

# Rapid Product Development in University-Industry Collaboration: Case Study of a Smart Design Project

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*“ He will win who, prepared himself, waits to take the enemy unprepared.”*

Sun Tzu  
Chinese Philosopher

University-industry collaboration aims at mutually beneficial knowledge and technology exchange between higher education and business. Prototyping new products is one sweet spot where industry can gain new valuable knowledge and understanding of technology, while higher education institutions develop the skills and competences of students by encouraging them to work on authentic real-life problems. From the “design thinking” perspective, rapid product development can be defined as the creation of new products, in the shortest timescales possible, that meet the criteria of desirability, feasibility, and viability. This article addresses rapid product development by presenting a case study of developing prototypes in university-industry collaboration. As a result, the study highlights key design principles, such as the importance of involving teachers, business representatives, and students in collaborative project design, of focusing on the customers or service users who will benefit from the design, and of guiding students participating in co-creation activities. Presenting conclusions for both academics and the industry, the article contributes to design thinking and rapid product development in university-industry collaboration.

## Introduction

Companies’ ability to innovate is more important than ever for improving their profitability and maintaining competitive advantage (Artz et al., 2010). Yet research has shown that only one out of four newly-developed products are a success (Evanschitzky et al., 2012), and approximately 40-50% of resources invested in product development are wasted on cancelled products or projects that yield poor results (Menold et al., 2016).

One reason for failure is a lack of flexibility in traditional research and development approaches that are typically based on waterfall development processes (Royce, 1987; Camarda et al., 2019). In contrast to traditional R&D approaches, where each functional department (for example, mechanical, electrical, software, manufacturing, service etc.) contributes sequentially to product development, more flexible approaches have

been proposed, such as set-based design, originating from Toyota’s product design and development system (Sobek et al., 1999; Camarda et al., 2019). In set-based design, several alternative technological functional solutions are developed in a parallel process, thus enabling a shift between alternative solutions to take place at the very end of the product development cycle, with little or no need to return to earlier stages in the design process (Camarda et al., 2019).

Design re-use is one alternative solution for speeding up product development.

In the case available, pre-existing designed hardware and/or software modules, with well-defined interfaces, can be repeatedly reused in subsequent designs, which can lead to reduced cycle times and result in shorter time to market (Höltkä-Otto & de Weck, 2007). Shorter time to market and the increased fulfillment of customer

## Rapid Product Development in University-Industry Collaboration: Case Study of a Smart Design Project *Jari Jussila, Jukka Raitanen, Atte Partanen, Vesa Tuomela, Ville Siipola, and Irma Kunnari*

needs were also the motivations behind a new stream that originated from the Silicon Valley startup scene, which is promising to radically transform product development practices. Customer development methodology began to question the narrow emphasis on product development and argued that companies should focus on learning about customers and their problems as early as possible in the product development process (Blank, 2007). What followed was the emergence of process models and canvases intended to guide the development of minimum viable products (Ries, 2011; Blank, 2013) or minimum desirable products (Sarvas et al., 2017; Pulkkinen et al., 2019) with the aim of delivering products both that customers desire and that are viable for the business.

“Design thinking” originated in the 1950s (Arnold, 2016), yet has recently gained popularity in business world (for example, IDEO, 1978), and gathered traction as an idea positing that any kind of business or organization can benefit from insights arising from a designer’s way of thinking and working (Tschimmel, 2012). In design thinking, the lack of a design’s desirability from the human point of view, the lack of technical and organizational feasibility of a design, along with the lack of financial and economic viability of a design from the organization’s point of view (Plattner et al., 2010; Faljic, 2019), are considered central challenges. Following the logic of design thinking, rapid product development can be defined as the development of new products in the shortest timescales possible, whilst ensuring that the criteria of desirability, feasibility, and viability are met. Rapid product development in university-industry collaboration therefore needs to address these design specifications, and aim to deliver new products to organizations in the shortest possible time, while simultaneously developing student competencies and achieving targeted learning outcomes (Biggs & Tang, 2007; Kunnari et al., 2019).

Our main research question for the study is as follows:

*What kind of design principles enable successful rapid prototyping in university-industry collaboration?*

In the pursuit of our research aim, the article is structured as follows. In the introduction, we first define our concepts, namely, rapid product development and pedagogical goals in university-industry collaboration. In the following two sections, the literature on co-creation in university-industry collaboration and on co-

creation pedagogy is discussed to frame rapid product development in university-industry collaboration. The case study and method description involve the presentation of a multiple embedded case study of smart design projects carried out in 2019. In the findings section, we describe what we learned, outline design principles that were found to be conducive to successful rapid prototyping in university-industry collaboration, and explore how teachers can play a supportive role in facilitating the process. In the conclusion, we contemplate the results of the case study and consider their significance to design thinking and rapid product development in university-industry collaboration.

### **Co-creation in University-Industry Collaboration**

Innovation is seldom a straightforward activity. It can be characterized as uncertain, co-constructive, experimental and interactive (Edvardsson et al., 2011; Jussila et al., 2019). Vargo and Lusch (2014) argue that the customer is always a co-creator of value, which is also the case in university-industry collaboration. University-industry collaboration aims at mutually beneficial knowledge and technology exchange between higher education and industry. Despite the growing interaction between higher education and industry, partners in university-industry collaboration often have challenges in utilizing the results of their joint efforts (Pennacchio, 2016; Kunttu, 2019). One root cause for the challenges is that the primary goal of universities is to create open and public knowledge, and provide education (Lee, 2011), whereas industrial partners have a strong focus on capturing valuable knowledge that can create competitive advantage, which is often directly associated with new product development and innovative company functioning (Bruneel et al., 2010; Lee, 2011). Thus, seemingly contradictory objectives, organizational goals, and culture have been found to limit the positive effects that can be achieved through university-industry collaboration (Gomes et al., 2005; Kunttu & Neuvo, 2019). Prototyping new products is one sweet spot where industry, as a customer for universities, can gain new knowledge and understanding of technology, and where higher education organizations can develop their students’ skills while working to solve authentic real-life problems.

Several models have been introduced to enhance co-creation in university-industry collaboration. One of the most well-known models is the Triple Helix (Etzkowit, 2003) principle that is based on the institutional triangle of government, business, and academia. The

## Rapid Product Development in University-Industry Collaboration: Case Study of a Smart Design Project *Jari Jussila, Jukka Raitanen, Atte Partanen, Vesa Tuomela, Ville Siipola, and Irma Kunnari*

entrepreneurial university, following the Triple Helix principle, encompasses a 'third-mission' of economic development for universities, in addition to their research and teaching remit (Etzkowitz et al., 2000). Economic development can, for instance, take the form of delivering products and services (Kunnari et al., 2019) for business as part of education. Governments can support such activities by, for example, funding research and development projects that involve both business and academia. Carayannis and Campbell (2010) have further extended the Triple Helix model by introducing additional element of citizens and users to the institutional triangle of government, business, and academia, thus forming what has been termed the Quadruple Helix.

### Co-creation Pedagogy

Co-creation pedagogy relies on the presence of common characteristics of competence-based education, as presented by Koenen, Dochy and Berghmans (2015). It includes the allocation of realistic tasks, the conduct of study in authentic settings, students' willingness to assume responsibility for their learning, reflection on the learning process, the performance of a facilitating role by teachers, and the use of competence-based

assessment methods. When providing competencies to meet the demands of a rapidly changing and disruptive business world, flexible and innovative approaches to learning are crucial. Learning is not just for students, but also for teachers and business professionals (Kunnari et al., 2019).

Similar to the triangle in the Triple Helix model, co-creation pedagogy is based on the collaboration of students, teachers, and business representatives as important co-contributors (Kunnari et al., 2019). In order to correspond to a real working environment, the challenges and problems to be solved in co-creation pedagogy are designed together with the business world (Figure 1). Students are key actors in creating solutions for business, while the teachers' role is to guide the process. Inclusiveness is supported both by the teamwork of teachers and the collective learning of students. A very important principle is the freedom to ask questions, which means that students can always consult with teachers during the project work, in order to discuss and obtain advice on their problems. Guidance can also involve the development of specific skills, for example, how-to 3D print or laser cut shapes using various materials. Co-creation pedagogy thus emphasizes learning-by-doing by providing an authentic

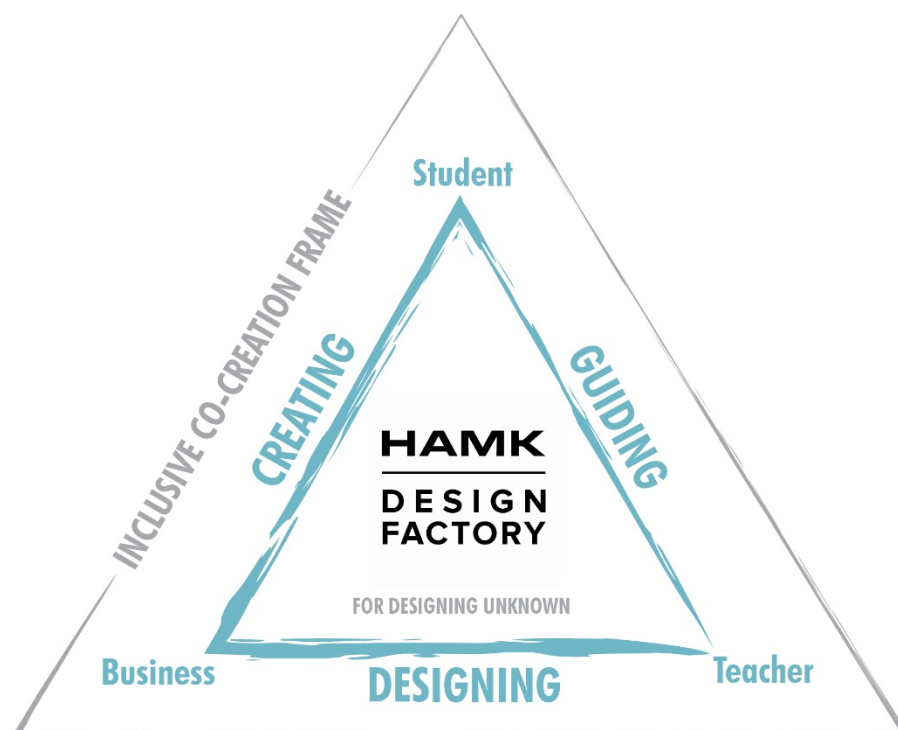


Figure 1. Co-creation Pedagogy

## Rapid Product Development in University-Industry Collaboration: Case Study of a Smart Design Project *Jari Jussila, Jukka Raitanen, Atte Partanen, Vesa Tuomela, Ville Siipola, and Irma Kunnari*

context where developing student competencies and targeted learning outcomes are tied to real and meaningful problems in the business world (Lombardi, 2007; Herrington et al., 2014).

Business challenges are often ambiguous, unpredictable and messy, involving many unknown factors (Faljic, 2019), and there is very seldom one single solution for any challenge. That is why the co-creation pedagogy, design tools and mindset provide a good model for building interdisciplinary student teams to solve ambiguous challenges. Businesses are often learners themselves in the process. In co-creation pedagogy, the shared journey itself is valuable, rather than only the end result. Co-creation pedagogy allows the formulation of a response to the original project challenge and, when found desirable, feasible and viable, also allows for course correction, that is, pivoting (Ries, 2011). Several iterations of any solution may also be devised, based on the active learning that occurs throughout the project's duration.

### Design Thinking

The concept of “design thinking” is a simplified approach where problems are approached and solved through collaboration and systematically creative methods. It is a non-linear approach that enables challenges to be resolved through iteration. The key characteristics of design thinking methodology are that it offers person-centered and cross-disciplinary ways of identifying creative solutions to problems. Design thinking methodology aims to develop a holistic view of the subject, meaning that it focuses on the needs, values, and experiences of all stakeholders in order to obtain the best possible solution to a given problem through collaborative work (Luchs et al., 2015). Design thinking supports the mindset of co-creation pedagogy as both their key characteristics and methods arise from equal, multidisciplinary co-creation and person-centered approaches.

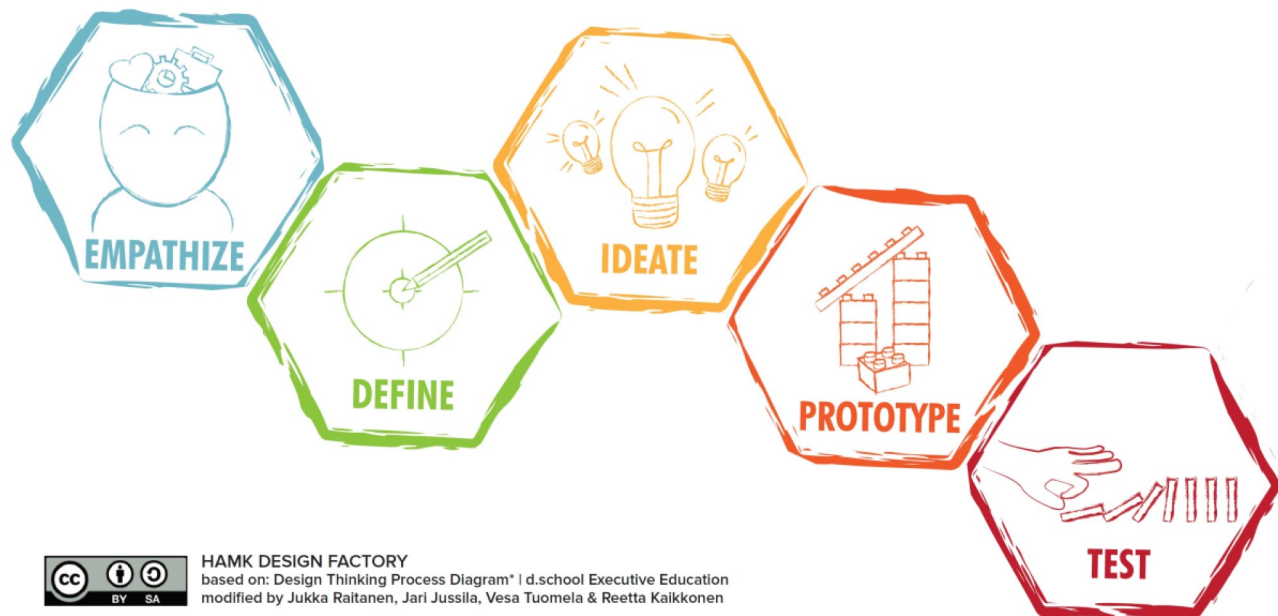
Several process models have been proposed and defended as the most appropriate for applying design thinking in business and innovation (Tschimmel, 2012). Some of the most well-known models include the 3 I model (Brown, 2009) and the HCD model (<http://www.ideo.com/work/human-centered-design-toolkit>), both developed by IDEO, the double diamond model from the British Design Council (<http://www.designcouncil.org.uk>), the service design model (Stickdorn et al., 2011) and the design thinking

model of the Hasso Plattner Institute ([http://www.hpi.uni-potsdam.de/d\\_school/designthinking](http://www.hpi.uni-potsdam.de/d_school/designthinking)) (Tschimmel, 2012). A variant of the design thinking model (Figure 2) of the Hasso Plattner Institute was selected as the process model in this study, as it has been previously applied in courses by the authors conducting the case study. The design thinking process has five aligned stages, but acts as a non-linear process where different modes contribute to the whole. The five stages of the process are: Empathize, Define, Ideate, Prototype, and Test. The goal of the process is to gain understanding of the users, confront their assumptions, define the frameworks in which problems exist, create new and tangible solutions for prototyping, and test the prototypes in real environments where meaningful data can be generated (Interaction Design Foundation, 2019).

The first stage of the design thinking process is to empathize and understand the problems the team strives to solve. Empathizing provides the platform that enables the information gathering necessary to locate enough information about the users, their needs, the user context, and any existing problems in the status quo. The second stage, Define, guides the team to gather data from multiple sources, and transform it into information. The real problem should then be identified, and user-centered problem statement clarified, in the Ideate stage. Ideating is literally the stage for creating new ideas from conducted research, for seeking alternative ways to solve the acknowledged problems, and for using ideation tools to create a vast array of new ideas. From ideation, the process proceeds to the Prototype stage, where the created ideas are sorted, and the most viable ideas investigated and subsequently improved or rejected. Prototyping will show the restrictions regarding the problems and products and provide a clear vision of how the final product will operate (Interaction Design Foundation, 2019).

Throughout the design thinking process, different questions arise during each phase. In the Empathize phase, the major questions, for example, are: Who is the user? What is the user's job to be completed? Where is the user doing this job? What is the purpose of the job to be undertaken? What is currently preventing the user from tackling this job? What are benefits of the job to be done? In the Define phase, typical questions may be: What is the problem worth solving? What is causing the problem? What are elements of the problem? What is nature of the problem? Which part(s) of the problem should be solved? Why has the problem occurred? In the

## Rapid Product Development in University-Industry Collaboration: Case Study of a Smart Design Project *Jari Jussila, Jukka Raitanen, Atte Partanen, Vesa Tuomela, Ville Siipola, and Irma Kunnari*



**Figure 2.** Design Thinking Process

Ideate phase, typical questions formulated, for example, may be: How might we solve this? (Berger, 2012) How might we design a solution? In the Prototype phase, a typical question is: How can we construct a model that would change the user experience? (Berger, 2012). In the Test phase, key questions include: What is the riskiest assumption we should test? What is unknown and important to test and know? Thus, learning through inquiry, during every phase of the design thinking process, is essential.

### Case study: A Smart Design Project

We chose a case study approach (Siggelkow, 2007) to explore rapid product development in university-industry collaboration. In our case study, the theories of co-creation, design thinking, and rapid product development were identified via the existing literature. Next, an embedded multiple-case study was carried out in 2019 using action design research methodology in a university-industry collaboration involving two external organizations: a glass factory and a startup company. The context of the case study is an interdisciplinary Smart Design Project organized at HAMK Design Factory.

HAMK Design Factory is the twenty-fifth design factory to join the Design Factory Global Network (Björklund et al., 2019). Located in Hämeenlinna, Finland, it provides an interdisciplinary product, service design, and

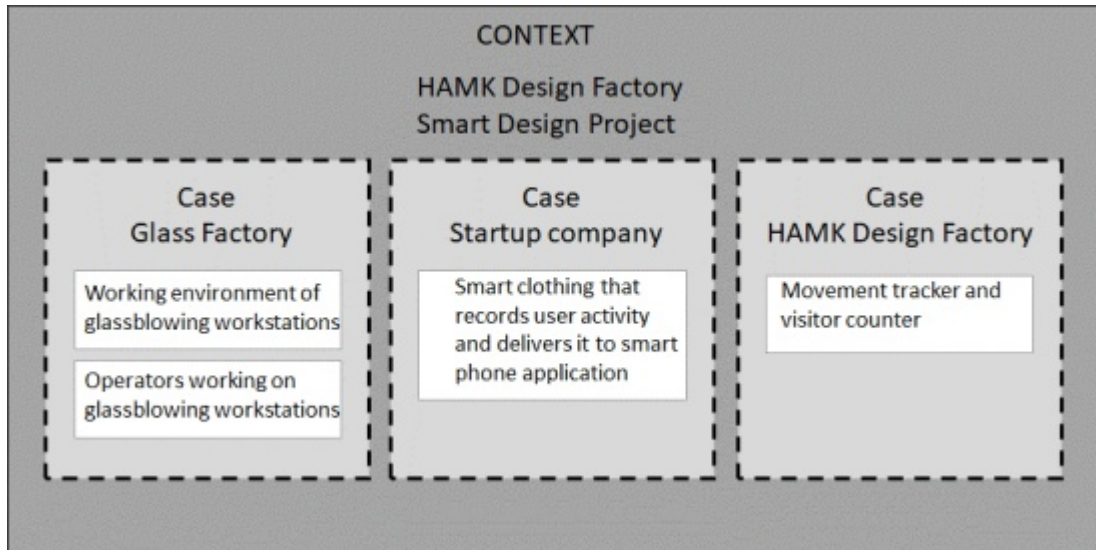
learning platform that unites students, teachers, researchers, and industry professionals (Jussila et al., 2019). The Smart Design Project organized in HAMK Design Factory lasted from June 10th to July 3rd 2019, and involved a course for students from mechanical engineering and production technology, electrical and automation engineering, business information technology, and construction engineering.

The idea of the course was to instigate intrinsically-driven development action that would result in the co-creation of a new smart design prototype to meet the specifications of the project challenge design. Originally, there were five project challenges, and students selected four of them to work on. The teaching staff belonged to Design Factory and School of Business and Entrepreneurship at Häme University of Applied Sciences, and were business, technology, and design lecturers. The project challenges were co-designed with representatives from the case organizations, and these challenges were then presented to the participating students.

The targeted learning outcome of the course were that each student team would create a rapid prototype of the project challenge in four weeks, while simultaneously developing new competences, such as design thinking, service design, 3D-modeling and printing, and working with programming microcontrollers. A design thinking process (Figure 2) was used as the process model for the

## Rapid Product Development in University-Industry Collaboration: Case Study of a Smart Design Project

*Jari Jussila, Jukka Raitanen, Atte Partanen, Vesa Tuomela, Ville Siipola, and Irma Kunnari*



**Figure 3.** Case Study Description

case projects.

The glass factory was a business owner in two of the project cases. The glass factory cases were both related to developing employee wellbeing at glassblowing workstations in the glass factory. The challenge was to gain new knowledge and understanding of the working environment and conditions that surrounded the glassblowing workstations, as well as to increase the wellbeing of the operators who perform glassblowing. The startup company was owned by a business working on the development of smart mobile phone applications that would collect data on users' activities, and use this data to engage and reward users based on their behaviors. HAMK Design Factory, in addition to providing the context, was also the owner of a case study focused on developing movement counters and visitor tracking for factory spaces.

### Findings

The students were first introduced to design thinking and service design. However, the application of the design thinking process was not uniform in the case projects. The degree to which each student team followed a design thinking process is illustrated in Table 1. Each team ideated one or more prototypes to be built during the four-week period. Only one student team was successful in testing their prototype during the four-week duration.

Due to the time limitation of the project, the students

aimed to rapidly devise solutions and, for the most part, swiftly advanced through the Empathize and Define stages. A crucial advantage, during the first phases, was that the glass factory provided an opportunity to visit and explore the glassblowing workstations, and for the students to interact with employees that were participating in the development project. Progressing promptly into the Ideate and Prototype stages meant that neither the problem, nor the users' needs, were profoundly investigated in all the cases. Thus, the solutions created ran the risk of being irrelevant to customer goals. The glass factory played an active role also in guiding the teams from early stages of the process toward focussing on the meaningful aspects of glassblowing operations. An active approach from the customer helped both the students and teachers guide their activities towards a desirable outcome for all stakeholders.

A key finding from the glass factory case was that having an active partner to assist with the guiding process, and to provide valuable knowledge, was crucial for the student teams' success. This is due to the fact that with limited knowledge, both the Empathize and Define phases are prone to failure. Only the student teams that worked on the glass factory cases were able to develop a prototype during the four-week period. The student team working on a device for measuring workstations temperatures and environmental variables was able to develop and built a prototype that was sold and put to active use in the glass factory after the project. The students working on a smart vest for operators were able

## Rapid Product Development in University-Industry Collaboration: Case Study of a Smart Design Project *Jari Jussila, Jukka Raitanen, Atte Partanen, Vesa Tuomela, Ville Siipola, and Irma Kunnari*

**Table 1.** Design Thinking process steps applied in Smart Design Project cases

	<i>Empathize</i>	<i>Define</i>	<i>Ideate</i>	<i>Prototype</i>	<i>Test</i>
<i>Device for measuring workstations</i>	X	X	X	X	X
<i>Smart vest for operators</i>	X	X	X	0	-
<i>Steps and calories counter</i>	X	X	X	-	-
<i>Visitor counter</i>	X	X	X	-	-

to develop and document a concept for their prototype, although time ran out before they could build and test the prototype. The smart vest case can, however, be considered a success from the industry perspective since the learned experiences contributed to a bachelor's thesis that developed and completed the prototype after the project had ended.

An important finding from the startup company case was that the business owner defining the problem must be active throughout the project in order for the design thinking process to have a higher probability of achieving desired results. The business challenge can be made more tangible through discussions and meetings with different stakeholders. If the activities are lacking during the Empathize and Define phases of the process, the results will incur a greater risk of being vague, and of failing to deliver the desired value, both for the students and the business owner.

The HAMK Design Factory case yielded a similar finding: students may be competent at ideating autonomously, but, in order to improve the likelihood of attaining desired results, active interaction between the parties is required. In the three cases that did not achieve their desired goals, enhanced guidance from the teachers could have improved the results.

In summary, giving the students the freedom to operate relatively autonomously opens up unique study paths and solutions, and empowers the team members to act independently, thus transforming the role of the teacher into that of a coach. Having an active business partner to help with the advisory process and to provide valuable knowledge is crucial for ensuring the student teams'

success. When this guidance is lacking, teachers should adopt a more active role in facilitating interactions.

### Conclusion

Co-creating rapid prototypes in university-industry collaboration was found to be an exciting and meaningful learning experience. Success and failure, when evaluated in terms of desirability, feasibility, and viability, is mostly influenced by the co-design of the challenge by business professionals, teachers, and students. This combines with opportunities and activities designed to generate empathy with the user, defining the problem based on understanding the user and the customer journey, in addition to efforts taken to build and test the prototype. The challenge needs to be future-oriented, open, and ambiguous enough to facilitate and foster student autonomy in the project (Björklund et al., 2017), but not so future-oriented, open, and ambiguous that the students are unable to decide upon any definitive course of action.

Defining the problem without conducting the Empathize phase is a good recipe for creating unsatisfactory results from the user's point of view. This supports previous findings of the necessity of relational learning, which includes sharing knowledge, joint sense making, and integrating new knowledge into the relational memory of active partners (Kunttu, 2017; Selnes & Sallis, 2003). The teachers can indeed facilitate and support the Empathize phase, but based on this case study, the key to success is that industry professionals take an active role in the co-designing of the problem, as well as providing opportunities for students to empathize with end users. Recommended

## Rapid Product Development in University-Industry Collaboration: Case Study of a Smart Design Project *Jari Jussila, Jukka Raitanen, Atte Partanen, Vesa Tuomela, Ville Siipola, and Irma Kunnari*

practices for knowledge sharing include enabling students to visit the site, making observations and experiments, and interviewing users. Joint sense making can be enhanced by organizing workshops with industry partners, where both students and teachers participate. By working closely with industry partners, students can validate their learning at university by testing their theoretical assumptions and hypotheses against success criteria that are perceived as important by industry itself. The benefit for industry of being active in co-designing and on the Empathize phase is that they do not waste time and effort waiting for solutions that provide little value for them. In this way, they also learn valuable knowledge about the users and their needs. Direct interaction between students and industry partners also helps to foster trust between partners that has been found to simulate rich social and information exchanges, and encourage more and valuable knowledge sharing (Ring & Van de Ven, 1992; Kunttu & Neuvo, 2019).

The aim of integrating knowledge into the relational memory of project partners is most supported by the Prototype and Test stages, thus producing practical results (Kunttu, 2017). Previous research has discovered that a without a prototype it can be difficult to communicate and integrate knowledge across different professional and student boundaries (Björklund et al., 2017). This also happened in the cases during our research that did not reach the Prototype stage. The prototype developed for a glass factory was found feasible, desirable, and viable by the company, and was modified for continuous use by the factory's engineers. Whereas the other glass factory student project, in contrast, ran out of time for creating a physical prototype, it nevertheless created valuable knowledge that was continued in the form of a thesis project. This also shows that relationships between university and industry can develop during student projects that lead to deeper collaboration between the partners.

From the perspective of developing and organizing courses, we discovered that when students apply the d.School's five-step design thinking process for the first time, an additional preliminary step of Prepare must be undertaken, before the subsequent five steps, in order to fully orient the students into design thinking. In the Prepare step, introducing, defining, and absorbing the core concepts, as well as recalling a good product experience, are the proposed activities to be conducted as a way of inducting students or practitioners in design thinking. As for the definition of rapid prototyping in

university-industry collaboration, we propose that it can be measured in terms of time taken to successfully complete all the design thinking process phases. In design thinking philosophy, the prototyping project is not complete until the product is tested and assessed. The prototype testing, if found to be unsatisfactory with regard to desirability, feasibility, and viability, will nevertheless yield new insights about users and help in redefining the problem. Thus, design thinking steps need to be repeated until satisfactory results are achieved, or until it is decided to abandon the prototyping project in light of increased understanding and knowledge gleaned on the topic. From the higher education perspective, the failure of a rapid product development project undertaken collaboratively with industry can, however, provide a valuable learning experience, while the students' development of personal and professional competences is not tied to the project's results. The project thus provides the business owners with useful new information, even if the expected result was not achieved. As a process, it requires commitment in terms of communications, as there are several variables, and that all stakeholders have access to the same information on where the project is being taken during each of the different phases.

In the optimal situation, all vertices of the triangle (Figure 1), that is, students, teachers, and business professionals, jointly learn while co-creating a rapid prototype in the shortest feasible time interval. The experiences of our case study indicate that rapid product development in university-industry collaboration is mutually beneficial, and from the students' perspective provides an authentic and meaningful approach for developing competences for their future working lives.

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# Rapid Product Development in University-Industry Collaboration: Case Study of a Smart Design Project

Jari Jussila, Jukka Raitanen, Atte Partanen, Vesa Tuomela, Ville Siipola, and Irma Kunnari

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## Rapid Product Development in University-Industry Collaboration: Case Study of a Smart Design Project *Jari Jussila, Jukka Raitanen, Atte Partanen, Vesa Tuomela, Ville Siipola, and Irma Kunnari*

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