INNOVATION GENERATION MODEL – FROM INNOVATION PROJECTS TOWARS RDI PROJECT CONSOTIUMS AND BUSINESS ECOSYSTEMS

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ABSTRACT

The use of CDIO principles should have influence not only in learning outcomes but also in RDI and business driven activities. In this paper, we will report how these pedagogical methods have helped us in game development education and relatively vital RDI activities. In addition, some early phase influences have been identified also in business driven activities. As a result, we will present an Innovation Generation Model which will illustrate our strategy to utilize students' capabilities as an important factor in our RDI and business development. This Innovation Generation Model will be concretized with five case studies. The first one, called Pikkuli Case, will show how results achieved in innovation projects have been used as a seeds in an RDI project which has received significant external (both governmental and industrial) funding. The second case study namely Rockodile Games Case, in turn, will be used as an example of our Capstone innovation projects which have led to startup activities. In our third case called NeuroCar Case, we will focus on reporting how scientific research (namely cognitive neuro science) and our game development activities have led from innovation projects to a business driven RDI project with objectives to generate new business based on the achieved research results. In our fourth case called Bet-Ker Case, we show how integration of education and RDI project resulted into an innovative marketing and sales tool which was created by game programming for a refractory materials and components manufacturing company. Finally, in our fifth case, we will show how integration of education and RDI projects have led to startup activities, commercialized web-based 3D interior design product and an innovative educational tool for interior design education in a 3D virtual spaces.

KEYWORDS

Capstone, CDIO, Innovation project, RDI, Startups, Standards: 1, 3, 5

INTRODUCTION

The use of CDIO standards (CDIO, 2015) has impacted engineering education significantly during the last few years. In this paper, we are interested in which kind of a role CDIO has had in our Research, Development and Innovation (RDI) activities. In previous studies, we have reported how Finnish universities of applied sciences (UAS) have contributed to our innovation system including the utilization of multidisciplinary teams, RDI integrated engineering education, technology transfer to the local industry, and innovative trials (Pieskä, 2012). We have also emphasized the teacher's role in RDI integrated education. That is to say, RDI staff in our laboratories do not have enough knowhow and tools to transfer the knowhow of the latest technologies to students efficiently. We have also reported how important learning and teaching methods, such as learning by doing, have been applied in industry-driven projects (Pieskä et al., 2012; Luimula et al., 2013; Luimula & Skarli, 2014, Kulmala et al., 2014). In one of our latest studies (Pieskä et al., 2015), we have focused not only on technology oriented engineering education but also on business oriented perspectives. We have seen that RDI-integrated engineering education is not only serving students but also local industry.

According to Pieskä (2012) one of the key findings has been the mixing of expertise inside an organization including also foreign students and exchange researchers. This has been actually found to be one of the key drivers for successful results in our applied research teams. The results of the collaborative applied research projects have influenced our engineering education. The advanced equipment and software obtained in these projects have given the students a possibility to study with the newest equipment and tools. Typically, students participate in the projects during the final phases of their studies and, when they have moved to local SMEs after graduation, they transfer their knowledge about the possibilities of new technologies to the SMEs. Also direct feedback from SME personnel or engineering students has been valuable to further develop our education. In many cases, we have used technology demonstrations as innovation generation tools. The received feedback has been used to develop technology demonstrations more concise and comprehensible. The results of the technology demonstrations have been distributed by using different digital media including video clips and simulations for smart phones, websites and digital video libraries.

Pieskä et al. (2012) have visualized a model in which educational and project personnel are overlapping is the core element of successful integration of applied research and education. The interaction of project staff and faculty members brings real-life project topics for students and it can also be utilized in focused visits to companies. Sometimes students can be employed in projects as project assistants or they can find jobs in collaborating enterprises. In Pieskä et al. (2015) in turn, we have introduced a model in which applied research and education has been integrated. The model contains technology expertise and business knowledge with collaboration involving enterprises, the research staff and faculty members. The model emphasizes to proactively take into account the needs of current and future customers. The research approach has been found beneficial on the both sides: innovation capability has increased remarkably in both partners.

Based on our experiences, we have seen that pedagogy, especially the use of CDIO standards, is one of the key enablers in innovation generation. On the other hand, we have to emphasize the role of RDI activities in this innovation generation process. Without vital RDI activities we don’t have up-to-date facilities including the latest technologies and the knowhow how to utilize these innovatively. For example, Turku Game Lab facilities currently has around 0.5 million euros external funding annually. This facility is a working environment, shared by two higher education institutes namely Turku University of Applied Sciences and University of Turku. The original idea since 2009 has been that students from both the technical and artistic fields can meet and develop games together. Annually around 30-40 new game developers graduate from the lab. Our students are especially interested in entertainment game development. However, we have seen some difficulties to succeed in this business. Therefore, it seems to be important to widen their understanding of business potential in game development. This has been done by focusing on serious games and gamification not only in our engineering education but also in RDI.

Actually a new research group namely Futuristic Interactive Technologies was formed early 2016. This research group aims to utilize the interactive technologies (including game technologies) in various fields in a comprehensive manner. The main goal is to find new interactive user interface solutions for new areas of applications, with novelty and innovation value, employing the practices of user centric design and agile, rapid prototyping. This course of action aims to create visually rich and engaging user experiences packaged in innovative product and service concepts for both private sector businesses and public sector organizations. Applying new interactive technologies enables development of new business models and contributes to turning the widely recognized Finnish technology know-how brand into a more lucrative form.

RFMedia Laboratory is an ICT know-how center located in Ylivieska, Finland. The laboratory is a high-level applied research unit consisting of personnel from the Centria University of Applied Sciences and University of Oulu / Oulu Southern Institute. Centria has very vital RDI activities and has succeeded extremely well to get external funding when compared to other Universities of Applied Sciences. Therefore, RFMedia Laboratory has the latest technology to use both in RDI projects and in education. Its research focus is ICT enabling business activities meaning the integration of ICT and software know-how to various business sectors. Based on business needs, RFMedia Laboratory studies, develops, and makes pilot solutions utilizing ubiquitous computing, mobile software, wireless communications, game technologies and 3D imaging.

CASE STUDIES

The ICT Engineering education of Turku University of Applied Sciences has applied CDIO standards in program development since 2007 (Roslöf, 2008). In this paper, we will report how the use of these standards has not only influenced in our engineering education but also to our RDI and business-driven activities. In this chapter, we will report case studies as examples on how to generate innovations in engineering education. The first one, called Pikkuli Case, will show how results achieved in innovation projects have been used as seeds in an RDI project which has received significant external funding (including governmental and industrial funding). The second case study, namely Rockodile Games Case, will be used as an example of our capstone innovation projects which have led to startup activities. Our third case called NeuroCar Case will focus on reporting how scientific high quality research (cognitive neuro science) and our game development activities have led from innovation projects to a business driven RDI project aiming at generating new business based on research results. In our fourth case called Bet-Ker Case, the focus is an interactive product presentation for metal industry created with game programming software. Finally, in our fifth case, we will show how game programming and 3D virtual spaces can be used in Interior Design Cases to boost web sales and interior design education.

Case Pikkuli

The first versions of the Pikkuli game prototypes were developed in Capstone innovation course (cf. Kulmala et al., 2014) of Turku University of Applied Sciences in a close cooperation with our industrial partner Sun In Eye Productions. Five students from the Information Technology (IT) degree program studying Digital Media were selected to this project. The results were demonstrated in the annual student exhibition ICT Showroom 2014. This demonstration contained two mini games. The prototypes were tested by game test experts from the Turku Game Lab for quality assurance. At the end of this project, students were testing the game prototypes with ten children from a local kindergarten. The received feedback was quite promising and formed the basis for the further development of the game.

In the next phase, three IT students studying Game Development were selected based on their experience of the Unity’s 3D game engine, especially coding their own plugins for 2D game development. Because the graphical assets came almost directly from the animation pipeline, also an Arts Academy animation student was needed to support the programmers so she worked as a bridge between the animation studio and the game development team. The only game concept included from the first prototype was the maze game but its gameplay, mechanics and some of the assets were redesigned. Our two main objectives in this second project were to commercialize the mini games and to study how to improve the workflow of animation processes so that the assets can be utilized efficiently in the game development. Moreover, the development team as well as the experts from the Turku Game Lab and Sun In Eye Productions tested the mini games frequently for quality assurance and to optimize the game. We tested them also with the target group to make adjustments in the gameplay and user experience. As a result, we designed and implemented two new mini games: music game and runner game (see Figure 1).

Figure 1. The three Pikkuli mini games developed in the second phase (from left to right): music game, runner game, and maze game.

Later, Sun In Eye Productions joined our Tekes (Finnish Funding Agency for Innovation) funded RDI project called Fast Wow Effects Boosting SME Business (total budget around 1.1M€) and these games have been tested in Finland and Middle East to get understanding of end user experiences in different cultural contexts. The first results seem quite promising and our partner has started their commercialization activities. The game development has continued intensively with our students during 2015. At the moment, totally seven mobile games are available in AppStore and GooglePlay. In Figure 2, innovation generation has been modelled based on Pikkuli case.

Figure 2. Innovation generation in the Pikkuli case.

Case Rockodile Games

A student group from our Game Development specialization area developed their first game prototype during their second year of studies. This game, called Elementale, was demonstrated in ICT Showroom 2014 and based on promising feedback (best game award) the group decided to join the Startup Journey program arranged by a local student-driven pre-incubator society BoostTurku. Their first game published in marketplaces was finished during the journey and the students decided to establish a company called Rockodile Games. The group has continued working and studying in parallel. Their personal study plans have been designed so that the group can work efficiently but still based on our engineering education principles. As a result, in early 2015 the next game called Lemming Dynasty was developed during a Project Course on Game Development. This game was presented in ICT Showroom 2015 in which the game was again nominated with the best game award (see Figure 3). At the moment, Rockodile is working in SparkUp (a local start-up community space) and the newest game Lowglow was published in Steam at the end of 2015.

Figure 3. Rockodile's Lemming Dynasty received the best game award in ICT Showroom 2015.

If we analyze how this case differs from the first one, we recognize that now our student group was entrepreneurially-driven from the first trials until the final success. In addition, this case shows the potential in entertainment industry. The student group has successfully published already many games in various marketplaces such as AppStore, GooglePlay and even Steam. We have found it useful to give such student groups some freedom in their study planning. On the other hand, we have underlined that the students have to pass through all the required curricular content. In Figure 4, innovation generation has been modelled based on the Rockodile case.

Figure 4. Innovation generation in the Rockodile case.

Case NeuroCar

At the end of 2014, a cognitive neuroscientist, a professor from University of Turku contacted the Game Lab. During early 2015, one of our student groups supported by our game development experts implemented the first prototype version of a virtual evaluation tool called NeuroCar which can be used for a simultaneous evaluation of driving acuity and spatial perceptual capacity. That is, this system has been developed in a multidisciplinary team consisting of systemic neuroscientists and computer scientists. Our approach has been to develop a portable system that is cost effective enough to be used in hospitals, driving schools or even police cars. In the first development phase, our main objective has been to present a prototype of a measurement device for driving skills and perceptual capacity. (Luimula et al., 2015)

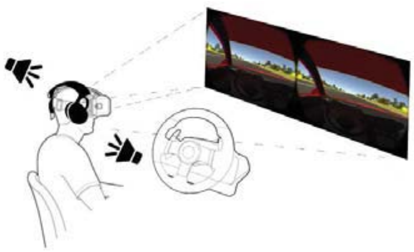

Figure 5. System illustration of the NeuroCar prototype.

Thanks to this prototype development, we received an RDI funding from Tekes for so called Virdi project (Virtual Reality in Driving Inspection). This time the funding was available for innovation generation based on the latest scientific results in neuroscience. Later, two other student groups have focused on prototype development in which we are illustrating how this system can also be utilized for training of driving skills and for various experimental purposes in cognitive neuroscience. We are starting the RDI project in which NeuroCar evaluation and training tool will be studied towards commercialization. So, the ultimate goal in this RDI project is to study different commercialization paths towards new business. Our students have been and will be in the center in this RDI project as well. In Figure 6, innovation generation has been modelled based on the NeuroCar case.

Figure 6. Innovation generation in the NeuroCar case.

Case Bet-Ker

In the Bet-Ker Case the metal industry company wanted to have a new kind of tool for marketing and product presentation purposes. A student group of our Pelipaja Game Lab took the task during their traineeship and implemented the first prototype version supported by our game development experts. The focus of the Pelipaja Game Lab and its projects is to increase game industry know-how and boost business incubator development towards start-up companies. In our RDI project the prototype was completed as an interactive product presentation and marketing tool by our game development expert.

Figure 7. Game programming applied for an interactive product guide for metal industry.

Figure 8. Innovation generation in Bet-Ker case.

Interior Design Cases

In Interior Design Cases we showed how game programming and 3D virtual spaces can be used to boost web sales and interior design education. In the web-based 3D interior design tool development, ideation, requirements definition and first demonstrations were made in the RDI project KKI, the commercialization was carried out with a start-up company (Mediaholvi cooperative association) where the members include Centria students and staff. In the Interior Design Educational case, student from the further education course carried out his job trainee in the Fast Wow project and created the first virtual model prototype of the holiday house. That virtual model was completed with the help of our game development experts as an interactive 3D tool for interior design education to a local vocational school.

Figure 9. An interior design view in the web-based 3D design tool *KokoTila* (left) and the virtual model of the holiday house for the Interior Design Educational case (right).

Figure 10. Innovation generation in the Interior Design cases.

INNOVATION GENERATION MODEL

In our previous studies (Luimula, 2010), a research as a combination of challenges related to ubiquitous systems and prototyping has been presented as our approach to IS research. We have compared our research activities including both academic field experiments and industrial pilots to Hevner's framework (Hevner et al., 2001). In this paper, our focus is in the left hand side of the framework as described below in Figure 11.

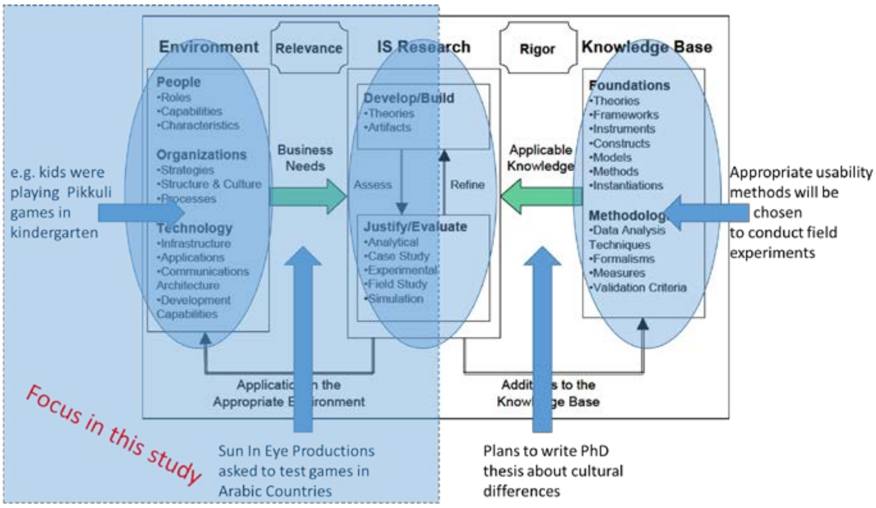

Figure 11. Our focus in this study related to Hevner's IS research framework.

In our previous studies, evaluations together with industrial pilots have been conducted in test generate cycles. That is to say both field experiments and industrial pilots have formed an iterative and incremental design process in which essential feedback has been gathered and analyzed for the next construction phases. Data gathered from the experiments has been analyzed with appropriate metrics. In this study, we have illustrated above how CDIO as a pedagogic tool can be used in business oriented RDI activities and in innovation generation. These case studies above can be seen as various test generate cycles. This time cycles are not covering rigorous academic field experiments but relevant business studies which are generating innovative solutions for Finnish society.

The innovation process which we introduced via our case studies can be presented by the Innovation Generation Model (IGM) showed in the Fig. 12. The iterative innovation process starts with open innovating and continues clockwise from conceiving to designing, implementing and operating. Rapid experimenting is an essential part of our model, it gives for the innovation process the speed which is needed in fast developing markets. Experimenting includes both technological and business experimenting. The results of the innovation process are innovative quality products and services. The students which have developed as true professionals can also be considered as resulting products of the innovation process. The potential spin-off or start-up companies are important outcomes of the innovation process. Figures 2, 4, 6, 8 and 10 show results and details of the intermediate phases in the five cases which were presented in this paper. With CDIO standards the quality of the innovation process can be monitored both from the RDI and educational view. CDIO can be seen as a basic strategy to utilize students' capabilities as an important factor in our RDI and business development.

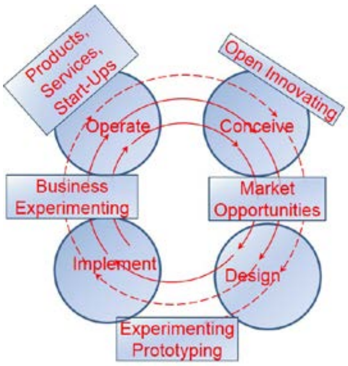

Figure 12. The Innovation Generation Model.

CONCLUSIONS

In this paper, we have presented five case studies which are used as examples of our innovation generation in two Finnish higher education institute namely Turku University of Applied Sciences and Centria University of Applied Sciences. Our RDI activities are quite similar because of our background in applied research. We believe that innovation generation as presented in this paper is at the moment needed widely in Western societies. For example Finnish society has been struggling already several years. In the same time our competitiveness has decreased and our demography is aging rapidly. On the other hand, we have in our economy also a lot of positive signals. Events like Slush annually organized by student association called Aalto Entrepreneurship Society underlines how our society is at the moment underlining entrepreneurship and innovation generation. Our IGM model has a lot of potential and we will encourage our colleagues and our partners to apply these methods in their RDI integrated education. As we have already seen these methods are generating innovative solutions and welfare for our society.

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BIOGRAPHICAL INFORMATION

Adj. Prof. Mika Luimula is working as a Principal Lecturer in game development for Turku University of Applied Sciences. He also holds the position of Adjunct Professor at University of Turku. He holds a PhD in Information Processing Sciences and a MSc in Mathematics. Dr Luimula is a Research Group Leader of Futuristic Interactive Technologies and is leading game development R&D activities in Turku Game Lab. His research interests include game development, gamification, serious games, health informatics, and location-aware systems. In 2014, he received the Work-In-Progress Award in IEEE VS-Games Conference with his colleagues. Dr Luimula has also extensive research and industrial expertise on mobile and ubiquitous computing and cognitive transportation systems. He has published around 70 scientific papers in the above mentioned research areas.

Taisto Suominen is working as a Laboratory Engineer in game development for Turku University of Applied Sciences. He holds a M.Sc. in Information Technology from Turku University of Applied Sciences. His competence areas include project management, 2D and 3D graphics and animation, image processing, game technology, and internet technology.

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