds.
Testing and validation	Confirming that the build system meets the requirements and performs as planned.	Systems thinking, Goal orientation	Ability to consider a product on very details level and concurrently understand a product as a part of larger system.
Market launch and delivery	Introduce a product first time into the market and organize easy access to it for customers.	Networking	Ability to utilize external network and productive cooperation with professional from different fields.

**Table 1. Descriptions of innovation competences required during an innovation process.**

### **5.1 INNOVATION COMPETENCES NEEDED TO MAKE INNOVATION PROCESS SUCCEED**

Cooper, the creator of one well known linear process model, emphasises (Cooper 2008) that applying a systematic approach with process phases is not the guarantee of success, but instead, better cooperation should be achieved in design teams and companies. As

referred earlier, the NPD process models only give principles or templates on how the innovation process flows in the ideal world. As long as the individual competence dimension is missing from innovation process descriptions, organisations will meet difficulties to turn these theoretical models into successful practices. Kairisto-Mertanen et al. (2011) defined the three levels of innovation competences: individual, interpersonal and networking. Räsänen et al. (2015) divided these levels to five sub dimensions: creative problem-solving, systems thinking, goal-orientation, team working and networking. All these dimensions are utilized in the Table 1 when forming an integrated model combining the innovation process and the competences.

#### *5.1.1 CREATIVE PROBLEM-SOLVING, GOAL ORIENTATION AND SYSTEMS THINKING*

Akgün et al. (2006) has stated that team information acquisition and sense-making within the team increase team intelligence, which helps the team members understand each other. It appears that understanding the socio-cognitive processes in the team facilitates learning and the team's ability to convert the problems into more versatile solutions. Information sharing and collaborative sense-making aims to encourage team members to communicate and negotiate with others to ease decision making and problem solving.

Innovativeness is a common valuable characteristic of designers. In addition, personal initiative and support from the organisation are necessary elements to implement creative ideas in the products. Janssen et al. (2004) emphasised that other personal qualities such as orientation in details and exactness are important for the creative designer to reach sufficient levels of quality and efficiency.

Pahl *et al.* (2007) have argued that design problems begin at the system level. This means that the whole problem has been understood and defined at the system level and then divided into subsystems and so forth, down to individual components that can be designed using the engineering knowledge and traditional analysis methods. The systems approach (Sterman 2000, Rodrigues et al. 2006) seems to be a missing perspective in many innovation processes. Often, the risks in design and product development are realised when the design teams do not understand the overall system and thus leave some important factors outside their considerations.

#### *5.1.2 COOPERATION AND KNOWLEDGE SHARING IN TEAMS AND NETWORKS*

The amount of information needed for successful product development is huge, and thus it is unfair to expect that an individual designer can manage all the relevant information and apply it during the design process. Therefore cooperation, knowledge sharing and external networks are important parts of team working in an innovation process where many different stakeholders collaborate. Instead, the management should organise the design in a way that supports teamwork and externalisation of the knowledge of the entire design team and the users. Still, individual creativity and intuition have a place among engineering methods when solving technical problems.

## **6. DISCUSSION AND CONCLUSIONS**

Previously knowledge, skills, or attitudes, i.e. innovation competences, were not required in the depiction of the innovation processes. This model describes which kind of innovation competences are needed in the different phases of the process. In this study we used a well-known product and service development process as an example to demonstrate the theme but the model could be applied in other fields as well. However the conclusions have to be considered carefully, because the results are based on exploratory study and a limited viewpoint. Although empirical data and a larger literature review are needed, the study gives an important perspective to the theme already. This model shows that innovation competences are generic by nature and that they are not

labeled to belong only to a specific phase of the processes. They are important in the whole process and expected in all fields in businesses and in organizations.

A capability to take part in the different innovation processes or to participate to some part of that can not be learn by books. It needs practicing and learning by doing. Therefore pedagogical practices in higher education should be formed to mirror the innovation processes. This model applies earlier innovation theories in the field of higher education and helps education planners and teachers to develop higher education and pedagogical practices to correspond to the new demands. It also helps the students to understand how important the application of innovation competences is in the innovation processes and in working life in general. When trying to respond to the challenge of today and build an "Innovation Union" we must start concentrating to this already during the beginning of the studies. Developing innovations calls for new methods and ways to think, enthusiastic people and supportive environments. The same elements are required in higher education as well.

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