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Anttoni Lehto, Liisa Kairisto-Mertanen &
Taru Penttilä (eds.)

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A new approach to teaching and learning for universities of applied sciences

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REPORTS FROM TURKU UNIVERSITY OF APPLIED SCIENCES 100

Turku University of Applied Sciences
Turku 2011

ISBN 978-952-216-168-0 (printed)
ISSN 1457-7925 (printed)
Printed by Tampereen Yliopistopaino – Juvenes Print Oy, Tampere 2011
Orders: publications@turkuamk.fi

ISBN 978-952-216-169-7 (PDF)
ISSN 1459-7764 (electronic)
Distribution: http://loki.turkuamk.fi

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PREFACE

Towards Innovation Pedagogy outlines the concept of innovation pedagogy adopted at Turku University of Applied Sciences. The collection consists of theoretical introductions to this pedagogical approach accompanied by texts illustrating its practical applications.

The book at hand is a follow-up to the Finnish-language work *Kohti innovaatiopedagogiikkaa* (edited by Liisa Kairisto-Mertanen, Heli Kanerva-Lehto & Taru Penttilä), which was published as a part of the same series in 2009. Although some of the articles found here are heavily based on the corresponding texts from the earlier Finnish version, the bulk of the material on these pages is either completely revised or written exclusively for this publication. I would like to take this opportunity to thank MA Annika Nuotiomäki for her invaluable help with the translation work required in connection to some of the articles.

The articles are grouped into two sections. The first half comprises items with a more theoretical point of view on innovation pedagogy. The latter part focuses on individual cases, presenting good teaching and learning practices from the Faculty of Technology, Environment and Business.

It is hoped that the publication inspires discussion and generates research for developing innovation pedagogy further. The texts are primarily targeted at the staff members of universities of applied sciences as well as all the planners, developers and decision-makers partaking in activities relating to higher educational institutions.

Turku, February 2011

Anttoni Lehto
Research & Development Centre
Turku University of Applied Sciences

INTRODUCTION

Liisa Kairisto-Mertanen

Innovations are a topic of interest in Finland as well as in the rest of Europe. The Finnish National Innovation Strategy, published in June 2008, sets diversifying Finland's innovation policy as its goal. The aim is to enhance the competence-based competitiveness of different regions and the national economy. In the vision presented in the strategy, Finland is a renowned and internationally attractive home for research, product development and innovation-based business. Besides innovations relating to technology, service innovations inspired by research and innovative conceptualising are also needed. (Kansallinen innovaatiostrategia 2008; Viljamaa 2009)

To reach the set goals, a top-level environment for the development of learning must be created in Finland. Education as well as its development demand emphasis, if one is to attain the role of an international pioneer regarding both content-relating methods and their technological environments. It is well known that in addition to theoretical knowledge, many other skills provided by the education system are needed for innovation activities; these abilities include professional competence as well as artistic, cultural and manual skills. It is vital to utilise the existing knowledge relating to the ever-changing needs for know-how as the basis for the planning and refocusing of education. (Kansallinen innovaatiostrategia 2008.)

Universities of applied sciences, or polytechnics as they were then called, were first established in Finland in the 1990s. In addition to the functions defined in the legislation, they are thought to have a significant role in innovation activities (Kettunen 2009). According to section four of the Finnish Polytechnics Act, carrying out applied research and development based on the industrial structure of its region is indeed a basic purpose for universities of applied sciences. Higher education, which supports the professional growth of an individual and simultaneously takes into account all the working life demands described in the Act, requires distinct pedagogical starting points from those ten years earlier. The world the new educated professionals face in 2011 is completely different from the one in the turn of the millennium.

It is important to recognise the pressures for change the society faces and to adapt to the new demands. According to the Finnish National Innovation Strategy, the key drivers for change are globalisation, sustainable development, new technologies and the demographic changes in the population. These factors have an effect on the planning and implementation of education, as the professional competence requirements tomorrow are going to differ from those of today. This is also the case with the knowledge base, skills and attitudes of new students admitted to higher education institutions in the future.

These changes in the operational environment necessitate that skills and attitudes matching with the new requirements are consciously and systematically developed alongside with the students' knowledge bases. Social and interactive skills, cultural abilities, understanding the prerequisites for working in contact with customers, preparedness for entrepreneurship, creativity and problem-solving skills as well as tolerance to difference and uncertainty are the kind of attitudes and skills that a future professional should have. (Kairisto-Mertanen & Mertanen 2005; 2006, Kairisto-Mertanen, Hänti, Kallio-Gerlander & Rantanen 2007, Mertanen & Kairisto-Mertanen 2006.) In the Finnish environment, which aims at becoming the best innovation environment in the world, innovative competences are vital. New frameworks for learning are required in order to reach the new professional competence requirements.

Learning environments where students of different fields are daily in contact with each other offer new interfaces for working. Such surroundings are known to be the best when innovations are hoped to be created. In addition, an innovative approach to teaching and learning are also needed as well as enthusiasm for trying new methods.

In 2000, the organisation of Turku University of Applied Sciences was renewed. The degree programmes were positioned in faculties, most of which are multidisciplinary entities by nature. The aim was to create a learning environment for enabling the development of multidisciplinary professional skills. The experiences have generally been positive. The students feel that studying in an environment where they can acquaint themselves with students of different fields is meaningful. The degree programmes complement each other and bring the desired colour and variety in the learning environment. Tolerating and understanding difference is a beginning for new thinking. The students spend their everyday life in the meeting points between different fields; they can, already while studying, participate in projects where work is done in groups with members from those other fields.

At Turku University of Applied Sciences, the Faculty of Technology, Environment and Business – also known as Innovation Academy – cooperates with the economic life. Future Masters and Bachelors of Engineering as well as Bachelors of Culture and Arts, Sustainable Development, Fisheries, Construction Management and Business Administration are educated under the same roof. Meanwhile, active and successful R&D work is conducted as a part of the innovation production process. The needs expressed by the business and industrial life are the basis for planning competence-based curricula; as it happened, a productive discussion in the advisory board also led to the creation of the concept of innovation pedagogy. Innovation academy is a multidisciplinary entity that emphasises the use of fresh learning methods that activate its students. It is felt that innovation pedagogy, as a term, describes well the procedures that all degree programmes belonging to the faculty must follow.

Kettunen has defined innovation pedagogy as "a didactic operational model based on the socio-cultural perception of learning that supports the work of universities of applied sciences as a part of regional competence and innovation networks. Applied research and development activities that support regional development and the production of innovations in working life are integrated into multidisciplinary teaching in accordance with the principles of innovation pedagogy. The education offered by the university promotes entrepreneurship and includes service activities while taking into account both the needs of the region as a whole as well as the constantly changing trends of working life." (Kettunen 2009) However, innovation pedagogy, as a new term, still requires further examination.

In this publication, the efforts to define innovation pedagogy are resumed. The focus is also partly shifted to its applications. In other words, this collection of articles presents examples of the many practical applications of innovation pedagogy visible in the daily work of our degree programmes. The examples included show, on a practical level, how teaching and learning can become more versatile and interesting to both teachers and students by applying this new approach. The use of social media is not yet discussed; this will surely be one of the challenges of innovation pedagogy to be faced in the future.

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EMBEDDING INNOVATION SKILLS IN LEARNING – DEVELOPING COOPERATION BETWEEN WORKING LIFE AND UNIVERSITIES OF APPLIED SCIENCES

Liisa Kairisto-Mertanen, Taru Penttilä & Ari Putkonen

INTRODUCTION

Finnish universities of applied sciences have an obligation to engage themselves in research and development (R&D) activities. When universities of applied sciences are assessed, the applicability of R&D results in working life is among the key criteria. This responsibility directs them to operate in environments where knowledge is applied to practice. In addition to mere theoretical knowledge, practical know-how and the ability to both recognise as well as to solve problems should be emphasised in learning processes. Thus a continuous interaction, in which breaking borders between different fields of know-how and organisations is encouraged and which encompasses all the actors involved, is a prerequisite for success. (Putkonen & Hyrkkänen, 2007). This is also the challenge innovation pedagogy aims to tackle.

As actors operating closely with the local economic life, universities of applied sciences have an impact on the activities of companies in their region. This influence can be strengthened by raising new generations of professionals, whose conceptions of producing, adopting and utilising knowledge make innovative thinking and creating innovations possible. According to the Finnish National Innovation Strategy (Kansallinen innovaatiostrategia 2008), proficiency of this kind is needed and demanded. Until now, Finland has thrived well in international competition and is, at the moment, one of the world's leading countries regarding innovativeness and the quality of companies' operating environments. However, the basic dilemma of the Finnish innovation system as a whole lies in determining in which fields of know-how the country is able to produce the most additional value in global value networks. In those same fields, tapping into Finnish know-how should produce the most profit for investors. Also education and its reinforcement emerge as vital points in this context.

In general, education, R&D and working life cooperation should form a solid and interactive whole that is able to respond to dynamic and ever-changing expectations. Embedding pedagogical knowledge in innovation activities may offer a long-desired theoretical basis for developing knowledge-based competitiveness in the cooperation between working life and education. Kettunen (2009) emphasises the internalisation of an 'innovation pedagogy mindset' relating to the construction of said basis. According to him, the cornerstones of innovation pedagogy are interdisciplinary operations, R&D, curricula and internationalisation in addition to entrepreneurship and service activities.

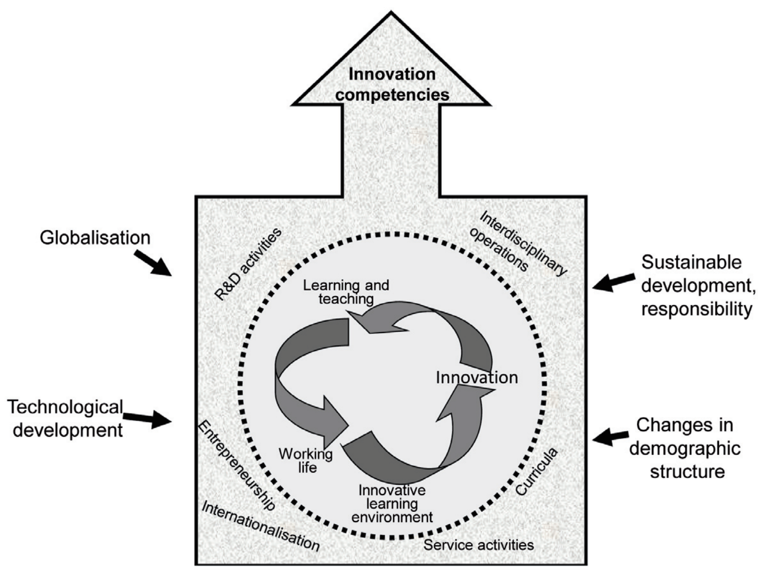

FIGURE 1. *The drivers for pedagogical development in universities of applied sciences.*

Figure 1 illustrates the drivers for pedagogical development in universities of applied sciences, the cornerstones of innovation pedagogy as well as the dynamics, operational environments and objectives between them. The key elements here are innovative learning and teaching methods, which can be interlinked with the surrounding working life and innovations by physical products, services and processes. Acting together in an interrelated, interactive and innovative environment, these elements operate within the circle of continuous improvement. In such settings, learning and teaching methods are developed more expediently, working life operations and competitiveness are enhanced and new innovations are created. *The overall aim of innovation pedagogy is to contribute to the development of student's innovation competencies. Innovation competencies refer to knowledge, skills and attitudes needed for the innovation activities to be successful.*

An open and network-based environment helps to observe societal development pressures emerging from the economy, to react to them, and to act in a value-increasing way in national and global value chains. The circle of continuous improvement contributes not only to the continuous development of the included elements but also ensures the professional qualifications of students. This professionalism is responsibility-centred as well as development-oriented; it encourages actors to absorb and create new knowledge, which supports creating innovations in working life.

ELEMENTS OF INNOVATION PEDAGOGY

Suppositions about learning

Learning can be defined as a process where behaviour changes as a consequence of experience (Maples & Webster 1980). The humanistic way of understanding people as the creators of their own future forms the philosophical foundations of innovation pedagogy.

Innovation pedagogy also includes assumptions that are in congruence with both cognitive and constructive learning. Cognitive theory defines learning as a behavioural change based on the acquisition of information about the environment. Through diverse learning environments, active learners are exposed to new situations where new insights can be gained in a dialogic process. In parallel, the basic assumptions of constructivism argue that humans generate knowledge and meaning from their experiences. This means that knowledge is always tied to the person who possesses it. (Ruohotie 2000.)

Also the cultural ways of behaviour that guide the learner must be taken into account, as the process of learning can never be separated from the specific culture by which it is surrounded. On a more general level, innovation pedagogy reinforces the development of understanding and learning, which in turn supports the central idea of innovation pedagogy: producing, further cultivating and finally commercialising innovations in higher education.

Suppositions about knowledge

When learning is understood as a learner's conscious knowledge formation process that takes place in a certain cultural and social context (see e.g. Tynjälä 2002), knowledge can be considered as an object having certain characteristics that enable it to be utilised in building internal cognitive models. These models are, in fact, born as a consequence of learning.

Gibbons et al. (1994) and Nowotny et al. (2001, 2003) distinguish two different modes of producing knowledge. They make a distinction between academic scientific knowledge and the knowledge originating in situations in which there is a need to solve practical and application problems. The concepts of expert knowledge, know-how, tacit knowledge and intuition are important in contexts relating to the latter type. In general, maintaining professionalism requires making tacit knowledge explicit and developing it further in a triadic interaction process between students, teachers and working life.

One of the basic assumptions regarding innovation pedagogy is that the knowledge produced and accumulated in learning environments expands the traditional way of understanding the nature of knowledge itself.

Innovation in the pedagogical context

There is no one and only way of defining an innovation. Schumpeter (2003) discusses innovative entrepreneurship and argues that it can lead to better performance in business. Rogers (2003) states that an innovation can be defined as an idea, object or a way of doing things that is considered new. According to him, an innovation does not have to be something new in absolute terms, but the individuals involved must consider it as such.

A report of Sitra (2006) suggests that any organisation possessing excellent innovation abilities is able to constantly channel the creativity, know-how and all other resources of its personnel, service producers and customers to new solutions and innovations, which results in financial benefits. In Finland's national innovation strategy (2008), the word 'innovation' refers to a utilised competence-based competitive advantage, where an innovation is generated by a combination of different competencies.

An innovation can be radical or incremental (Tidd, Bessant & Pavitt 2001). Innovations have also been linked with education. Tella and Tirri (1999) define an educational innovation as a product or a process that did not exist before. Innovations can also be considered as constant improvement. When discussing innovation pedagogy, Kettunen (2009) defines innovation as an idea utilised in working life. Pedagogical innovations sometimes lead to technological innovations, which can be patented.

In the context of innovation pedagogy, innovations are seen as an integral part of the process of constantly improving know-how as well as generating new ideas and practices applicable in working life.

FRAMEWORK AND DEFINITION OF INNOVATION PEDAGOGY

Learning is a gradual process which consists of collecting, assimilating, adapting and generating new information. In other words, learning is what happens when new information is added to existing mental data structures in the learner's mind. According to innovation research, knowledge and the skills relating to applying that knowledge play a crucial role in creating innovations. Thus, creating new services, products and organisational or social innovations requires knowledge and skills that are applied in an innovation process. Traditionally, the role of education has been to offer knowledge-based readiness, which later would be applied in practice to various innovation processes in working life.

However, simultaneously applying the principles of constructive learning theory and innovation theory in education could lead to an operational model, through which it would be possible to determine how to support the development of students' innovation skills from the very beginning of their studies. Consequently, the traditional gap between 'theoretical teaching' and 'the practical requirements of working life' would be filled and the reshaped learning process would also enhance the professional growth of students during their studies. For instance, useful innovations can be created already in the educational context by working in multi-disciplinary teams together with companies and other organisations; additionally, innovation skills can then be scaled more accurately to correspond to future working environments.

In universities of applied sciences, learning can occur at the university, in the context of working life or at the interface in between. Virkkunen (2007) presented a model about the development of occupational education, which was based on the above mentioned learning contexts. Hyrkkänen (2007) considered the model from the viewpoint of the individual's learning and introduced a refined two-dimensional model as depicted in Figure 2.

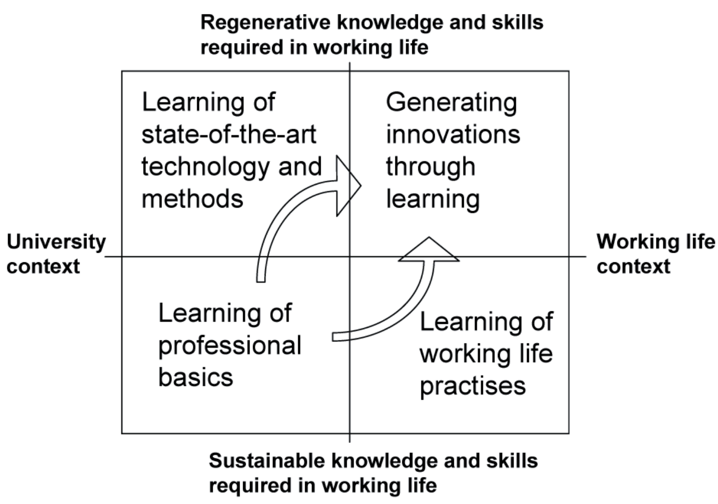

FIGURE 2. *Framework for generating innovations through learning (adapted from Virkkunen, 2007; Hyrkkänen, 2007).*

On the one hand, the learning context can be a university or working life (horizontal axis). On the other hand, working life requires both knowledge and sustainable or regenerative skills (vertical axis). The left hand side refers to traditional learning in a university context. Students learn professional basics at the beginning of their studies and the state-of-the-art technology and methods during the later stages of their studies. The right lower hand quadrant refers to learning in close cooperation with working life, such as during training periods. In that case, the main learning target is related to working life practises. When the aim is to generate innovations through learning during the studies, the upper right hand section should be pursued. The concept of innovation pedagogy presented in this paper can be positioned in this quadrant. There, new regenerative knowledge and skills are required in order to achieve innovations for working life purposes. It can be seen as an end point for the two optional connective paths that originate from the learning of professional basics. (Putkonen, Kairisto-Mertanen & Penttilä, 2010)

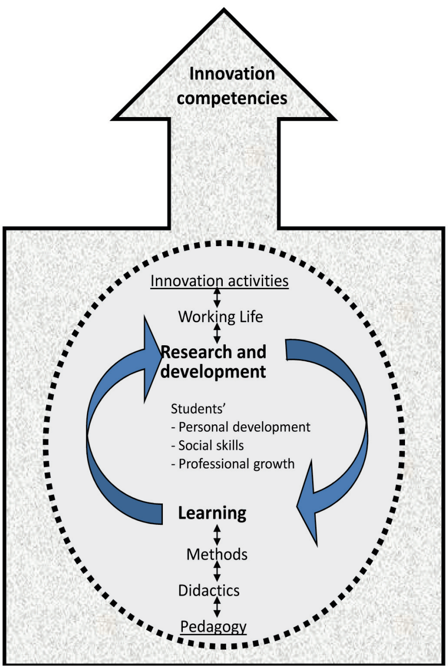

FIGURE 3. *The framework for innovation pedagogy. Innovation pedagogy is a learning approach that defines in a new way how knowledge is assimilated, produced and used in a manner that can create innovations.*

The framework for innovation pedagogy (figure 3) presents a model that aids in bridging the gap between the often too separated contexts of education and working life. With the help of the model, the learning and teaching processes improving qualifications for students entering working life can be charted, thus enhancing the enablement of personal and professional growth as well as social skills. The learning processes are deepened and strengthened when the previously gained knowledge is continuously applied in practical contexts. Innovation pedagogy does not start with knowledge and proceed to its application later; on the contrary, the new information is applied to practical situations immediately, even before the information is assimilated. *Innovation pedagogy combines learning with information creation and its application.*

Referring to the theory introduced by Nonaka and Takeuchi (1995), a creatively stimulating learning environment facilitates producing intuitive knowledge and transferring tacit knowledge. The intuitive and tacit kinds of knowledge cited here include, for example, better understanding the customers with different backgrounds and needs. In these situations, cultural literacy and awareness can be notably improved. As they work together as a group, students gain experience on networking and on the often very distinct manners in which people work towards common aims in a network. If the assignments given to the student groups are versatile and comprehensive enough, the interconnections of the task at hand can become more transparent. Furthermore, when working in a group with a preset goal, it can happen that the objectives are not reached. In these situations, it is important for students to learn that a failure does not mean the end of the world, but actually always leads to a new beginning.

On a practical level, innovation pedagogy refers to an approach to learning and teaching that emphasises working life and R&D skills. This means applying existing learning and teaching methods in a creative, value-increasing way. Simultaneously, new methods are developed and put into practice while ensuring that students take responsibility for their learning and that they actively pursue their learning objectives. As a result, graduating students have professional skills and qualifications that are both innovative as well as development-oriented. Innovation pedagogy moves further from traditional theoretical learning to the application of learned skills to practical development challenges.

In this context, however, it is important to notice the difference between *innovation pedagogy* and *innovative pedagogy*. The latter refers to the implementation of teaching and learning methods such as e-learning or other pedagogically innovative uses of technology (Kankaanranta 2005). Innovative pedagogy often contributes to the objectives of innovation pedagogy, but innovation pedagogy is more of an *approach* in its focus on pedagogical contents and on how creating innovations can be promoted in education and working life. Naturally, implementing innovation pedagogy requires innovative teaching and learning methods.

DISCUSSION

The aim of this introductory article was to consider the theoretical and practical questions concerning innovation pedagogy: what innovation pedagogy is, why it is needed and what kind of educational benefits it offers. In itself, innovation pedagogy can be seen as a pedagogical innovation touched upon by Manninen et al. (2000). Separated from the traditional view, a pedagogical innovation is based on a new outlook on learning and possibly utilises new technology in a fresh manner.

As referred to here, innovation pedagogy is *a learning approach that defines in a new way how knowledge is assimilated, produced and used in a manner that can create innovations*. Thus the question regarding the nature of knowledge behind innovations becomes essential. Naturally, the model for innovation pedagogy was constructed based on previous studies on pedagogy and innovation research.

The basis of innovation pedagogy rests on knowledge the need for which arises from social and economical contexts. The starting point for producing this knowledge lies in practicalities congruent with the views presented by Gibbons et al. (1994) and Nowotny et al. (2001, 2003) on mode 2 knowledge. Similarly to mode 2 knowledge and R&D, innovation pedagogy strives for contextually emerging and cumulative knowledge that is boundary-breaking, practical and societally durable by nature. This is why innovation pedagogy is a suitable theoretical framework for developing new innovative cooperation between working life and universities of applied sciences.

Creating innovations presupposes know-how and the ability to apply it. Innovation pedagogy challenges the traditional way of educating students by making them apply new information already while processing it. The traditional view held by educational institutions is that students receive new information and skills as a student and only begin to apply what they have learnt after finding employment. This is exactly the way of thinking innovation pedagogy wants to challenge. According to this new approach, know-how should be accumulated and applied simultaneously. Furthermore, individual expertise should be transformed into communal expertise, which promotes controlling knowledge and developing problem solving skills (Haarala ym. 2008). These arguments are supported by Viljamaa (2009), who found that innovation processes must be based on a new kind of synergy and collective learning between local companies and the operational environment.

Learning has also to do with constructing meanings based on dialogue. According to social constructivism, knowledge is founded on individuals participating in solving shared problems and discussing them (Ruohotie 2000). Innovation pedagogy underpins learning by favouring actual working life development challenges being brought under discussion, in which students, teachers and working life representatives all take part. In addition to efficient learning, innovation pedagogy strives for new ideas, operating models and innovations applicable in working life. These aims are consistent with sociocultural theories as discussed by Vygotsky (1982), Wenger (1998) and Hakkarainen et al. (2001) in regard to the two-way interaction of theory and practice. Theory helps in solving practical problems and sometimes operating models born of practical contexts may evoke scientific breakthroughs, so why not innovations in general as well.

There is demand for an approach like innovation pedagogy. The aim of innovation pedagogy is to generate environments in which know-how-inspired competitive advantage can be created by combining different kinds of know-how. When utilised, this edge provides opportunities for the whole society, as innovation skills sharpened by innovation pedagogy are the key in introducing new competitive advantages via know-how. In a multi-disciplinary environment, it is possible to evoke regional innovations and increase entrepreneurship through research and development.

Being as recent as it is, the concept of innovation pedagogy offers an abundance of opportunities for further study. One of the most interesting objects of study would be creating an innovation barometer. The barometer would be used to determine how to evaluate and measure the execution of innovation pedagogy. The innovation barometer could be utilised as a shared instrument when evaluating the maturity of both working and educational communities. Additionally, modelling collaborative projects relating both to innovation pedagogy and the companies involved also offers an interesting research subject. In any case, this article sought to illustrate the fact that the innovation pedagogy approach can be a powerful starting point in developing learning environments as well.

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VIEWS

RESEARCH HATCHERY – A CONCEPT FOR COMBINING LEARNING, DEVELOPING AND RESEARCH

Heli Kanerva-Lehto, Jouko Lehtonen, Ari Jolkkonen & Jussi Riihiranta

INTRODUCTION

Closely connected to the emergence of innovation pedagogy, the research hatchery concept has been developed since 2004. The operational idea of the concept is to offer a functional learning environment, where students, under counselling, can create new information with reliable methods by carrying out assignments originating from companies and other organisations. In other words, the goal is to combine teaching and learning with research and development activities as well as serving the purposes of working life. This article describes the development of the research hatchery concept and also discusses the concept as a whole.

PEDAGOGICAL BACKGROUND FOR RESEARCH HATCHERIES

As everyone knows, there is a paradox involved in conventional school teaching. After graduation, a typical student will remember only a small part of the different matters they have been taught and they have initially learned. This is because the pieces of information taught are mainly presented as static facts to be committed to memory. As a result, students are able to pass their exams without any deeper understanding of the issues concerned. Even something as trivial as school lore may help students to cope with their studies (Lehtinen 1989). School lore, however, has little to do with real-world requirements.

There is a gap between classroom skills and the demands for professional skills; the development of learning environments like the research hatchery aims to narrow that gap.

Another basic reason behind the need for the research hatchery concept is the complexity of expert knowledge. According to the conventional definition, knowledge is a true and justified belief. When a certain person is said to know something, it is thought that the person believes things to be in a certain way and that the person's belief is correct and well-justified. A large portion of our knowledge is based on personal experience. We know how to do something based on our own experience, but it is not always possible to present that knowledge and verbalise it in a conceptually useful way. This practical know-how is not only limited to everyday life, but it is also a central aspect of expert knowledge. The practical know-how the experts possess is often called 'tacit knowledge'. Tacit knowledge cannot be learned by conceptual presentations or by reading books; it is learned in practice with the experts. (Collins & Evans 2007, 18–24.)

Investigative learning

By nature, innovation pedagogy is an umbrella approach comprising many aspects of different pedagogical trends and tendencies, one of which is investigative learning. Investigative learning itself, as one of the focal points of innovation pedagogy, consists of many different approaches and can consequently be implemented in many different ways. Investigative learning is based on cognitive psychology and the constructivist view of learning. (Hakkarainen, Lonka & Lipponen 1999). Investigative learning can be defined as follows:

> *Investigative learning represents learning that creates something new. It does not merely aim at committing information found in books to memory and bringing it back in an exam, but recreating and constructing the information connected with a given relevant matter and phenomenon. (own translation from Hakkarainen et al. 1999.)*

Investigative work is needed in all areas, not only in scientific work, when resolving complex problems. To resolve any problem with no direct answer, research has to be done to find a solution. Investigative learning, however, is connected to a kind of deeper researching and to something that is typical for experts doing creative work relating to knowledge. Investigative learning also underlines the learners' activity in setting the objectives and asking questions as well as reflecting on the newly generated knowledge, in other words what is known and what is still needed to know. (Hakkarainen, Bollström-Huttunen, Pyysalo & Lonka 2005, 29.)

When utilising the investigative learning method, students are guided to take part in research projects to share their knowledge and gathered know-how. Thus it is important that students work together to solve joint problems and contrive new ideas. Nevertheless, investigative learning can also be seen as a strategy for individual growth. It is also vital that lessons are given in the same context in which the information is needed. (Hakkarainen et al. 2005, 30–31.)

Typically, any pedagogical environment involving the investigative learning method features an informative, wide-ranging and challenging subject to research. In such settings, students acquaint themselves with the subject from top to bottom, making it easier for them express their opinions. In any case, investigative learning is communal learning, requiring the members of the community to share their thoughts and efforts. The role of the teacher is important as both an encourager and an expert. (Hakkarainen et al. 2005, 25–26.)

DEVELOPING THE CONCEPT

The research hatchery concept came into existence out of the practical needs for a research project that concerned underpinning. After the project started, it was quickly discovered that the project workload was going to grow remarkably, perhaps even multiply. The project budget was clearly insufficient for such an increase. As a means for balancing the budget, a decision was made to try out students as research assistants for the project. Their task was to participate in the collection of data from different sources as well as to the assorting and interpretation of the material.

In the first phase, several subprojects involving the students were set in motion. These research projects were carried out under group counselling as well as individual counselling. When the efficiency level of the project work was initially worse than was hoped for, a more intensified counselling of student work was started in the form of research hatcheries. The functions of the research hatcheries were planned in a working group. In addition to the project leader, the group consisted of three students who had been working in the project as research assistants. The working group drafted the following preliminary outlines for research hatcheries:

- The voluntary students were to be divided into small teams of three.
- Each working group member – former or present research assistant – was to be given the duty of counselling one of the teams.
- Each individual research hatchery was to be opened with one or several meetings, during which both the substance and the methods of the research were to be carefully discussed.

Other working methods were not planned in detail beforehand. The students carried out the research work partly at the project facilities and partly at home. It was soon discovered that group counselling was needed on a regular basis. Meetings in intervals of a couple of weeks were started for the whole hatchery staff. The meetings included each student's oral report on their progress, and any questions or problems arising from the reports or the following discussions were considered at length. A part of the meetings was always used for counselling.

Afterwards, feedback on the research hatchery was collected from both the students and the counsellors. Counsellors, the students intimately familiar with the subject matter, had worked full-time at the project facilities and they felt they had received enough counselling themselves. The amount of actual teamwork had been rather small in the end, as the students had worked mainly independently and asked for help when problems had occurred. On average, the students felt they had received enough counselling during the research hatchery period, but further aid would have been needed in some substance matters. General knowledge of underpinning had grown, the literacy of drawings had improved and the use of software had strengthened. The problems in the actual work were seen to be caused by other study obligations. The working facilities were considered to be functional.

The second research hatchery was started in the next term. The tasks and methods were mainly the same as in the first hatchery, but the problems that had come up were naturally taken into account. Group meetings were held once a week in order to secure the working schedule. Also, the groups and the project leader met once in two weeks to discuss the project and the possible problems that the students had faced in their work. Still, although the number of meetings was increased, there were similar problems as in the first research hatchery. The feedback from students and counsellors was also in parallel with the previous hatchery.

Again, because of the somewhat disappointing results, the working methods were discussed thoroughly. It was decided that the common meetings for all groups should also be held once a week, but in the way that every meeting would have a certain subject that was to be discussed deeply. These topics would include, for example, underpinning diaries, costs or load transfer systems. The schedule principle is presented in Table 1.

TABLE 1. *Example of a research hatchery schedule during one term.*

Task	*Week 1*	*Week 2*	*Week 3*	*Week 4*	*Week 5*	*Week 6*	*Week 7*	*Week 8*	*Week 9*
Starting lectures	x								
Counselling meeting, all groups		x	x	x	x	x	x	x	x
Counselling meeting, group 1		x	x	x	x	x	x	x	x
Research hatchery work, student 1	→	→	→	→	→	→	→	→	→
Research hatchery work, student 2			→	→	→	→	→	→	→
Research hatchery work, student 3	→	→	→	→	→	→	→		
Counselling meeting, group 2		x	x	x	x	x	x	x	x
Research hatchery work, student 4			→	→	→	→	→		
Research hatchery work, student 5	→	→	→	→	→	→	→	→	→
Research hatchery work, student 6		→	→	→	→	→	→	→	→

The biggest change in the working methods themselves was the fact that all the work was done entirely at the project's facilities. Also the material the students accumulated during the project was stored there at all times. With these arrangements it was ensured that the project's staff and all the research material as well as counselling were easily reached and available when needed.

Taking full advantage of the project's facilities made the work more compact during the third research hatchery, and many of the earlier problems were solved as a result. However, the compactness of everyday activities on the project underlined another potentially negative aspect relating to research hatcheries – that the students' motivation is one of the most crucial factors of success. Even though more counselling and formal meetings were organised, even these newly introduced efforts did not result in every student passing the study unit. Although taking the research hatchery was optional, some students took it for obligatory project work credits, making them less interested in the subject matter than others.

RESEARCH HATCHERIES REVIEWED

As a concept, the research hatchery can be described as follows:

> *Research hatchery is an environment for learning and research, where students can carry out their studies under counselling and where new information is produced for research and development work. In research hatcheries, the students work on their own subprojects. During regular meetings, students report back on their work and receive guidance to manage their work as a whole. (Lehtonen, Kanerva-Lehto & Koivisto 2006.)*

The actors of a research hatchery consist of students, student assistants and a project leader or teacher. The student assistants, older students with experience on project work, who counsel the student groups play an essential role in the system (see figures 1 and 2). This method makes it possible for both the assistants and the students to get natural support from their fellows.

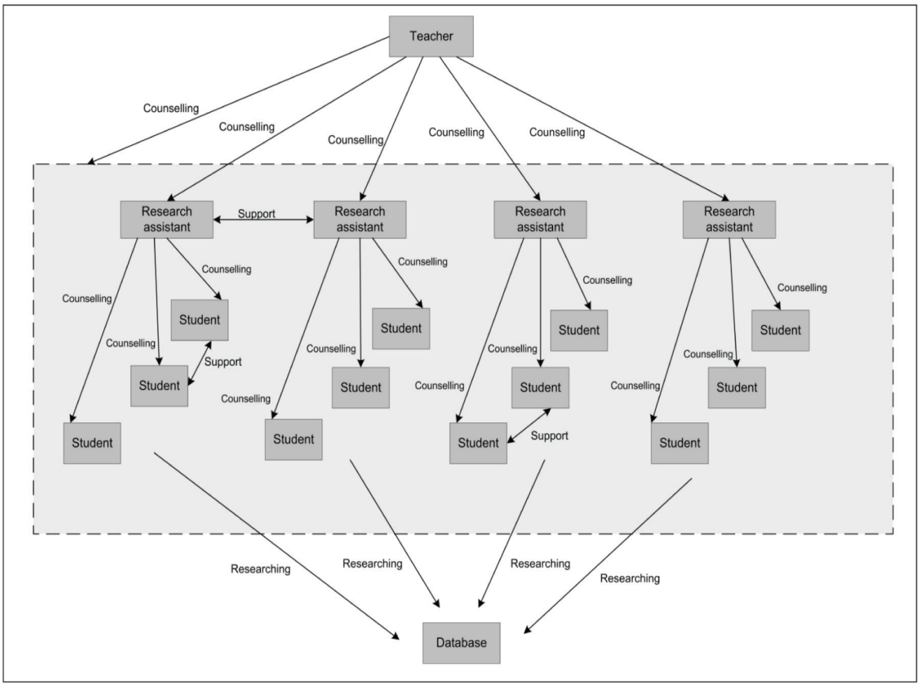

FIGURE 1. *Counselling and knowledge transfer in research hatcheries.*

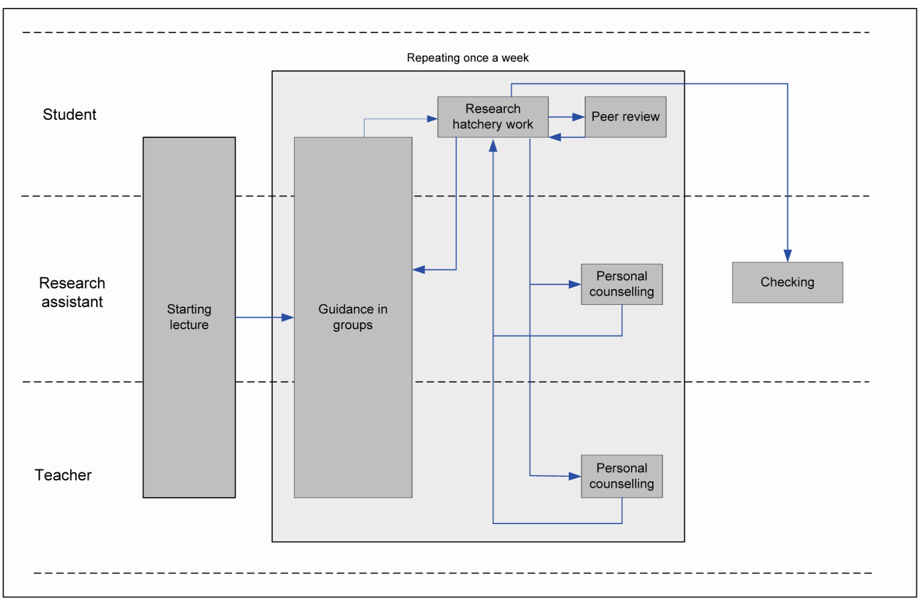

FIGURE 2. *A process chart for the counselling taking place in research hatcheries.*

The research hatchery differs from a usual classroom learning environment as it has more to do with teamwork than traditional school teaching. The research hatchery method can be applied so that the basic idea does not have to change to suit particular subject matter. Nevertheless, the planning of research hatcheries should include careful consideration regarding sufficient resources in the form of financing, personnel and scheduling.

To sum up, the focal features of the research hatchery concept are:

- Research subjects arise from real-world needs for new information.
- Students take on different responsibilities of the research and get credits for their work.
- More experienced students act as tutors for their group.
- Meetings organised in regular intervals aid in keeping different subprojects together and the work flow steady.
- Peer support is always available for all participants.
- Learning occurs in different ways: through self-study, counselling and guidance as well as with the help of fellow students and more experienced researchers. (Lehtonen & Kanerva-Lehto & Koivisto 2006)

CONCLUSION

The most important objective of the research hatchery concept is for the students to get acquainted with the conventions of working life. The working methods have been created to reflect that goal and to offer the students a fruitful environment to practice the skills in question. During their studies, it is possible for them to try out different working routines and make mistakes. As the learning process takes place under close counselling, the students can be given support on a personal basis.

In addition to working life skills, another important aspect for the students to learn is the project managing skills. When the students familiarise themselves with project managing already in their first study year and continue to do so throughout their studies, they have time to digest plenty of details concerning project work and its pitfalls before making the transition to working life. In addition, the connections the students make with the representatives of working life add to the students' future working opportunities and the development of their professional expertise in general. Besides the students, working in a research hatchery offers also the teachers and other employees a chance to enhance their vocational skills.

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PROJECT HATCHERY – INTERDISCIPLINARY LEARNING THROUGH PROJECT METHODS

Sami Lyytinen

INTRODUCTION

This article describes the Project Hatchery study unit at the Faculty of Technology, Environment and Business at Turku University of Applied Sciences (TUAS). The study unit itself is one of the applications of innovation pedagogy at TUAS. In this article, the centre of attention is the idea and implementation of the study unit and the relating feedback.

As the name suggests, The Faculty of Technology, Environment and Business (later TYT after its Finnish name) is a vastly multidisciplinary education unit, which comprises more than ten degree programmes of different fields. The combination of various fields naturally creates novel possibilities for the faculty. Taking advantage of those possibilities in a manner that best serves teachers and students as well as the surrounding society, however, is a rather imposing challenge. Therefore, the teaching at the faculty is intensely focused on connecting with the common practices of working life and emphasising the importance of interdisciplinary activities in addition to the role of cooperation in all working practices. An integral part of building the students' future is the project-like approach to working implemented according to the principles of innovation pedagogy. From the very beginning of the studies, this approach introduces them to the present-day working life.

After research and development activities were legislatively added to the responsibilities of universities of applied sciences, R&D projects carried out together with external operators and undertakings funded from external sources have become everyday functions at TYT. An increasing amount of work conducted in the projects is performed by the students of the faculty.

Thus the ability for independent and responsible working methods as well as the mastery of the basics of project work is expected of them throughout their studies. At TYT, one of the new ideas for augmenting interdisciplinary activities, the cornerstone of innovation pedagogy, and for integrating project-like work methods to the studies in general is the Project Hatchery study unit, which was originally launched in the autumn term of 2008. The target group for the project hatchery are the first-year students; the study unit begins right after the first autumn term has started.

The idea of the project hatchery is based on the research hatchery learning concept that is in use at TYT and also some other faculties at TUAS. The aims and contents of the former, however, differ considerably from the latter. Unlike the project hatchery, the research hatchery is meant for the students who have completed their basic studies and, as a result, are familiar with the basic methods of the field and have thus reached an appropriate level of general knowledge on the topics of the more advanced hatchery. The students may also have experience of project activities when they get involved with the research hatchery.

As a learning concept, the research hatchery is essentially content-orientated. In other words, the target learning outcome of research hatcheries relate to the subject matter itself. The difference between the research hatchery and the project hatchery is at its greatest in this context, as project hatcheries are aimed at the students in the beginning of their studies and their orientation is towards methods rather than contents. Working within the conceptual sphere of the project hatchery and gaining methodological skills precedes the production of content. The Project Hatchery study unit has two objectives. The first is to generate novel thoughts, methods and innovations by bringing together students specialising later in different fields. The second is to teach the students how to turn problems and differences in interests to a creative resource base.

Liisa Kairisto-Mertanen, Director of Education at TYT, who originally conceived the idea of the project hatchery, has described the teaching goals of the concept as follows:

The aim is to increase the sense of work community and to create a situation where students of different fields know each other, trust each other and respect each other as future professionals who are different and study different subjects. At the same time, we want to introduce the students to project-like learning and independent work as well as to help them to tolerate uncertainty right from the beginning of their studies. In addition, enhancing presentation and teamwork skills is also vital. Learning the actual content is considered less important, but it is expected from students that each group will increase their knowledge during interesting projects. Be that as it may, the most essential goals belong to the realm of soft skills. Indeed, they are the skills that have become a crucial part of any profession learned in a university of applied sciences.

In the curriculum, the aims of the concept are described as follows. During the Project Hatchery study unit, the student

1. is trained in a research-minded approach to working and learning.
2. learns to search and utilise information independently.
3. learns to work in a multidisciplinary team.
4. becomes familiar with different degree programmes of the faculty.
5. begins to create the networks s/he will need in working life.
6. improves his/her skills relating to working in projects.
7. enhances his/her presentation and interactivity skills.
8. begins to enhance his/her innovation capabilities.

IMPLEMENTATION OF THE PROJECT HATCHERY

Over 400 new students begin their studies at TYT each autumn and the Project Hatchery study unit is compulsory for all of them. The extent of the study unit is 3 ECTS credits comprising weekly contact lessons and independent study. In the project hatchery, the students are placed in groups with one teacher tutor and one or two student tutors each. The student tutors are more advanced students who are retaking the study unit in the role of a tutor as a part of their optional studies. They help both the students and the teacher. The average size of a project hatchery group is around twenty students. In each group there are students from every degree programme of the faculty.

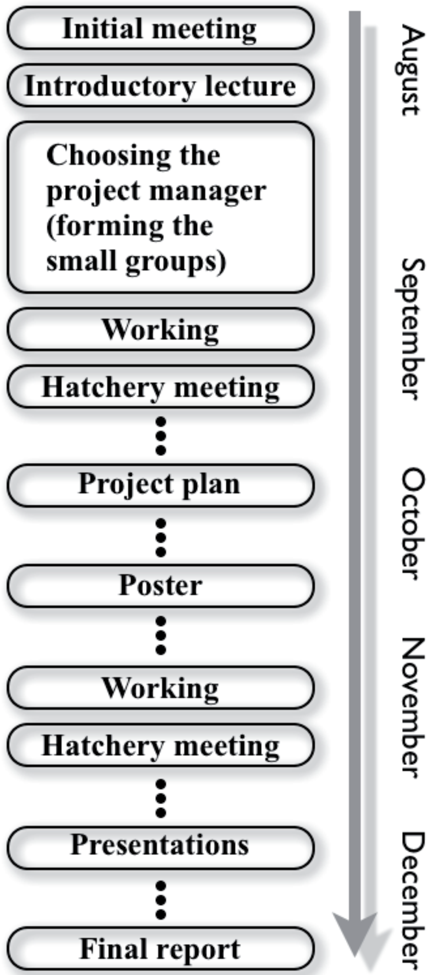
In the beginning of the study unit, the students are given a short orientation to the implementation and aims of the study unit, after which they are put into groups and given the topic that each group will work on during the autumn. Then the teacher tutors take the students under their guidance. Generally in the beginning of the project hatchery, very few of the students know each other or the university of applied sciences as a working and studying environment. Thus the central initial challenge is to create a sense of belonging to the group between students who come from different fields of study. Little by little, the primary aim becomes directing the time and resources of the study unit to the actual work as the students become more familiar with each other as the course progresses.

The study unit contains both independent work and weekly contact lessons. In the timetable of the first year students, there is a continuous period of four hours each Friday morning reserved for the project hatchery lessons. Each group selects a project manager who takes the lead when the topic assigned to the group is taken into examination. The groups are allowed to choose their working methods freely, but the attendance on Friday mornings is compulsory. The actual brainstorming of the project and other separate tasks take place mostly outside the contact lessons in the manner the group desires. This method works in parallel to the progression of the study unit itself, as the teacher's responsibility for successful project work and reaching the set goals is gradually diminished.

Four separate goals have been set for each group involved in project hatcheries:

1) Drawing up a project plan for the support of their work in the hatchery.
2) Drafting a poster relating to their results and future plans.
3) Preparing a presentation discussing their work and results.
4) Writing a final report on their activities and results.

The aim then, despite of dissimilar topics, is to provide all groups with a common template. The template introduces the basic features typical to project work and aids in achieving the central goals of the study unit.



PICTURE 1. *The timeline of the Project Hatchery study unit.*

PERCEPTIONS OF PROJECT HATCHERY AS A STUDY UNIT

A comprehensive body of feedback about the project hatchery arranged in the years 2008 and 2009 has been gathered from both the students and the teachers. The feedback, in addition to the opinions and thoughts that have been otherwise reported regarding the study unit, has helped to form the basis for the following review.

The basic idea of the Project Hatchery study unit differs profoundly from any study unit arranged at TYT before. No other course has ever included students in such a large scale. The exceptionality of the study unit was obvious even before the first course in 2008. The opinions of the teachers were rather divided and even some change resistance could be detected. On the other hand, the possibilities provided by the new study unit were silently anticipated and expected. One of the most common concerns raised in discussions was how students who are only beginning their studies could participate in projects where certain results are sought. It seems that in the beginning stages the method-oriented aims of the study unit were not made clear enough.

On the other hand, the dominating characteristic from the beginning, both among the teachers and more advanced students, was the fairly vivid discussion raised by the new and different study unit. It is very probable that such a discussion had never before been provoked by any single study unit; furthermore, no study unit had ever brought teachers from different degree programmes together as vastly to discuss one single matter. The situation has remained unchanged to this day. It can be confidently said that one of the objectives of the study unit, increasing cooperation between students, has been similarly realised among the teaching staff. This result can be seen as a rather positive by-product for a multidisciplinary faculty.

The arranging of the first project hatchery in 2008 was characterised, on the part of the teachers, by uncertainty even about the basics aspects of the study unit to a considerably greater extent than in the following years. The problem could not be reacted to partly because of the incompleteness of directions provided for the teachers, which surely caused some pedagogical problems that reflected upon the students as well. In other words, the ideas and aims of the study unit were not yet fully developed during the first run.

The uncertainty about some of the basic guidelines among the teachers must have been transmitted to the students to some extent during the first year. The feedback received from the questionnaire targeted to all first-year students in 2008 helps in forming a general view on the progression of the study unit and the experiences of the students, although there was quite a lot of variation in the answers between each project hatchery group. The results of the questionnaire emphasise the following things as the advantages of the project hatchery:

- Getting to know new people and different fields.
- Learning to work in a project-like environment.
- Team spirit and working in a group.

Generally speaking, the disadvantages of the project hatchery were considered to be as follows:

- The topic that the group worked on (too narrow, too wide, not connected to own field, uninteresting).
- Differences in workloads between the groups and among individual group members.
- General unclarity regarding the work, scarce instructions.
- Implementation (the idea was good, but the execution was not).

Feedback was also gathered from students for the future project hatcheries in particular. The following suggestions for improvement were made:

- Topics better thought through and more specifically targeted.
- All topics equally easy or hard for all groups.
- Clearer instructions.
- More contact lessons.
- The teacher more familiar with the topic and project work.

In a similar questionnaire conducted among the teachers, the respondents were pleased with little more than interdisciplinary cooperation. They considered the timing – the first autumn of studies – and the sizes of the groups as disadvantages. Improvement suggestions showed the need for uniforming the hatchery. Uniform directions and an introductory lecture were demanded for the beginning of the study unit, which was also a sign of the above-mentioned uncertainty among teachers; it could also be plainly heard in the word of mouth at the time.

The questionnaires to both the students and the teachers show that some of the set goals were indeed achieved as early as the first year. Still, when considering the feedback, it is necessary to remember that although the advantages recorded were pointed out in several answers, there was a greater part of respondents who did not mention them and the greatest part of them that did not mention any advantages at all. Certainly all had not experienced the advantages that the results of the questionnaire showed as rather general opinions. In any case, the responses drew a picture that showed that the direction was, at least to some extent, the correct one.

The Project Hatchery study unit has been modified for the future on the basis of the feedback. The main criticism against the subject matter was that the students did not find it purposeful to work with a totally ‘random’ topic. Instead, they would have preferred a topic that would have been raised to satisfy a real need. This problem was tackled in later occasions when ideas and assignments for the study unit were sought from the R&D activities of the faculty.

There have been attempts to solve the problems relating to different workloads for different people, which were reported by the students via the questionnaire, by tightening the instructions and uniforming the guidelines offered to the groups. However, it was not deemed necessary to completely eradicate this problem, because a central aim of the study unit is to reflect the reality of group work and the importance of taking responsibility. In 2010, the assessment scale of the study unit was changed from the former pass/fail to fail/1–5. It was hoped that this alteration would offer an opportunity to take into account the different workloads. In addition, much more time was spent in clarifying the objectives of the study unit; the aims were discussed together not only with the whole class but in each of the hatchery groups as well. Both self and peer evaluation were also included into the assessment of the study unit.

The initial unclarity regarding the assignment descriptions and the whole idea of the study unit as well as the scarcity of instructions are aspects that have been bettered after the first project hatchery. Underlining the method-orientation of the target learning outcome has been a central message, which has improved the attitudes of both the teachers and the students towards the study unit and made working easier in general. In their feedback in 2009, the students expressed opinions that were similar to the ones received a year earlier. However, among the disadvantages reported, the unclarity of the study unit and the difficulties in grasping its idea were notably diminished. The topics that the groups worked on were still criticised, but not as strongly as before.

THE FUTURE OF THE PROJECT HATCHERY – AUTUMN 2010 AND THE CHALLENGES TO COME

When this article is written, the last stages of the third project hatchery were still in progress. Despite the sometimes harsh criticism, the character and objectives of the study unit have gradually become increasingly accepted. The unclear issues related to the practical details of the course have been cleared further, which can be seen at least in the work of the teachers.

Among the topics of the hatchery, the assignments based on real-world needs, either from within or outside of the faculty itself, have become more common every year. In accordance with the students' wishes, there have been attempts to enhance the feel of authenticity regarding the topics. These attempts have indeed been successful. Simultaneously, the contents of the study unit have been steered towards the mindset of innovation pedagogy with increasing vigour by the even stronger integration of real development problems and needs. In 2010, this led to positive feedback from the student tutors who had participated to the project hatchery earlier as first-year students.

The criticism against placing the study unit right on the first term of the studies has continued. The idea and objectives of the study unit are such that it was still considered purposeful to leave the timing of the study unit unchanged at least for the year 2010. However, the matter does require further consideration. Apparently, both the students and the teachers consider it more or less problematic that the students form a sense of belonging with their study groups both in their own degree programme and in the project hatchery.

Be that as it may, it can be concluded that the project hatchery has found its place as a common study unit at the Faculty of Technology, Environment and Business. As a method, it is an extremely basic example of the principles of innovation pedagogy: it brings together students from different fields to a project-like environment and clearly creates something new every time in addition to promoting the sense of responsibility in the students' everyday life. At this point, it is still too early to evaluate how well the project hatchery supports the continuing cooperation of students from different degree programmes in the later phases of their studies. However, on the basis of the encouraging feedback relating especially to working together with different people, it seems obvious that the project hatchery does contribute the cooperation between degree programmes in our multidisciplinary faculty in many, although sometimes unexpected, ways.

INVENTIONS AS SUPPORT FOR LEARNING

Jouko Lehtonen, Raimo Vierimaa, Sirpa Hänti & Laura Kalén

INTRODUCTION

At Turku University of Applied Sciences, innovation pedagogy has a notable role in the institution's strategic policy. Innovation pedagogy aims at providing the students with professional skills that enable them to participate in innovation processes of their future organisations. It has been discovered that the development of inventions and patents offers an interesting learning environment in itself. Although inventions and innovations are often developed for solving technical problems or challenges, a growing share of new innovations deals with the development of service processes, for example improvements in nursing care. The rights for technical innovations can be protected by applying for a patent; similarly, attempts can be made to protect innovations in service processes with a registered trademark or other similar methods.

Innovations can be used, in addition to pursuing economic benefits, as learning objectives and learning environments in many ways. The first portion of the article describes how innovations generated in the Degree Programme in Civil Engineering are used as a support for learning. In addition, the article discusses assignments from The Foundation of Finnish Inventions, in which cases the inventor comes from outside Turku University of Applied Sciences (TUAS). Finally, the article describes the use of funding from the TULI programme, which also creates fascinating learning environments for students by funding innovations made at higher education institutions.

DEGREE PROGRAMME IN CIVIL ENGINEERING AS AN INNOVATION ENVIRONMENT

Various forms of active learning have been developed in the Degree Programme of Civil Engineering:

- *Projects*. Each student acquires a project assignment from working life to be completed in the guidance of a teacher from the degree programme. The compulsory project work strengthens the student's project skills and produces a natural channel for networking with working life.
- *Research hatcheries*. A form of project-based learning that emphasises tutoring. A vast assignment from working life or a R&D project from TUAS is developed as teamwork.
- *Expert hatchery*. As a team, the students prepare the questions and record an interview with an expert, conducted either in a classroom or in the expert's own work facilities, for example a construction site. Other students watch the interview and make additional questions. The expert hatchery method encourages experts to join teaching and results in the students performing better in their studies as their topic gains attractivity.
- *Planning and building detached houses*. The degree programme has its own construction projects.
- *CDIO cooperation*. The degree programme participates in international cooperation via the international engineering education development initiative CDIO. The core idea is to increase working life participation in the teaching by using active teaching methods. (Saarela et al. 2009)

Working with inventions, research hatcheries and other forms of active learning are constantly developed further within the framework of innovation pedagogy. (Saarela et al. 2009). Several inventions, for which a patent or a utility model has been applied, have been made in the degree programme by teachers, project workers and students alike (see Table 1).

TABLE 1. *Inventions and patents in the Degree Programme of Civil Engineering (Saarela et al. 2009).*

	patent	utility model	patent application	registered trademark	licensing
Timperi timber frame system		x	x	x	agreement
Sealing sheet pile walls	x				under preparation
OSD pile	x				under preparation
Maintenance cleaning system for a bottom dam	x				
Panel 3 Lock as a base floor structure			x		
The development of the energy efficiency of building mantle			x		
Kopler steel mesh for road reinforcement	x				corporate patents

The students of the degree programme partake in R&D projects in various ways. They can participate as trainees, summer workers and student assistants as well as through thesis work, student cooperatives and research hatcheries. In addition to these possibilities, there are study units that are implemented as parts of ongoing R&D projects. Some parts of the studies related to R&D are compulsory (project work, thesis, certain study units), and some optional (research hatcheries, practical training, work in development projects).

The teachers of the degree programme often act as project managers in R&D projects. They also have additional responsibilities in the projects, for example as members of the project boards or as researchers. The work in R&D maintains their professional skills and provides them with interfaces regarding the latest developments of their field. On the other hand, for example in research hatcheries, the project workers can also participate in teaching duties and supervising by counselling other students.

Please see Table 2 and Figure 1 for details connected to the different possibilities the students have for being involved in R&D during their civil engineering studies.

TABLE 2. *In the Degree Programme in Civil Engineering, it is possible to complete parts of studies by participating to R&D projects in various ways (Saarela et al. 2009).*

Project	invention, patent	theses	project works	research hatcheries	work as practice assistant	exercises in study units	year of studies
Timperi timber frame system	x	x	x		x	x	3–4
Modern wooden town		x	x				4
DATU (database on Turku underpinning projects)		x	x	x	x		2–4
MIDA (micropile database)		x	x			x	4
MITRA (micropile training programme)			x	x			2–3
Protection of the River Aura		x					4
Ground water basin in Laitila		x					4
Protection of small lakes in Eura		x					4
Protection of Lake Littoistenjärvi	x				x		
Sealing sheet pile walls	x	x	x				3–4
Kopler (steel mesh road reinforcement)	x	x			x		3–4
Panel 3Lock base floor	x	x	x				2–4
Reed project		x					4
Kunnonkoti (a model home for housing supported with disability aids)			x	x			3
Energy curtain	x	x					4
OSD pile	x	x	x				3–4
Real estate strategy		x			x	x	4
Building restoration centre		x			x	x	2–4

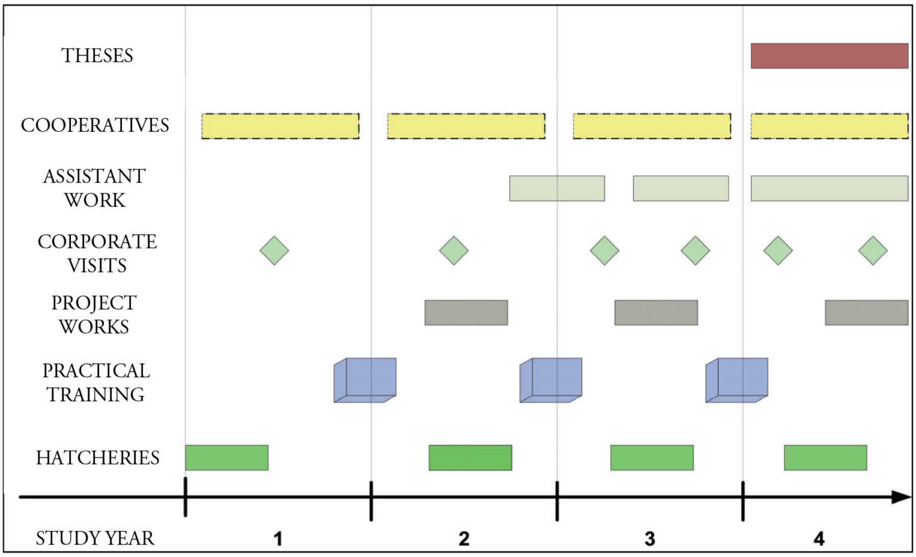


FIGURE 1. *Environments of active learning and working life connections in civil engineering studies.*

Timperi timber frame system

Timperi timber frame system is a production technology of prefabricated houses created at Turku University of Applied Sciences. The Timperi structure has been granted a utility model and it is licensed to two companies that employ 15 people so far thanks to the system. With Timperi technology, an entirely new line of production has been started in Southwest Finland.

The development of the Timperi timber frame system has offered a whole range of study possibilities. Several theses and other works have been completed within the project. In addition, the students have participated in the design and construction of the houses as assistants. As the operations have stabilised, a type of design agency has been established within the degree programme. The students involved have developed 3D modelling software for the Timperi timber frame system together with the software development company Vertex Systems Oy.

In the summer of 2005, a detached house was constructed for Parainen Holiday Home Fair with civil engineering students as designers, workers and supervisors. The construction was carried out in cooperation with the Degree Programme of Sustainable Development of TUAS, Novia University of Applied Sciences, Turku Vocational Institute and Parainen Vocational School. Similar sites have also been planned for the vocational institutes of Raisio and Loimaa. Together with Turku Vocational Institute, TUAS has purchased a site from the city of Turku for the construction of two detached houses, whose construction began in 2009. The degree programme will carry out the construction design, structural design and element design for both sites as thesis projects, as well as 15 to 30 project works related to production technology. Additionally, parts of supervised practical training will be conducted at these construction sites.

PICTURE 1. *In Timperi timber frame system, each wooden part is planned separately before machining and construction.*

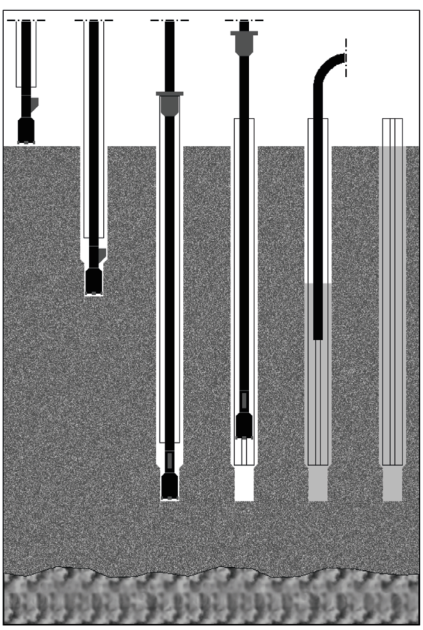
Timperi timber beam

Related to the frame system, an edge-glued laminated timber beam was researched in cooperation with students in 2010. The lamels were finger-jointed. The research results were encouraging and the decision to start the production of the beams was made.

OSD pile

The OSD pile is a patented new way of making a so-called drilled pile. Unlike former steel piles, Open Section Drilling – that is, OSD – is utilised in an open profile and installed into the ground with a new kind of an eccentric drill. Developing the method sets challenges for the development of both pile material and pile driving equipment. (Heiskanen 2007.) The OSD pile is developed in cooperation with Emeca and Robit. A license agreement has been made with Emeca for commercialising the product.

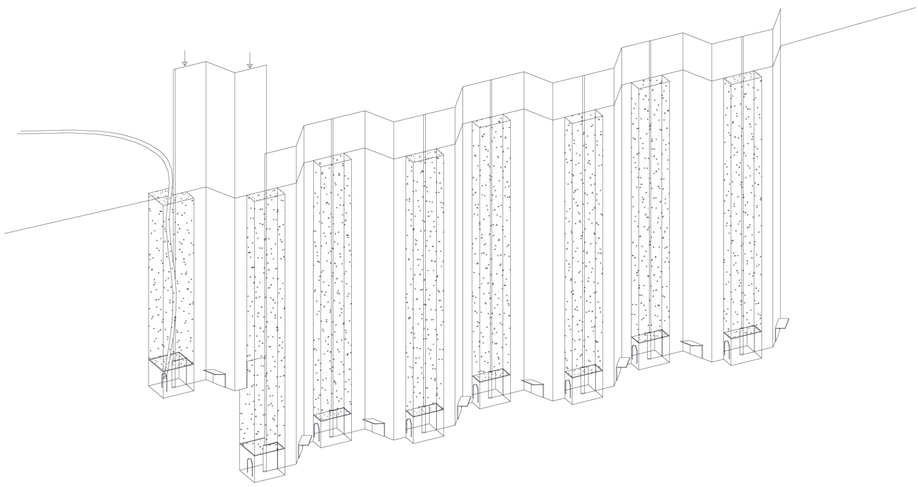
The OSD pile can be used for various kinds of lightweight structures, for example for the foundation of traffic sign posts. As a learning environment, the development of the OSD pile has produced half a dozen theses and several project works. When foreign exchange students have participated in research hatcheries at TUAS, they have been given a learning task related to the invention. A typical example of these learning tasks might be to find possibilities for the use of the invention in their home country. In the future, the development of the OSD pile could be continued in, for example, sales teaching or student cooperatives.



PICTURE 2. *An OSD pile is installed by drilling a steel open profile to the ground. Finally the pile is encased in cement mortar (Heiskanen 2007).*

Sealing sheet pile walls

Sealing sheet pile walls with cement is a new patented invention made by a teacher and a student from the Degree Programme in Civil Engineering. By applying this method, it is possible to construct a completely watertight underground sheet pile wall (Laaksonen 2006). Such a structure could be used, for example, when constructing an underground car park. The invention has been a learning environment for theses and several exchange students who have mapped the possibilities for its use in Central Europe, Portugal and Brazil.



PICTURE 3. *Sheet pile walls can be sealed watertight underground by injecting cement grout with the patented method (Laaksonen, 2006).*

Using steel mesh in road construction

Steel mesh can be utilised in road construction in various ways. With steel mesh reinforcements, the bearing capacity of soil can be improved, dents repaired and frost heave cracks prevented. (Kanerva-Lehto 2009). At TUAS, several Bachelor's theses in engineering and one Master's thesis in engineering have been completed on the subject.

Steel mesh has been studied and developed for several years in close cooperation between Tammet and TUAS. The company has developed the method from the point of view of technical production and applied for several patents in connection to the technology. The students of civil engineering have received the latest innovations as learning environments as soon as they have been made public.

PICTURE 4. *There is a patented method for installing the steel mesh, which has been developed further by the students of TUAS. Photo by Olli Heinilä.*

INNOVATION INCUBATOR AS A LEARNING ENVIRONMENT

In 2009 at The Foundation for Finnish Inventions, an invention development service for private people and micro enterprises called Innovaatiopaja (innovation incubator) was tried out. The purpose of the service was to specify the development needs of new product and service ideas. In the concept, the examination of possibilities for protecting the inventions was conducted mainly by the advisors from the foundation itself. However, the tasks connected to defining the business potential of the idea, the matters related to the costs and pricing of the product, product development, the aspects concerning product design and the creation of the product's image, the production of prototypes, package design, various kinds of research as well as marketing and selling the product were all services that could be purchased from external operators.

Students from the Faculty of Technology, Environment and Business participated in the pilot of the innovation incubator model in the autumn of 2009. The students were taken on in two different ways. While student cooperatives offered services in the form of innovation feasibility studies, a separate project was started for the students of Industrial Engineering and Management, who developed an operating model which enables the student cooperatives to offer high quality services in urgent real-life assignments with an additional challenge of confidentiality. The inventions and the feasibility studies connected to them are exiting and demanding learning tasks that fulfil many of the principles of innovation pedagogy – activity, students' own responsibility for their learning, the creation of new information, close cooperation with working life and, above all, entrepreneurship. Figure 2 illustrates the cooperation model for the feasibility study of inventions. Its main operators are the innovation incubator of The Finnish Foundation for Inventions, the inventor and the student cooperatives. The teacher tutors support both the cooperatives and the student project.

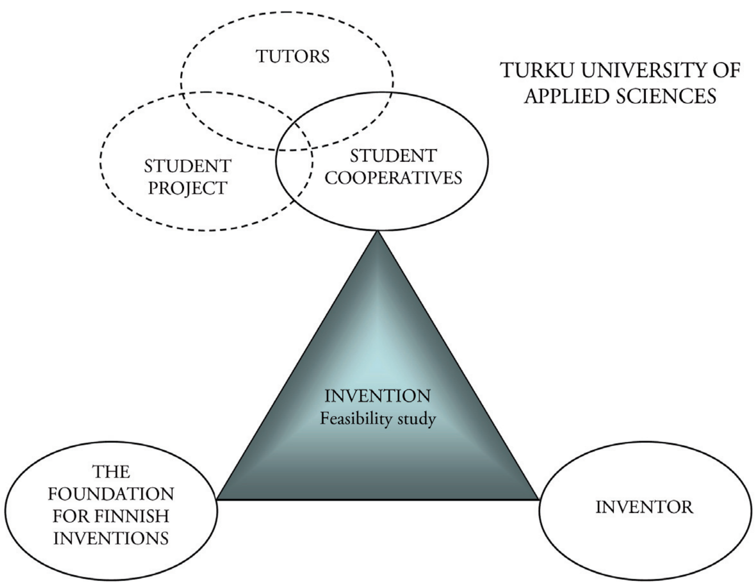


FIGURE 2. *The cooperation model for invention feasibility studies.*

The assignments of this pilot touched upon the areas of product development, production planning, experimenting with various materials, cost calculations, package design and mapping out sales channels, to name a few. The multidisciplinary nature of the faculty resulted in a useful variety of students in the cooperative; those participating in the assignments mentioned above study Industrial Engineering and Management, Mechanical Engineering as well as International Marketing. Two of the student cooperatives are officially established businesses that charge their clients for services. In this cooperation model, the students learn matters related to promoting and commercialising inventions in a real environment. In addition, they acquire knowledge on the development of their own business from the perspectives of feasibility, work organising, effectiveness and high quality business operation models.

FROM RESEARCH TO BUSINESS

Also TULI funding can create new learning environments from student-inspired inventions and innovations. TULI is an acronym for 'TUtkimuksesta LIiketoimintaan', which means 'From Research to Business' in English. Tekes (the Finnish Funding Agency for Technology and Innovation) allocates TULI funding for development work conducted at higher education institutions. TULI funding is divided into three phases: the initial evaluation of the project, the evaluation phase and the refinement phase (Table 3).

TABLE 3. *Funding provided by the TULI programme (Tekes 2009).*

	Initial evaluation phase	Evaluation phase	Refinement phase	Proof-of-concept
Funds/Idea	Less than €5000	Less than €20000	Less than €30000	€100000-200000
Decision-maker	TULI contact person	Project group	Project group	Tekes
Response time to the client	Immediately	Less than a month	Less than a month	Normal project process
Phase duration	Some weeks	1-3 months	1-6 months	

TUAS has been involved with the TULI programme from 2008. During these couple of years the number of project ideas brought to the TULI programme has multiplied and the role of innovations has gained emphasis alongside with other R&D activities. At TUAS, more than 30 projects for commercialising services, research findings or inventions have received TULI funding. Some of the projects have been initiated by the students, and several inventions have been patented and licensed.

TULI funding in universities of applied sciences have been planned to end in the spring of 2012 at the latest; later, similar funding can be applied for from the Foundation for Finnish Inventions. TULI has offered an operating model for the development of innovation activities at higher education institutions as well as for supporting the commercialisation of innovations in such environments. For example, the confidential evaluation of ideas in consortium project groups has guaranteed the projects opinions of several experts and a neutral funding decision. Overall, the TULI programme has given birth to good results at TUAS, the previously presented Timperi beam and the OSD pile being good examples of this.

Ecologic design from hemp

Saana Sipilä and Olli Sallinen are two students of design in Turku University of Applied Sciences who have in their textile design studies looked at environmental friendliness of textiles and the industrial applications of new ecological textiles. For their Bachelor's thesis, they examine textile production with the ecological hemp and its qualities as a furnishing fabric. As a material for furnishing fabric, hemp fibre is nearly the most ecological option that Sipilä and Sallinen found but it is still not used in a large scale in industrial production. With their products the designers aim at improving the image of hemp and at producing modern, visually interesting and minimalistic home decor accessories and linens.

The furnishing fabrics made of hemp are sold under trademark Saana ja Olli. The business has been, for example, selected to participate to the Hirameki Design × Finland exhibition produced by Design Forum Finland in Tokyo Designers Week. The exhibition presented Finnish design in order to promote its export. The TULI funding was used in the early stages of the business when the export possibilities to Japan were looked at.

CONCLUSION

Inventions and innovations offer an interesting possibility for innovation pedagogy and their production is one of its central objectives. In the production of innovations two closely related concepts are connected: learning and developing. They often appear as two aspects of the same concept. At its best, innovation is an inspiring and challenging learning environment for the learner – developing is like being at the frontiers of existing knowledge and abilities, reaching out for the unknown. When developing innovations, the students recognise the information that is supposed to be found through studying. Innovations also include the risk of failure which is an integral part of development in the context of working life. Facing risks and failures is valuable capital which a student can acquire when working with innovations.

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BUSINESS GROWTH POSSIBILITIES THROUGH INNOVATION PROCESSING

Juha Leimu & Kristiina Meltovaara

INTRODUCTION

Most engineering programmes were planned years ago under a different educational system, when all starting engineering students had at least one year of working experience. This meant that students were already familiar with the practical work and its working environments. The theoretical teaching offered in classrooms was based on this work experience and therefore practical laboratory tests were deemed to be an adequate supplement for the theoretical teaching.

Now the system and the situation have changed. Numerous students commence university degrees directly from high school with little or no relevant work experience, thus lacking practical skills and the basic understanding of how a working environment functions. The need for a change in the engineering education has been recognised worldwide (www.CDIO.org and engineerofthefuture.illinois.edu). The common question coming up is why the change of the education system is taking place at such a slow pace. Turku University of Applied Science (TUAS) has taken part in both the CDIO framework and the Engineering of the Future summit. The CDIO initiative is a framework providing students with an education that stresses the engineering fundamentals of Conceiving, Designing, Implementing and Operating real-world systems and products. The Engineering of the Future summit discusses the transformation of the engineering education by specifically emphasising student engagement in and for the transformation. Both the framework and the student involvement method have been applied side by side at TUAS throughout the project described in the article.

Nowadays, the students require a more practical approach to their studies and also experience as to how a business environment functions with its own rules and goals. In the following, we introduce an alternative learning approach, which encourages students to undertake independent studies and work as well as to utilise the work methods and practices used in the industry. The hands-on experience in a business environment will help students in acquiring a position and also provide them with skills to better fit in the organisation of their choice. This alternative approach offers students practical and attitudinal skills and abilities, almost by osmosis, in addition to the theoretical knowledge obtained in the class room.

Cooperation and communication skills have become an increasing success factor and a prerequisite for most positions whether in sales, finance, production or marketing. Most employees do not work alone but as team members (Hänti 2009). Cooperation and the efficiency of the information flows between team members and different organisational teams become increasingly important, especially for companies operating in a dynamic and complex competitive environment.

The conventional approach to teaching, by transferring information in a rapidly changing business context, is a further challenge faced by engineering programmes (Paanu, Nieminen & Nousiainen 2009). At the same time, the business environment overall requires an innovative approach in order to maintain and also to enhance the competitive edge of those working within it. The innovation process has also been adapted to the higher education system to provide students with appropriate knowledge and tools to further promote other innovation processes and innovation management upon graduation and the transfer to business organisations. Kettunen emphasises advancing further from the adoption of the innovative process towards an 'innovation pedagogy mindset', which should be considered analogous with the legally defined goals of the higher education system (Kettunen 2009). According to Kettunen, the cornerstones of innovation pedagogy are interdisciplinary operations, R&D, curricula and internationalisation as well as entrepreneurship and service activities.

Innovation pedagogy defines 'innovation' as the process of constantly improving know-how, which in turn leads to further know-how, new ideas or other practices applicable in working life (Putkonen, Kairisto-Mertanen & Penttilä 2010). Innovative teaching methods improve both the quality of the teaching and the students' awareness of the innovation process as the implementation of project work within the curriculum in close contact with companies. Such an approach enables students to apply the methods and equipment used by the companies in a controlled environment, in other words to apply learned skills to practical development challenges.

In addition to sharing resources and knowledge, it also gives companies the possibility to form confidential long-term relationships with future employees, as a company's technological competence is not the only significant determinant relating to the level of its innovation processes. Indeed, the ability of a company to interact with its environment and satisfyingly use its inter-organisational relationships is one of the other innovation success factors (Ritter, Gemünden, 2004). By forming relationships with higher education institutions, companies can broaden their research programmes. Furthermore, it allows the company to focus its in-house expertise on the more critical projects with possibly tighter deadlines.

PROJECT BACKGROUND

Starting cooperative projects with companies is costly and time-consuming. The transfer of the background information and agreeing on the goals, scheduling, methods, equipment, confidentiality, reporting, among other things, demand a lot of work from both partners. All of the aforementioned require the company to be fully in control of its current processes. It also has to be willing to transfer the knowledge relating to the processes, the written knowledge as well as the unwritten practices and behavioural patterns, to both the teaching staff and the students. The ones receiving this information, on the other hand, will have to understand and absorb it.

By transferring both the written and unwritten knowledge to the students successfully is a key factor in producing innovative project results. The time required by a student to execute tasks is greater than that of professionals due to the ongoing learning process alone. Companies are used to completing fast and compact projects and high starting costs combined with slowly produced results is not an easy equation. For optimal results, the work should be organised so that several student groups can carry out their project work based on already finished basic work. Student groups should also have overlapping project work schedules in order to ensure that previously acquired know-how and experience gets transferred during the learning process.

TUAS has started a long-term cooperation with a leading paper machine manufacturer, hereafter called 'partner company'. The partner company has patented, years ago, a new type of vacuum roll which has a good potential for reducing the electricity consumption of the paper machine's cylinder dryer runnability system. The energy consumption of such a system has been widely researched (Juppi, 2001), (Leimu, 2008). The partner company's original idea had been to test the new roll with its own runnability simulator and pilot paper machine at its own research plant. The testing process turned out to be slow and expensive.

TUAS made a two-year project agreement with the partner company. The approach was to build a small-scale model of both the new type of roll and the drying fabric with which it made contact. The student work was organised into a chain of student projects. The learning and know-how cumulated from project group to project group, offering the students practical experience as to the importance of co-operation and communication. The natural communication between the teachers and the partner company was also of great importance to ensure all aspects relevant to the company were examined over a jointly agreed timeline. A cross-professional team could easily recognise and pick out a number of problems to be solved by the student teams from various areas of engineering. All the methods and equipment that were used in the project are commonly utilised in the development work of the machine industry; thus, all the skills learned can be applied to different areas of machine building and automation.

The teaching staff of TUAS participated in the project by forming a part of the project steering group. The steering group meetings were held regularly, but also whenever necessary. The project work that had been undertaken was discussed as were any problems and questions arising from the work. Furthermore, the next steps of the research project were talked through and agreed upon during these meetings. The continuous contact between the TUAS staff and the partner company was essential both in the original implementation of the project but also in the successful completion of the research. In fact, the most important aspect in obtaining this partner contact was the understanding the TUAS staff had of the partner company's research and manufacturing process as well as the understanding of both the internal and external business environment in which the company operated. On the partner company's side, participating in an external research project undertaken by students required that the company's current business processes were well internalised and documented.

INNOVATION PEDAGOGY PUT INTO PRACTICE

The extensive use of student labour had been the basic idea in this process from the very beginning. As a first step, the students made a suggestion for a test rig with the help of which the experiments could be carried out. To get started, an engineering competition was arranged. Three student groups produced their proposals as three-dimensional computer models. The partner company, based on the winning suggestion, undertook the professional engineering work and also manufactured the test rig.

After the delivery of the equipment, two new groups started their work. One planned a layout for experimental work, moved the equipment to their places and performed the start-up. The second group started planning the data logging system. They were followed by measurement groups and further development groups of the data logging system. The system was developed continuously according to the feedback from the measurement groups.

In the beginning, each group received their instructions from the tutor teachers. In spite of careful guidance something went wrong. During the first half-year period, the most common results of the work were smoke and damaged equipment. As a consequence, the organising of the work was changed so that each new measurement group worked two weeks together with the previous one helping and participating in the routines. This adjustment to overlapping working periods, which allow for the information to be shared, practically put a stop to the equipment damages and also had a clear positive effect on the quality of the measured data.

Systematic and cooperative development work between the students, the teachers and the company led to a sophisticated data logging system. It appeared to be more advanced than the one used by the partner company itself. The project manager of the data logging system was invited to the partner company's research plant to undertake his bachelor's thesis and update their data logging system.

Moreover, when the results of one of the measurement groups were reported to the partner company, they asked for a new series of experiments, as verification experiments for a computational fluid dynamics model of grooved rolls were needed. The model was included in a doctoral thesis which was made as a part of a large and long-lasting research project. The original idea had been to do experiments to verify the computer model at the partner company's research plant, but the modification of the heavy runnability simulator had been so slow and expensive that the experiments were moved to the small-scale model. The experiments succeeded well (Nurmi, 2009).

Today, the student groups produce experimental data of good quality for the needs of the partner company's product development. Analysing the results has led to new questions as well as new experiments, and the partner company has invested in the test rig, sensors and supporting work. The cooperation agreement has now been continued for a third year as a new experiment plan has been accepted and the work continues. After a half-year of cooperation, the work had reached the quality level where it has commercial value for the partner company, proving that TUAS is a good partner for a company in a situation where there is enough time to repeat the measurements, if needed. The cooperation in question has worked as a good reference and there are several ongoing discussions with a number of companies concerning the same kind of work with student participation.

CONCLUSION

The successful completion of a project of this type requires many kinds of commitments from those involved with the project. In the beginning, the participating company needs to appreciate the fact that it has to incur extra personnel costs to fill the need for the transferring of know-how to the students. On the other hand, there has to be enough resources available on the side of the education institution to absorb that know-how and the company's processes. Another prerequisite is the long-term nature of the cooperation involving an unchanging group of key people to form a concise knowledge pool.

An innovation process, combining a company's R&D skills with the know-how of the teachers and the learning possibilities of the students from a higher education institution, has numerous advantages for both parties. Student work can be organised so that it provides the students with an authentic experience of project work and the company with reliable experimental results. It also offers a natural contact opportunity for the company's development staff and the teaching personnel. Also the students are able to put their communication skills into practice not only within their own team but also with other teams, whilst passing on relevant information and expertise. The importance of sharing information and teamwork is highlighted as hands-on experience is gained on effective communication and co-operation skills within a controlled environment. The needs and requirements of working life also become clear to students participating in the project.

A long-term confidential relationship between the partners acts as a basis for the kind of innovation process in question and forms the foundation for the work to be carried out. For the process to be successful, the company as well as the teaching staff will need to communicate on a regular basis. In addition, the company personnel need to transfer their process knowledge to their partners, who have to be willing to absorb all the information provided and act accordingly. Utilising the mixture of student skill and teaching staff expertise can provide companies with a means to enhance in-house competences and offer them a competitive advantage in addition to a solid economical basis for a profitable innovation process. The approach allows companies to outsource a part of their R&D functions, thus reducing the amount of in-house expertise required for the task at hand and freeing in-house expertise to focus on other ongoing project work. Furthermore, it allows companies to make contact with possible future recruits. All of the aforementioned benefits provide companies with growth possibilities and competitive advantages at reasonable costs and low recruitment requirements.

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COMMUNICATIONAL ASPECTS OF INNOVATION PEDAGOGY AND STAKEHOLDER DIALOGUE

Taru Penttilä, Liisa Kairisto-Mertanen & Ari Putkonen

INTRODUCTION

Like all organisations, universities of applied sciences are a part of network economy with numerous interconnected interest groups. While continuous stakeholder dialogue is relevant for any organisation at any given time, it is especially the case when new concepts or ways of action are introduced. At the moment, the concept of innovation pedagogy is still making its way into pedagogical discourse on higher education and thus research reports or academic discussions available on the topic are yet scarce (Kairisto-Mertanen, Penttilä, Putkonen 2010; Putkonen, Kairisto-Mertanen, Penttilä 2010). The concept itself is also wide and multidimensional by nature, making its interpretation demanding and often dependent on the context, forcing its focus on specific issues connected to the task at hand.

This article concentrates on the expected outcomes of innovation pedagogy and aims to describe its communicational aspects regarding the various interest groups of universities of applied sciences. The text discusses the reasons why these messages need to be communicated and why it is advantageous to regard them also as a part of stakeholder dialogue, alongside with other channels of communication at universities' disposal.

Innovation pedagogy can be approached from several standpoints. In the context of stakeholder dialogue, it is useful to divide its conceptual core into three different spheres in parallel to the three primary interest groups connected with universities of applied sciences.

- *Creation of innovations* – having primarily to do with *students and graduates*, who are expected to create innovations while affiliating with working life.
- *Learning of innovation competences* – being mostly connected with *working life*, which provides students with ideal surroundings to acquire the competences needed in innovation processes.
- *Meta-innovations* – referring to methods of learning and teaching utilised by the *university staff*, enhancing both creating innovations and innovation competences.

As can be seen in figure 1, this approach illuminates the relationships between these critical interest groups as well. The methods applied by the staff constitute a base for learning and thus enable the forming of innovation competencies. The methods used also facilitate intuitive learning during the learning process and make transmitting tacit knowledge possible when dealing with working life. Finally, innovation competencies enable students to contribute to creating innovations, which is the ultimate target of innovation pedagogy.

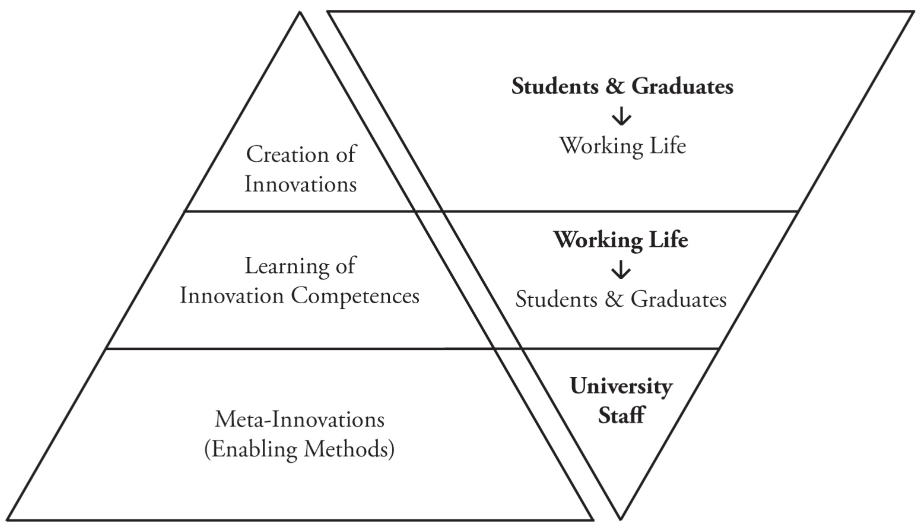

FIGURE 1. *Competence hierarchy of innovation pedagogy and its respective interest groups.*

The relevance of innovation pedagogy, including its expected outcomes, depends on the different viewpoints of each interest group. Therefore the relevant messages of innovation pedagogy are also different for each party. In addition to the three already mentioned, also the most important secondary interest groups for universities of applied sciences are presented below. The discussion is accompanied by insights on the relevant messages of innovation pedagogy for each group.

DIFFERENTIATING BETWEEN STAKEHOLDERS IN REGARD TO INNOVATION PEDAGOGY

There are several factors that encourage universities to respond to the pedagogical challenge of enhancing innovation skills and competences. These factors can be discovered both in universities' internal and external environments. Universities have to have continuous dialogue with their stakeholders within their operational area to be able to communicate and develop their pedagogical approaches and to positively influence the creation of competences required by working life to the best of their ability. At the moment, some of the most essential competences required are those connected to students' competences to actively participate in the creation of innovations in their future professions, i.e. innovation competences.

For each large organisation, there are likely to be numerous stakeholder groups with different, possibly conflicting, expectations. This means that organisation management needs to identify not just the interest groups, but also their various levels of influence and different expectations as well as to which of the groups the most attention should be paid in general (e.g. Johnson et al, 2008; Ambrosini et al. 1998; Freeman 1984). Typical major stakeholders for universities are presented in figure 2.

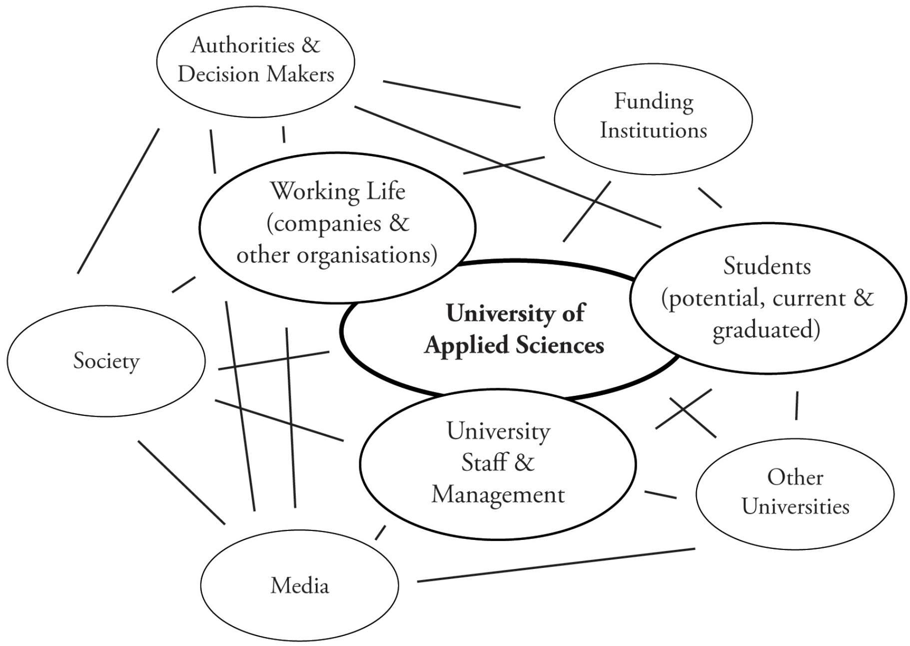

FIGURE 2. *Network of primary and secondary stakeholders of universities of applied sciences.*

As stated above, the stakeholders of an educational institution can be classified as primary or secondary stakeholders. The inner circles describe universities' typical primary stakeholders, with whom universities usually have close, regular and often highly interactive relationships. The relationships with secondary stakeholders located in the outer circles are more distant and usually less regular, but some of these groups can also become primary stakeholders over time. The primary stakeholders can be considered as those having more direct and concrete benefits from innovation pedagogy than the secondary stakeholders.

The possible messages and outcomes of innovation pedagogy for each interest group are discussed briefly in turn below. This compilation of stakeholders presents the most common and important interest groups that can benefit from the outcomes of innovation pedagogy, but it is not meant to be comprehensive as such. One reason for this is that universities, differing equally in their internal structures as well as in their surroundings, can have extremely diverse stakeholders.

CORE MESSAGES IN INTERNAL DIALOGUE WITHIN UNIVERSITIES

Students, belonging to primary stakeholders, can be seen either as direct or indirect customers of educational institutions; direct, if they are considered to be studying primarily for personal and professional growth, or indirect, if working life is seen as the "end user" of education (e.g. Ruben 1995). Either way, students are the key actors of innovation pedagogy. The goal of innovation pedagogy is to provide students with innovation competencies such as knowledge, skills and attitudes needed in diverse innovation processes. The acquisition of these competencies requires students' own will and motivation, as they cannot be simply transferred to their disposal without their own input. These educational goals can be reached only through dialogue and cooperation, by tutoring and guiding students to cultivate their own characteristics.

According to the principles of innovation pedagogy, students' professional growth and good innovation skills are not seen as the final outcome of education, but as a part of a continuous learning process. During their studies, students, often in cross-disciplinary teams, work with real-world development tasks in which working-life representatives typically participate. Often faced with difficult and even chaos-like situations, students' expertise evolves through cooperation and dialogue; at best, the process itself might result in creating new innovations.

However, the crucial aspect of the pedagogical connection with working life is that the students are exposed to regenerative (and even tacit) knowledge as well as superior know-how (Putkonen, Kairisto-mertanen, Penttilä 2010). It is also essential for students to learn to appreciate the significance of intuition in relation to knowledge application. By reflecting upon the learning processes themselves, students enhance their professional growth in a way that provides them with qualifications that help them function productively in the dynamic and ever-changing contexts of working life in the future. They also create relationships and networks with working life organisations already during their study time, which often motivates them to graduate faster to seize the new job opportunities.

Upon entering the university, students naturally have their own expectations and past experiences about learning and teaching. Some of them may need a lot of motivating when they are brought in contact with innovation pedagogy, as the learning methods it applies require a remarkable input from the students themselves. The requirements can be initially regarded as too heavy and demanding, or even unclear and chaotic. Since the students are expected to negotiate their way through the learning process by experiencing, participating and acting, it is possible that these methods cause resistance or misunderstandings if they are not pre-examined in detail together with the students. In other words, a lot of attention should be paid to communicating the targeted aims of innovation pedagogy from the start.

When discussing innovation pedagogy with students, it should be stressed that it is a long-term approach by nature. The emergence of innovation competencies is gradual and does not necessarily offer instant gratification in the beginning stages of the process. *Thus, in the case of students, innovation pedagogy should be approached primarily from the viewpoint of innovation competences and benefits they offer in the long run*. The core message for them is that the methods applied in innovation pedagogy prepare them better to the requirements of working life.

Also the motivation and expertise of the *university's teaching staff* can be significantly enhanced by innovation pedagogy. Typically at first, some change resistance may occur and the unknown may be seen as frightening or even threatening. However, when the concept is discussed openly, the attitudes are often altered and the teachers are empowered by the insight that they actually have the pedagogical knowledge needed to implement innovation pedagogy already. After all, innovation pedagogy does not attempt to play havoc with pre-existing pedagogical knowledge, but gives opportunities to implement it in new motivating ways.

As with students, the benefits of the approach do not necessarily manifest themselves at once but with time, as the teaching focus shifts more towards tutoring and guiding the students. The change, however, can be quite liberating, since teachers are not regarded any longer as bottomless sources of information and they are free to learn and evolve in parallel with their students. The work itself becomes more diverse, teachers' own professional expertise gets polished and they can refine their working life know-how and cooperation skills with their own industry.

In the context of staff interests, it is fruitful to discuss innovation pedagogy not only from the perspective of work motivation, but also from the viewpoint of meta-innovations, in other words the methods of teaching and learning that enhance innovation competences and the creation of innovations itself. These are the tools teachers wield as a means to encourage and support the students to create, develop and maintain innovation competences and also to use them as productively as possible after they finish their studies. In conclusion, the core message regarding innovation pedagogy for the teaching staff should not only be that when implementing innovations pedagogy, they can better serve both their students and the surrounding working life. They also get a unique chance to make their own workdays more meaningful and less stressful for themselves by applying fresh teaching methods. To ensure commitment and good results, however, the change calls for dialogue and networking between university staff, management and other stakeholders.

For university *management*, innovation pedagogy can provide a coherent strategic direction regarding how to develop the organisation. The approach can be utilised for improving the organisation's regional impact as it enhances networking between stakeholders as well as amplifies commitment and co-operation between university staff members, management and external stakeholders. Additionally, it functions as a motivational tool, ensuring that each member of the teaching staff has new ways to develop their work. The ability to enhance innovation competences and to create innovations together with working life can naturally improve the university's reputation and offer more financing or new opportunities for development. Indeed, the core message for university management should be that innovation pedagogy provides the university with an opportunity to create a unique profile, which enables the organisation to distinguish itself from other educational institutions.

CORE MESSAGES IN DIALOGUE WITH EXTERNAL STAKEHOLDER GROUPS

Outside the university, innovation pedagogy is especially valuable to *working life*. One of the tasks given to a university of applied sciences is to serve the surrounding businesses and organisations in the best possible way. Innovation pedagogy offers working life an opportunity to have input on the education relating to their field and strengthen the competences needed in innovation processes within their own operating environment. The students get acquainted with working in real-life situations, sharpening their skills connected with development-oriented tasks in the process. As an outcome of innovation pedagogy, students are skilful in acquiring information independently and applying it to practice on their own, requiring less guidance and instructions than before. They get used to working in insecure circumstances, where they have to take calculated risks. They also have the opportunity to work with different kinds of people, which helps them to appreciate different ways of thinking and become, even in a broad sense, more culturally literate. Furthermore, by bringing development projects and tasks into the learning environments and participating in the learning processes, working life representatives can be treated to new insights, ideas and even innovations to enhance their own working habits and end products.

The relevant outcome of innovation pedagogy for the working life as a whole is naturally the creation of innovations. Innovation competences can only be fruitfully developed in close cooperation with working life representatives in order to ensure that the learning taking place provides the intended results. The core message for businesses should then be that when they are involved with a university engaging itself in innovations pedagogy, they get a chance to recruit young professionals better adapted to the requirements of the ever-changing working life. The added value is in the likelihood of gaining a competitive advantage through raising the maturity level of new recruits.

Other universities of applied sciences share similar goals. They include providing high quality education enhanced with innovation competences, cooperating closely with the surrounding working life and fulfilling their obligation of R&D work in order to contribute to innovation processes in general. Innovation pedagogy offers additional methods and tools to achieve these objectives and a forum to jointly develop these meta-innovations further.

Authorities and decision makers, for example the ministry of education, the board of education and other political decision makers, are interested especially in the outcomes of innovation pedagogy. They can be seen to include higher graduation rates, shorter study times, improved R&D results, stronger regional impact and upgraded student satisfaction. These benefits must be clearly highlighted in the communication.

Funding institutions are typically interested in development of innovation know-how. Innovation pedagogy can offer more external funding opportunities for universities through providing innovative and profitable results for the funding institutions in turn.

The success of education and its capability to produce innovations is relevant for any *national economy*, as the processes in question are those enabling positive developments in competitiveness in the *global context* as well. Innovative and sustainable pedagogical solutions also offer opportunities for *education export* and create international cooperation especially in the pedagogical sector. Additionally, the *media* plays an important role in communicating the positive outcomes of innovation pedagogy, which can result in tax revenues and more public financing targeted for education.

CONCLUSIONS

Different stakeholders have dissimilar needs and expectations. Together, they form a network of values. An approach concentrating on stakeholders emphasises the active management of the business environment, the relationships within it and the promotion of shared interests (Freeman and McVea, 2001.). Thus, it is important for a university to have detailed information on its interest groups as well as their needs and expectations regarding the pedagogical approach of the university. Stakeholder management refers to the management of questions related to the university's value network, but it can be terminologically widened to encompass the interaction between a given university and its stakeholders, in other words to include the stakeholder dialogue as well. The absolute prerequisite for this interaction is that the university is informed enough about its stakeholders' interests and values. This is a fruitful starting point for active and mutually beneficial cooperation and communication.

A well-functioning network is maintained through well-functioning relationships. These relationships are always a consequence of good interaction between people. Thus, it is safe to say that a network well-fitted to its purpose always comprises individuals personally committed to the dialogue. A successful network is able to create added value to the people involved in the interaction processes. It is also important to keep in mind that in the wake of the individuals primarily involved, there are always more individuals who are engaged with indirectly and they may, or may not, get to share the benefits of this added value. It is at the responsibility of the university's management and staff to create good relationships in the educational surroundings. (For networks and relationships see e.g. Dwyer, Schurr & Oh 1987; Crosby, Evans & Cowles 1990 and Vargo & Lusch 2004.)

A successful dialogue between the university and each of its stakeholder groups is an essential requirement for the development of innovation pedagogy. As it is one of the core ideas of the concept to utilise information gained from the surrounding stakeholder groups, it is obvious that this information must also be provided for the use of the whole university and its teaching staff. In other words, all information relating to these processes must always be easily accessible for the whole organisation.

This principle of open access calls for the development of many different ways of collecting and sharing appropriate information. In addition to general openness, the strategy requires the implementation of different kinds of information processing tools designed for this purpose. However, these developments are in vain if the university and the interest groups do not, once in a while, actually sit around a common table, be that table virtual or not.

For the innovation pedagogy to succeed in its purpose, it is essential to understand the needs of each stakeholder group functioning within and without the university. The information acquired through dialogue on the versatile needs of a given interest group has to be spread across the whole university to every relevant level of organisation. This requires broad networks, functioning relationships within those networks and the capability and will to nurture those relationships.

The core idea of innovation pedagogy is to combine external working life needs to the internal needs of the university to create working environments that result in better learning possibilities for students. In these environments, the students begin to develop their innovation capabilities, which consist of substance-related knowledge as well as intuitive knowledge produced in the learning situations.

The various perspectives to innovation pedagogy presented in the introduction of this publication should be kept in mind when discussing the outcomes of innovation pedagogy. Since the concept is so wide-ranged by nature, the stakeholder group in question often determines the emphasis. On the other hand, the extent of the concept as a whole offers many approaches to the discussion. Hopefully, more research on the benefits of the concept will be conducted from various viewpoints in the future.

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CASES

INNOVATIVE APPROACHES TO SALES LEARNING AND SALES COMPETENCE DEVELOPMENT

Sirpa Hänti

BACKGROUND

Today, it is understood that no one is born a salesperson. Instead, the preconditions for the competence and development of a good salesperson are constant self-development and learning to learn. In the B2B market, the salesperson must know how to be the trusted person and partner of the client in a way that contributes to the success of the client's own business. The salesperson must also know how to anticipate future developments rather than only react to the moves of competitors. In the labour market, there has been growing anxiety over how to improve the appreciation of sales as a profession and where to find the expert salespersons of the future to the increasingly international market. This growing need of working life was partly answered when a higher-education-level degree programme in professional sales was started in Turku University of Applied Sciences in 2008.

The messages from working life about their expectations of future employees underline social skills, such as interaction skills, teamwork skills, cooperation skills and problem-solving skills. All these skills are also important for a sales expert. In the research on sales training (e.g. Luthy 2000), the most important competence requirements listed for the new generation of sales experts are the critical significance of human interaction (listening skills, writing and speaking) and skills connected to the use of information and communication technology in addition to recognising and resolving the problems of the clients, which often includes cooperation with both the salesperson's own sales team and the client's buyer team. Without a doubt, sales representatives must be well-versed with the solutions they provide as well as with the line of business of their own organisation.

However, they must also understand the business operations, competitive situation and problems of the client; this is best achieved by listening to the client. The skill of building trust is a crucial element. All abovementioned are skills which a salesperson is expected to have and which are not acquired by the means of traditional didactic teaching with an active teacher and a passive student (see e.g. Luthy 2000, Gibb, 2001). New views and approaches to learning are required in order to create new perspectives and to develop sales competences. Learning these skills requires close contact with the practical reality of selling and participation to the sociocultural environment within which today's salespersons work. Innovation pedagogy offers excellent opportunities for learning these skills. The purpose of this article is to describe how innovation pedagogy is applied to the learning and development of personal selling techniques in cooperation with companies in the Degree Programme in Professional Sales at the Faculty of Technology, Environment and Business at Turku University of Applied Sciences.

SALES LEARNING COMMUNITY

Innovation pedagogy is more than just using innovative learning methods, which all have one characteristic in common: the requirement of learners' activity and responsibility for their learning. (Paavola & Hakkarainen 2005, Kettunen 2009, Penttilä, Kairisto-Mertanen & Putkonen, 2009). According to innovation pedagogy, knowledge does not exist in a depository somewhere waiting to be collected by the student, but the student must actively seek and create information in cooperation with others. Learning is not only transmitting information already in existence to an individual, hard reading and repetition; rather, it should be viewed as regenerative learning (see Mezirow 1998), which enables each learner to create new perspectives and knowledge in a fast-changing world. The study of Luthy (2000) mentions, for example, sales-related projects and presentations performed either individually or in groups, visit lectures of sales professionals and role-plays on selling situations as highly beneficial sales learning structures. All these elements are used in the Degree Programme in Professional Sales, some of whose operating models are developed in close cooperation with working life. One of the latest learning such methods is a selling competition where the participants are given different roles. In the Best Seller Competition, as it is called, the competitors sell a document management system by Canon to a buyer from business life in a face-to-face encounter, judged by representatives from companies and the university. The selling competition is described in more detail in a latter section of this article.

The curriculum of the Degree Programme in Professional Sales is constructed in the way that several of the sales study units are implemented in cooperation with corporate partners, or so-called corporate patrons. The corporate patrons of the first two groups of students in the Degree Programme in Professional Sales, started in 2008 and 2009, are Canon, Eckes Granini Finland (formerly Marli), Fujitsu Services, Cargotec Finland, Hiab, JohnsonDiversey (now Diversey), Lassila & Tikanoja, LänsiAuto, Magneetti Turku, Sonerapiste and as the newest ones Lindström, Restatop and Wulff Group. The sales learning community, formed by students, corporate patrons and the university itself, is illustrated in Figure 1.

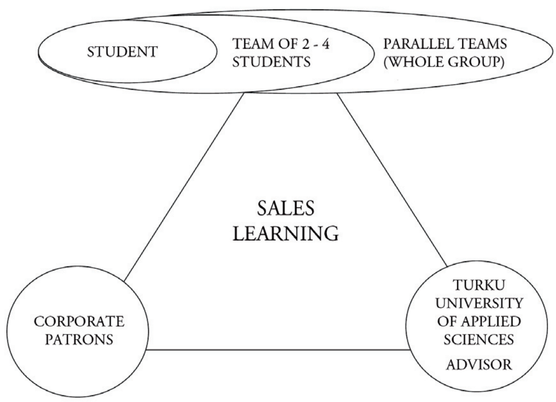

FIGURE 1. *Sales learning community.*

The students as individuals, parts of student teams and the group as a whole as well as their advisors and corporate partners together form a community for learning and developing sales processes. In the sales learning community, the students are able to cross the borders between the learning institution and working life. As a result, the social spaces for learning are formed by various learning tasks (see Tuomi-Gröhn and Engeström, 2001:108), and the assignments from the corporate patrons contribute to the contents of those tasks. The students use these assignments to build a project through which they can segment the vast sales business world and sales competences into reasonable and controllable parts of the whole. From these parts, the students can then forge a comprehensive overview on both sales and the required competences as their abilities grow. The learning tasks could be described to form subprojects during the period of the patron cooperation, which extends over the entire duration of studies. First, the students familiarise themselves with the sales process and then deepen their understanding of selling competences and telesales. After selling practice, they finally prepare a thesis focusing on sales development in the last phase of their studies.

TOWARDS LEARNING BY INNOVATION PEDAGOGY

Understanding learning – what is learned, how learning happens and who learns, for example the individual or the community – can be approached by looking at learning conceptions. One of the learning concepts behind innovation pedagogy is trialogical learning (Paavola et al. 2005). According to the trialogical approach to learning, learning can be characterised with three metaphors: knowledge acquisition metaphor, participation metaphor and knowledge creation metaphor.

- According to the *knowledge acquisition metaphor*, knowledge acquisition is based on the view that individuals stores information in their minds. This view relies on the traditional cognitive tradition and partly also on the constructivists' view on individuals.
- According to the *participation metaphor*, learning is an interactive, dialogical process where different cultural practices and shared learning activities in the learning community define learning, and where learning equals participating in the social process of constructing knowledge.
- From the perspective of the *knowledge creation metaphor*, or the so-called trialogical learning, the abovementioned knowledge acquisition and participation metaphors interconnect because of their collaborative, shared artefacts and targets of development.

In the Degree Programme in Professional Sales, it is possible that the whole tripartite learning community – the students, the advisors and the corporate partners – learn and create innovations and new thinking. Table 1 presents the initial phase of sales learning in cooperation with corporate partners as well as the learning tasks following the initial stage and the assignments related to this second phase. In addition, it is shown in the table which learning task bears the most connection to which learning metaphor.

TABLE 1. *Sales learning tasks and the related learning metaphors.*

Learning tasks/phases	Cooperation practices	Learners	Learning metaphor
Acquainting the students to the sales of B2B companies, their organisations and selling in such organisations → report	Presenting the corporate partners (8 companies) – what selling is, how it is organised in each company etc.	whole group, advisor, representatives of companies (e.g. sales director, sales manager)	knowledge acquisition
Drafting an application	Applying to work for a corporate patron	individuals → to advisor and representatives of companies	participation
Agreeing on communication practices → Optima (learning environment)	Forming and organising the team of students looking for patronage	student teams	participation
Planning of making contact (e-mail, telephone)	Booking appointments with corporate patrons	student teams	participation
Drafting a project plan (content, aims, target group, schedule and agreed practices of the assignment)	Acquiring an assignment from the corporate patron, appointing the contact persons	student teams & corporate patrons, advisor	participation, knowledge creation
Planning of a presentation (visualisation and interactivity of the presentation)	Giving a sales presentation	individuals, student teams, company representatives, advisor	knowledge acquisition, participation, knowledge creation
Peer assessment according to mutually agreed criteria	Listening to and assessing other teams' sales presentations	individuals, student teams, whole group, company representatives, advisor, other sales degree programme teachers	knowledge acquisition, participation, knowledge creation
Project report, feedback and learning diary	Closing the learning subproject	students as teams and individuals, advisor, company representatives	participation

When the cooperation with the students is initiated, the corporate partners introduce themselves and describe their line of business, their clients and the markets as well as how sales are organised in their company. Thus, the students can form a coherent picture of what selling is in various branches of the B2B field. During this initial phase, they can also consider which company they wish to have as their corporate patron and express their well-grounded wishes to the advisor. The aim is to form teams of 2–4 members.

After the teams are formed, the students book a meeting with a representative of the company. The meeting takes place in the facilities of the company to let the students to get to know the organisation. In the meeting, the students aim at receiving an assignment. The contents of these assignments have been discussed in lectures, and the students have been given an assignment template which describes matters they should take into consideration. The first assignment was planning and giving a sales presentation. For this presentation the company specifies the target group and the objective, and provides the students with adequate sources of information for planning the presentation. Next, the students meet as teams to plan their presentation. When necessary, they meet with the contact persons of their patron company, who may advise them to meet also other representatives from other organisations and seek information from different sources. Bulletins concerning the qualities of a good sales representation and drawing up client and rival analyses are utilised for the benefit of the students while they are working on the assignment. In addition, the students acquaint themselves with literature which is then discussed in study circles. Finally, a seminar day is arranged. During the seminar day, each student team gives their presentation which is recorded on video for later analysis and assessment. As a part of the process, the students prepare a report that reflects on their activities and learning. The report gives the advisor a chance to follow the students' progress during the assignment.

Looked at from the point of view of innovation pedagogy, the knowledge acquisition metaphor is realised in the presentations of the companies. They offer the student a vast overview of what selling is in the context of their operations. Additional knowledge acquisition takes place in the form of the bulletins and the guidance relating to the sources of information and literature. On the other hand, interactivity, teamwork and creating a common undertaking, in other words working on the assignment together, are key factors regarding the participation metaphor. The metaphor resembles the sociocultural perspective on learning in which the culture is understood to include not only thoughts, values, knowledge and the interaction with the environment, but also different tools, such as the language used as well as information and communication technology (Säljö 2001). Indeed, a significant part of identifying oneself to sales lies in the language, to which it is only possible to get involved in within the sales communities themselves: by seeing, hearing and participating in the cultures of companies, clients and the field as a whole. The path towards the knowledge creation metaphor, and trialogical learning, leads through the combination of the ”good” questions and open-minded views of sales students and the practices of experienced professionals. This mixture may produce new insights to all parties.

SALES COMPETITION AS A MEANS OF DEVELOPING COMPETENCE

The latest tool for learning selling competences is a sales competition for students attending higher education institutions named Best Seller Competition. The competition was first arranged in April 2010. The roots of the competition are in Kennesaw State University in Atlanta, USA, which is a partner university for Turku University of Applied Sciences (TUAS). Their models (Loe 2009) have served a basis for the development of the Finnish version of the sales competition, planned and implemented by TUAS and Haaga-Helia University of Applied Sciences (Haaga-Helia). The competition has been financed by the Finnish Foundation for Economic Education. Best Seller Competition is carried out in cooperation with companies; in the first competition the main partner was Canon with its document management system as the product to sell.

The sales competition is preceded at both TUAS and Haaga-Helia by their own study unit of sales training. The study unit includes practising sales conversations from a successful beginning through mapping the client’s needs, suggesting solutions and discussing the possible objections to closing the deal, as well as communication and interaction skills, the right attitude and the correct general impression when meeting a corporate client. These same aspects are also the evaluation criteria used in the sales competition. The profile of the buyer in the sales competition is given to students well in advance. Thus adaptivity, which is essential in sales, can be taken into special consideration also during the training (Kairisto-Mertanen 2003). In the end of the sales training a preliminary competition is arranged and the best participants gain access to the national competition.

The competition is carried out as a role-play, during which a salesperson, the student, has 20 minutes to sell the product to the buyer, the representative from the company. The judges are personnel from real-world companies and the higher education institutes. The competition comprises three qualifying rounds whose winners are welcomed in the final. The finalists receive the buyer profile an hour before the final. During the last hour before the final, they can prepare for the meeting with the new client with a peer student of their choice. Both the students and company representatives have given excellent feedback regarding the competition.

Indeed, the sales competition has worked in the lines of innovation pedagogy: fresh thinking patterns and the concrete learning-by-doing have already raised new ideas about developing sales learning and skills through cooperation between companies and higher education institutes. The next sales competition will be held in Turku in 2011. Inspired by the experiences, a European sales competition is also under development. A multinational sales competition will improve the cultural literacy of students, which has been often insufficient among us Finns thus far (Kairisto-Mertanen, 2009).

CONCLUSIONS

Sales learning and enhancing sales competence can be carried out in a useful manner by employing the mindset of innovation pedagogy. It is important that students learn from the very beginning to be active, responsible, focused and to appreciate the importance of constant self-development. These qualities are best learned by doing and by accepting responsibility for one's actions as well as competences and their development. The participation of important corporate partners urges the students to strive for better results and to be willing to show what they can do. This certainly leads to better learning results. The student teams are intended to be formed for the whole duration of the studies, which ensures deeper learning. The method also has a positive effect on the possible internship or thesis work done as a commission for the corporate patron, because at that stage the company's practices have already become fairly familiar to the student.

Today, cooperation skills and interactivity are essential in all jobs and especially in the demanding client work performed by salespeople. Today's salespersons rarely do their hard work alone, but rather as a part of a sales team. The cooperation with the rest of the organisation to fulfil the promises given to clients is likewise an increasingly important success factor, not to mention the cooperation with the organisation of the client. Thus, cooperation and teamwork skills play a vital part in the work, and they can only be truly learned by doing and participating. The real-life sales projects that are made possible by the corporate partners have a determining role in applying innovation pedagogy and allowing all participants to learn and create new. The opinions and questions of student teams, combined with literature perspectives, may stir the current sales practices in such a way that it is possible, through cooperation, to introduce brand new views, perceptions, competences and knowledge in the field.

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UTILISING A BUSINESS GAME IN TEACHING AND LEARNING BUSINESS

Kari Jalkanen, Kati Falck & Rauni Jaskari

INTRODUCTION

One of the main objectives of business teaching in universities of applied sciences is to fulfil the competence requirements set by the business sector. Excellent theoretical and professional expertise in any one specific area of studies is not enough in today's society. New competence requirements coming from the corporate sector challenge students in their learning and teachers in their teaching. Companies expect their employees to understand how to manage their working context as a whole and how to put theory into practice. Thus it should be made possible for students to apply their basic theoretical learning in dynamic decision-making situations as a part of their day-to-day studying, and not just through separate internships in companies. The student, a soon-to-be employee, is also expected to possess skills and attitudes which can be pursued with the help of innovation pedagogy. These include skills having to do with business, problem-solving, team-working and decision-making as well as a general willingness to learn.

Content-based curricula, largely utilised in business teaching at universities, have been criticised for not being adequately supportive of students in the development of knowledge-based key competences and the formulation of a holistic view. Therefore, the integration of teaching and combining curricula should be considered to better provide that support. Understanding and managing large entities is emphasised especially in the teaching of business logistics.

One innovative pedagogical solution utilised by the Degree Programme in Business Logistics at Turku University of Applied Sciences (TUAS) in promoting the importance of holistic attitudes has been the learning environment provided by a business game called Realgame. In the game, the different elements of business can be taught and studied in an interactive setting. The game also provides a platform for integrating different study units horizontally.

Integrated teaching is a way to provide students with the holistic competences required by the business sector. In this context, integrated teaching refers to combining different curricula in order to meet shared objectives. The integration can be either horizontal or vertical. In horizontal integration, the simultaneous study units are grouped together. A good example of integrated teaching is integrating the communication studies with the professional studies. In vertical integration, on the other hand, learning takes place in a series of consecutive study units. (Aaltonen 2003) Integrated teaching is also an element of innovation pedagogy widely utilised by the faculty of Technology, Environment and Business at TUAS.

The positive effects the business game has to teaching and learning are mainly based on real-time transactions, experimental learning and working in a group. In Realgame, the students act as decision-makers and see the consequences of their decisions. From the point of view significant for innovation pedagogy, all learning takes places through direct experience and students have an active role in their own learning process. As mentioned above, in Realgame the learning process is constructed on experimentation on the one hand, and sharing information and interactivity on the other. Multiple roles are available for team members within the game setting, offering not only a platform for experimental learning, but also possibilities for enhancing one's team-working skills.

This article discusses the business game as a pedagogical method, an innovative learning environment and a tool for integrating teaching in the Degree Programme of Business Logistics at the Uusikaupunki unit of TUAS. The text describes different ways of utilising the game from the viewpoints of both content and implementation.

REALGAME AS A BUSINESS GAME

Realgame was initially developed at Turku School of Economics and Business Administration for the business training purposes of companies, but later on it was also introduced in universities. The business game was developed to help its players to understand how a business functions as an entity and to improve their decision-making skills. Time-dependency, transparency and its process-oriented approach to simulating businesses make Realgame a unique and pedagogically advanced learning method.

Realgame is a computer-based interactive business simulation illustrating the interdependence and effects of business processes and operational decisions on business strategy and company performance. Realgame presents business processes as time-bound, continuously evolving, dynamic processes. A team of two or three players is set up as the management board of a company. During the game, the team makes operational and strategic decisions about the future of their company. Each company then competes for customer orders, based on the performance metrics, with up to eight other companies in the industry.

The decisions the teams make have to do with sourcing, production, pricing and sale offers, among others. This means that they are expected to manage material flows, make ordering and manufacturing decisions based on projected sales as well as to react to competitors' actions on the market. For example, decisions are made on terms of delivery, sales prices, terms of payment, product development, marketing investments, to name a few. The participants also have to manage their material processes (steering the production process, purchasing and deliveries) and monetary processes (loans, repayments and interests) in addition to making investment decisions regarding new computer systems, manufacturing equipment and the number of employees.

The business game is able to model the interdependences within a company in a satisfying manner. It links causes with their effects and provides opportunities to grasp business processes holistically. Through different kinds of tasks and operations mentioned above, students' capabilities on strategic, managerial and operational levels can be enhanced. The game shows how different functions and different people come together to produce the company result. It shows, in a realistic way, how upper-level decisions are connected to lower-level operations and the importance of appropriate operational and strategic responses to a given market situation. These skills are all valued by the real-world business sector. (Magisys, www.realgame.fi)

Success in the game can be evaluated by several different indicators. Customer data, raw material suppliers and the management of the game environment are located on a separate computer that is operated by the game master. The time rate of the game can be adjusted, but the decisions the companies make impact the market dynamics immediately.

BUSINESS GAME AND CURRICULUM

The business game has been targeted to be integrated to the curriculum of the Degree Programme of Business Logistics at TUAS. The game can be either a part of the basic or the professional studies. The business game has not yet been played on its own, but it has functioned either as a part of a single study unit or a part of a larger whole of integrated study units. The degree programme utilises a curriculum-based model, in which stand-alone study units do not constitute large competence units as in a module-based or theme-based curricula. (Karjalainen, Jaakkola, Alha & Lapinlampi 2003). This, to certain extent, makes the integration of the business game to teaching more complicated. In order to get the business game to support the teaching in general, the content and learning objectives of each study unit have to be clarified in detail. That is why the possible links between each individual study unit and the business game have been mapped in detail at the Uusikaupunki unit. (Falck 2008).

When examining these links, it should be taken into account that Realgame covers a broad range of various financial and business topics. The game enables its players to deepen their learning by offering opportunities for applying their theoretical knowledge to practice across the boundaries of individual fields of study. For example, the key learning objectives of the Financial Management study unit are that the student understands concepts like company profitability or variable and fixed costs. The game clearly facilitates the understanding of these issues. The game also includes a wide range of financial and other reports which could be utilised as course material. For a player studying financial management, analysing the reports and extracting information from them becomes an essential aspect of the learning process. Furthermore, as the information in the reports is based on the decisions of the students themselves, the analysis makes the causal relationships of the simulation more transparent and thus the learning process deeper.

For the students of business logistics, for another example, the business game helps in gaining a comprehensive and illustrative overview of logistics as part of a business: which issues it has an effect on and what is the significance of its different variables. The main features of Realgame are the areas having to do with material controlling, process-based thinking and the overall interest in the importance of visualisation. As previously mentioned, one of the most important advantages of the game is that the economical impact of the decisions and practical measures are directly visible. On the other hand, the study unit Study skills and professional growth has as one of its central themes the growth of professional identity, which a process the game is able to support as well.

Realgame can be also used for building teams, as it typically requires a partner to play. The teams are part of a common experience and common decision-making, providing a natural environment for new students to get to know each other. During a gaming session, the teams find themselves in different communication and interaction situations at every turn. This aspect of the game becomes more important every day, as team-working skills are emphasised more and more by the recruiting real-world companies.

The analysis of achieved results is an important part of utilising Realgame as a learning environment and to disseminate the data in question, various written and oral reports and presentations can prove to be absolutely vital to the learning process as a whole. Combining communications teaching with the business game is likely to provide excellent results.

Moreover, the business game and its incidental activities discussed above support the learning of professional vocabulary in English relating to business management and logistics. The utilisation of the various reports available can also be used, for instance, in learning the use of Excel graphs. Excellent skills in Excel are often expected from a Bachelor of Business Administration. All these elements aid in meeting the challenges presented by the business sector of today.

DEVELOPMENT AND USAGE OF REALGAME AT TUAS

Realgame was played in the Degree Programme of Business Logistics at the Uusikaupunki unit of TUAS for the first time in 2005, when the developer of the game took a student group through a game session. Excellent feedback from the students led to a license agreement between the game developer company Magisys and TUAS. After this, the business game has been widely used in the teaching of business logistics. The gaming sessions have varied from a simulation of a few hours to a series several all-day sessions. Positive learning outcomes and feedback from students in addition to the awareness of the unexploited potential of the game have all encouraged continuing its usage and development.

Since the business game had not been originally developed for teaching at universities, there were several challenges related to the technical setup and to the content of the game itself. The Uusikaupunki unit of TUAS has actively taken part in developing the game to make it more suitable for teaching business logistics and several methods have indeed been developed for utilising the game to its fullest. One of these methods is the backbone model described below in more detail. The idea of the backbone model is to integrate several curricula to a single game implementation.

Another developed model is the solo simulation, where every company can play their own game without having an impact on the other companies. In a solo simulation, the students can focus in a limited number of issues at a time and experiment on different options. Students play the game at their own rate and have typically more time to digest the effects of their decisions. In case of the solo simulation, both the game company itself as well as the control functions of the game are loaded to the computer of the player. In a normal game environment, the teacher is the only one in control of the functions. (Falck 2008)

Implementation in individual study units and vertical integration

The first business game implementation was carried out on the Materials and Inventory Management study unit in the autumn of 2006. The business game suited the context well and its role as part of the study unit has been become more comprehensive, as the game was discovered to be very supportive of the objectives of the study unit. Game scenarios, simulation exercises and other tasks have been developed since. The latest implementations have consisted of focused simulation exercises, extensive preliminary tasks (like creating the company strategy), interim tasks and final analyses. Other methods of enhancing learning and self-reflection have included free-form personal tasks in addition to learning diaries, which push the student to consider the effects of learning evoked by the game and also serve as an important channel for collecting feedback.

In a recent implementation of the business game, and as an example of the utilisation of the vertical integration model, an initial gaming session is held during the first study year as part of the Professional Growth study unit. During the second year of studies, the students participate in a more complex version of the game in the Materials and Inventory Management study unit.

After the evaluations for a given study unit have been otherwise finished, game performance evaluations can only improve the grades. Genuine effort, well-executed tasks and active participation in the gaming sessions as well as profound analysis of the sessions, the cause-effect relationships and the learning process itself are the key evaluation criteria of the overall performance.

Feedback of implementation in individual study units

Feedback concerning Realgame has been collected from the students systematically since 2007. Compiling the feedback has been rewarding, since Realgame, still being an experimental learning tool, has a liberating effect on the students. In other words, they are typically willing to express their opinions of the game more extensively than is the case with conventional teaching. The feedback has had a significant impact on the different implementing styles and methods of the game and their development. The feedback has also offered valuable information about the students' views on how Realgame has supported their learning.

The majority of the students introduced to Realgame have not had prior experience of any kind of business game. Feedback concerning the first game sessions have been mostly positive: the game has been found to be a concrete, realistic and pleasant tool for learning as well as for familiarising oneself with business skills. It has also been noted to improve team-working skills and team spirit. Most of the students have also expressed their wish to have further opportunities to play the game.

However, the experiences and feedback have varied between different students and groups, even to the point of being totally contradictory. What was easy for one student was difficult for the other, and what was educating for some was considered useless by others. In general, the opinions of the students have often reflected their attitudes in the gaming situations and tasks; attitudinal aspects have a direct impact not just to the students' effort and the learning outcomes but also to the behaviour of the team as a whole.

Overall, Realgame has been met very positively. It has typically been described as a pleasant and refreshing change, and it has been noted to really facilitate the learning process. Actual playing has been considered more pleasant and useful compared to the solo simulation, but also the solo mode has been regarded to helpful in focusing in a specific detail or operation as well as for learning how to play the game in the first place. The game has aided especially in presenting 'the big picture' of business operations on a general level.

The backbone model and horizontal implementation

The backbone model is one of the newly developed pedagogical methods for utilising the business game. The method's function is to integrate several study units in the degree programme's curriculum to enable single games to extend over multiple sessions and study units. In other words, the game can be played in parallel with the ongoing studies. The method emphasises the holistic attitudes that are essential for students making the transition to working life at the end of their studies.

The target of the method is that the game acts as a coherent practical playground and the game sessions themselves are supported by the parallel theory teaching. Thus students can continuously apply their newly acquired knowledge in practice. Implementing the game in the way that the history of the company is carried over from previous sessions increases the students' motivation to learn even more. As students get a good hold of practical matters, they begin to see the impact of their own actions and decisions more clearly and hopefully also come to understand their still existing limitations regarding their know-how. This makes it easier to overcome the boundaries slowing down their development as future professionals.

In addition to a deeper kind of learning, the backbone model also enables more effective use of resources. Any one study unit cannot possibly take full advantage of all the potential and information offered by the business game, but on the other hand, the resources required by the game does not change depending on the number of students groups participating in a given session. As a result, the utilisation of the game becomes more beneficial for everyone involved. If each study unit organises their own gaming sessions, there is a risk of overlaps or gaps in the handling of even the most basic aspects of the game. It is thus more useful, student-friendly and motivating if the implementation is jointly planned and coordinated by the teachers. This way, the teachers can each focus more freely on the desired areas of the game.

The cooperation can be broad or narrow, as it can be limited to simply agreeing on which topics each study unit will discuss. Alternatively, the tasks, reports and evaluation can all be coordinated. The cooperation between different study units also makes 'the big picture' behind the individual pieces of information more transparent for students.

Feedback of the backbone method

The backbone model, involving eight different study units from Basics of Logistics to Transport and from Warehousing and Materials Management to Communication, was implemented for the first time during the study year 2008–2009 with 48 first-year students. The goal was to better exploit both the synergies between study units and all the elements in the game. The new method was also spurred on by the fact that according to their curriculum, these students did not have a single extensive study unit concerning materials and inventory management. Thus utilising the game widely within one study unit, as with the students studying according to the previous curriculum, would have been impossible. Additionally, some of those previous students had already proposed this new kind of arrangement in their feedback.

The backbone implementation was very different from the earlier implementation styles, and both the teachers' own experiences and the students' feedback brought forth the fact that the reception had been ambiguous in many respects. Indeed, the new implementation method was relatively challenging to carry out, since the business game itself was unfamiliar to students and even to some of the teachers. The game lasted two semesters after being started in the very beginning of the studies, when basically everything was new for the group. The implementation demanded an active attitude towards studying and completing tasks, as well as the capacity to take initiative. Teachers, on the other hand, had to cooperate and coordinate their teaching in a way that had not been done before.

The feedback received from the group in question strengthened the view that had already become apparent during the implementation: the opinion of the group regarding Realgame differed from the opinions of the previous groups. There were fewer enthusiastic students who were convinced of the benefits of the game. Despite of this, the answers also clearly showed that the majority had still experienced the game as a helpful learning tool that had inspired to find out more about the topics at hand. The feedback also showed a correspondence between the effortlessness of the integration process, which varied among the different study units, and the learning outcomes of the students from their own point of view. The reports drawn up for the communications study unit were described as the most pleasant part of the implementation and working on them had been especially useful. Also the oral reporting of the students demonstrated that the students' business skills had developed significantly during the first year of study.

As it was desired that the benefits of the implementation were observed also from the perspective of general and business competence skills, the questionnaire also dealt with some of the learning objectives based on those topics. The students were asked to analyse how well the implementation had enhanced the development of the skills in question. Some 20% of the group responded that the implementation had supported the development of the skills well and 60% responded that the implementation had at least made them to think beyond the apparent in connection to the topics.

What then are the reasons behind the fact that the students who participated in the backbone implementation were not quite as enthusiastic and positive about the game compared to the previous groups? As the previous implementations had been different in many ways, it is difficult to say exactly, but at least the following aspects have had an impact on the matter:

- Differences between individual students.
- Experimental learning as a method.
- Differences in learning methods as a whole.
- Change resistance.
- The planning stages of the implementation.
- Long period of implementation.
- Required attendance in the sessions.
- Group work.
- Implementation right in the beginning of the studies.

According to the feedback and the learning results, the backbone model is indeed a potential method for utilising the game. The feedback also made apparent some key development areas, relating to elements like planning and cooperation, for future implementations:

- Planning the main learning objectives and themes in study units.
- Timing of discussed topics.
- Commitment and seamless cooperation from all teachers.
- Clarifying in detail the full content of the game implementation to all involved before starting the process.

The emphasis on the planning and cooperation will help the students to get a clear and systematic picture of the implementation right from the beginning. Overall, the backbone model proved to be a useful and interesting method, but at the same time very challenging to implement.

CONCLUSION

Teaching at universities of applied sciences has to be able to focus on fulfilling the growing competence requirements of the business sector. Understanding and managing ‘the big picture’, in other words assuming a holistic attitude towards working, is being emphasised in the demands. A content-based curriculum does not adequately support the development of knowledge-based key competences and the formulation of a holistic view.

Realgame, an innovative learning environment in the form of business game, has emerged as a solution for teaching the understanding of large entities, as well as combining theoretical knowledge with the know-how relating to practical processes. The game is based on real-time transactions, experimental learning and team-working. In addition to collecting feedback from younger students, positive feedback about the benefits of using the game in teaching and learning business skills was also received when Realgame was implemented with a student group doing their master's studies. Adult students with already at least three years of working experience stated that the game simulates real-life events and supports the development of necessary skills very well.

In addition to the usage of the business game in teaching, extensive development work around the topic has also been carried out in the Degree Programme of Business Logistics at TUAS. The development work has comprised, for instance, expanding student tasks (pre-tasks as well as reporting before and after the game) connected both to the individual study units and the horizontal implementation model. Close cooperation with the game developer to enhance the game even further has resulted in new improved versions of the game. Teachers utilising the game have also done further development work in connection to the teaching itself, for example by looking into how by changing different parameters or settings in the game, certain market changes can be taught to students more transparently.

The good news is that utilising the business game does not require a curricular reform. However, it is obvious that the usage of the game would be much easier if the curriculum was already planned to include wider themes. Realgame has been found to work well in demonstrating and practicing supply chain management and the business activities within a company. The game has proven to be a useful, inspiring and innovative pedagogical solution for developing comprehensive business competences and the skills relating to logistical knowledge.

The challenge today is to provide students with learning environments that support the emergence of competences required in business life in the future. In order to succeed in creating innovations, companies need to have holistic business know-how and networking skills at their disposal. In this context, networking skills also have to do with the ability to locate, utilise and distribute knowledge. Functioning in a network, learning from others and building results on raw ideas are skills that require practicing. According to our four years of experience with Realgame, the goals mentioned above are that much closer with the help of the business game. Realgame offers a platform not just for experimental learning, but also for the development of other such key elements of innovation pedagogy as active learning, problem-solving, collaboration and the overall understanding of the theories of the field.

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IMPLEMENTATION OF INNOVATION PEDAGOGY IN THE STUDIES OF AUTOMOTIVE AND TRANSPORTATION ENGINEERING

Markku Ikonen

INTRODUCTION

New teaching and learning methods have been applied in Degree Programme in Automotive and Transportation Engineering of Turku Univer¬sity of Applied Sciences (TUAS). The newly created and implemented methods aim at gradually shifting the focus from teacher-focused teaching to activating the students towards unprompted and sponta¬neous attitudes to learning. The students are encouraged to move towards active hands-on type of doing regarding their studying and learning processes, as opposed to just passively listening to lectures. These methods are applications of innovation pedagogy, which is the leading pedagogical approach at TUAS.

Innovation pedagogy is a fresh approach to teaching and learning. The target of the approach is to educate professionals capable of creating innovations in their working lives. Innovation pedagogy combines learning with the creation and application of new knowledge. It is a philosophy of learning that defines learning, creating and utilising knowledge in a new way to create competence for generating innovations (Penttilä et al. 2009, 20).

The new student-centred learning methods, diverging from traditional lecturing, cannot be used in all teaching. However, by implementing innovative methods in carefully selected, precisely targeted fields, clear improvements in learning outcomes have been recorded (Kortetmäki 2009). Also, the feed¬back from students has been affirmative. The students attending courses which are implemented by utilising the methods of innovation pedagogy are expected to become capable of creating innovations during their professional careers.

The benefits derived from the implementation of innovation pedagogy are expected to be substantial. The learning results of students will improve, and they will get acquainted with the challenges typical for working life already during their study years. After graduation, the threshold between studying and the working life environments will hopefully be much lower.

In the article, four examples will be discussed regarding the implementation of innovation pedagogy in Degree Programme in Automotive and Transportation Engineering. The examples are as follows:

1. Guided problem-solving sessions in mathematics
2. Dismantling of cars in automotive technology studies
3. Co-operatives
4. R&D Projects.

There are, however, already plans within the degree programme to apply the principles of innovation pedagogy in other ways besides those described here.

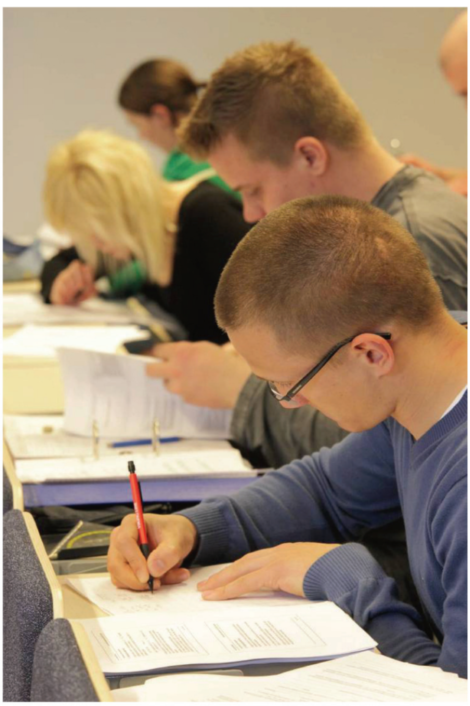
GUIDED PROBLEM-SOLVING SESSIONS IN MATHEMATICS

Due to the economical restrictions of the university, the typical amount of contact hours offered for students equals about 50% of the nominal working hours required for each credit point. In another words, students are supposed to work one hour on their own for each hour of lecturing. The nominal amount of work for an average student to achieve the grade 3 (scale 0–5) is about 27 hours per credit point. Usually, the university provides 12 to 13 lecturing hours per credit point. This means that students should work over ten hours by themselves to earn each credit point.

However, the surveys conducted on the time spending behaviour of students, as well as some of the previous learning outcomes, have indicated that typically students work notably less than the targeted amount of hours on their own (Tuohi 2010, 113). Because of this, the guided problem-solving sessions in mathematics were created to increase the amount of working hours students spend on mathematical problems. The fundamental aim of this decision was to improve the learning outcome of mathematics by increasing students' routine for calculations.

The basic idea of the problem-solving session is simple. A few older students, having been successful in their mathematical studies in the past, are hired to work as assistants for the teacher of the course. Their duty is to be present in the classroom during certain hours, marked in the regular weekly schedule, to help the less experienced students to do their homework in mathematics given by the teacher of the course. These problem-solving sessions are offered as an addition to the conventional classes of the course; in other words, they do not replace any lecturing. They are also organised in smaller groups than the lectures.

As a result of this arrangement, students receive help from both the student teacher and each other. This method also ensures that students actually use the time required for mathematics. Increased time usage has proved to have a positive influence on the learning outcome.



PICTURE 1. *Students working on mathematical problems. Photo by Markku Ikonen.*

After implementing this method for the first time, the students were asked how they liked the guided problem-solving sessions. The responses for the questionnaire yielded, for instance, the following comments:

> *The sessions were very useful from the learning point of view*

> *I was able to work on the problems at my own pace and get help whenever I needed it*

> *The student-assistant sessions are a good invention. The group size is small. This means that the assistant has time to concentrate on each student's difficulties.*

The results of both the starting exam and the final exam of the course are shown in Figure 1. Altogether 49 students took part in the exams. It can be clearly seen that almost all students ended up with a better result in the final exam compared to the starting exam.

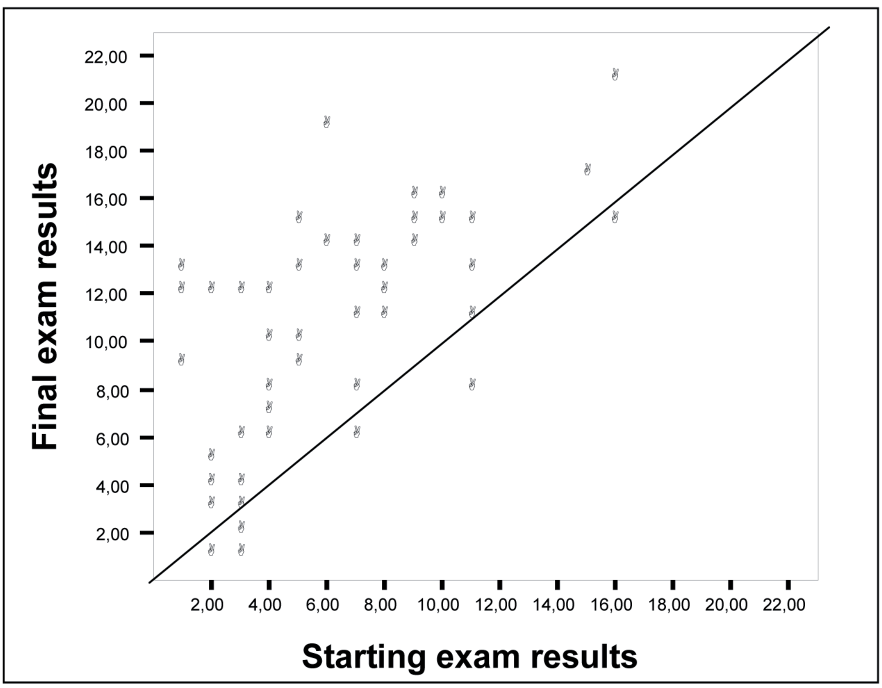


FIGURE 1. *Exam results before and after the course that utilised problem-solving sessions (Kortetmäki 2009).*

Along with better learning results, additional benefits have been noted. New students, just enrolled at the university, get to know each other better and the group formation process progresses more rapidly. The skills relating to group working are improved, and the peer support available is utilised to full extent. Additionally, the mathematical capabilities of the student teachers themselves are enhanced, because they really have to digest the problems completely in order to be able to explain them to others. Moreover, the student teachers also gain working life experience.

The number of working hours devoted for the course by the responsible teacher has not been reduced as a result of this arrangement. As mentioned before, the purpose is not to replace teacher work with student work, but to complement the conventional classes and to alleviate the workload of the teacher. However, the responsible teacher of such a course faces some new responsibilities. He or she has to be able to pick the most suitable assistants out of the older students, and also has to coach them to act as mentors for the younger ones.

The results of the problem-solving sessions in mathematics can be summed up as follows:

- less failed exam results
- students learn to work together – group formation benefits
- less merely mechanical and more applied calculations – better understanding of mathematical concepts.

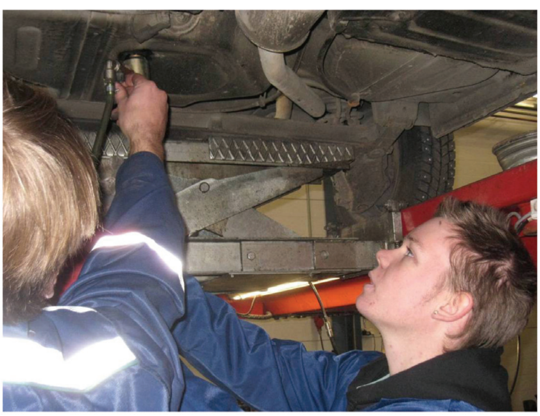
DISMANTLING OF CARS IN AUTOMOTIVE TECHNOLOGY STUDIES

The students accepted in the engineering study programmes come from a vocational or senior high school background. Especially students from senior high schools often lack practical experience related to the structure or the functioning principles of an automobile. Just by lecturing in a classroom environment, it is quite demanding to teach about the operational subsystems or about the structure of a single part in a vehicle. Of course, the modern audiovisual aids are useful to an extent, but they are not worth real hands-on experience.

To improve the students' knowledge about the structure of vehicles, the course unit "Fundamental structures in automotive technology" includes a period during which the students dis¬mantle parts from real automobiles. The parts are recognised, named and cleaned, and also their structure and operational principles are analysed. By going through this procedure, the students will gain concrete understanding about the dimensions, shape, mass, purpose and functional principles of every part they dismantle. At the same time, they grasp the role of each individual component belonging to the technical wholeness of a vehicle.

The dismantling is possible only in relatively small student groups. Operating in small groups leads to a greater number of groups and also to a greater need of vehicles to be dismantled. To avoid the hassle related to acquiring and handling old vehicles to be scrapped, the dismantling is carried out as a joint-venture type of practice together with a commercial vehicle recycling company. The students are transported to the premises of the company with sufficient facilities and all the equipment readily available in addition to the vehicles themselves.

After the dismantling of parts and the analysis of the vehicle structure, the students also "dry up" the vehicles. In other words, they drain the fuel, brake fluid, engine oil and other fluids from the vehicle, preparing the vehicle for recycling. This way the recycling company benefits from the work of the students, making it a clear win-win situation, in which no money changes hands.



PICTURE 2. *Students draining the fuel system of a car to be scrapped. Photo by Markku Ikonen.*

CO-OPERATIVES

Understanding financial and management issues have become a more and more important part of good engineering expertise. In the case of Degree Programme in Automotive and Transportation Engineering, these fields of knowledge have previously been covered in course units like 'Entrepreneurship and Enterprise Economics', 'Marketing and Sales Promotion' and 'Managerial Duties'. In a new innovative teaching approach, these course units have been replaced by real legal entities, co-operatives, which are founded and run entirely by students.

Each student group of roughly 20 students founds a legal enterprise, in the form of a co-operative, already during the first study year. The students work as entrepreneurs by selling their knowledge and services to companies and private clients, as well as to the university itself. For instance, students have changed winter tyres for a small fee for the personnel of the university. Organising the local transportation of foreign students and teachers during international events at the university is another good example of these activities.

PICTURE 3. *Group of students working towards a common goal. Photo by Markku Ikonen.*

The students take the necessary steps to found the enterprise, including all reporting to the authorities. They are responsible for paying their enterprise's value added and other taxes, employer fees as well as for general administration, managerial duties, marketing and sales promotion. Additionally, they are responsible for accounting, profitability, customer satisfaction, and, naturally, for carrying out the actual services ordered from them. Running a real-world business provides them with a deeper understanding of business life than can ever be achieved just by reading or attending lectures.

What comes to the financial side of this studying method, the profit accumulated from the enterprises during the first three years of study is to be used to promote skills having to do with international activities in the fourth year. In practice, this means a study trip to one of the most important automotive-related shows in Central Europe.

R&D PROJECTS

The R&D projects carried out in the degree programme are usually mainly financed by companies with the co-financing coming from the university. There are, however, also purely university-financed projects. Regardless of the way of financing, the main idea concerning projects is that the students are offered an opportunity to work with real-world problems and actual working life concepts are developed. Depending on the type of the problem, the number of students in a given project group can vary notably.

Especially the projects with subject matter relating not only to the personal interests of students, but to their previous knowledge already acquired on the subject as well, motivate them to actively find out more and more. It is a pleasure for the teacher to observe students' enthusiasm to gain new information, familiarise themselves with new concepts and act towards common goals together.

Ongoing or completed project activities include the following undertakings.

Developing delivery truck drivers' work ergonomics

Most of the studies discussing ergonomics in the field in question have been related only to the driving itself. However, handling cargo in various ways is an essential part of the workload of a delivery truck driver. This study concentrates on these issues.

Study on the payloads of different trucks and combination vehicles

If the curb weight of trucks could be reduced, the amount of payload could be increased while maintaining the gross-vehicle weight constant. Increased payload results in less fuel consumption and less greenhouse emissions per each ton-km of cargo transported.

Developing the quality of car care services

The wish of a customer of a repair-shop is that they would not need to visit the place more than once because of a single problem with their car. Unfortunately, in many cases, vehicles are not serviced well enough during the first visit to the shop. This study aims, for instance, at finding ways to motivate the mechanics to work more carefully.

Developing the official technical inspection of heavy-duty vehicle brakes

The current official technical inspection method of heavy-duty vehicle brakes is somewhat cumbersome and still produces imprecise results. A more precise and cost-effective inspection method is searched for in this project.

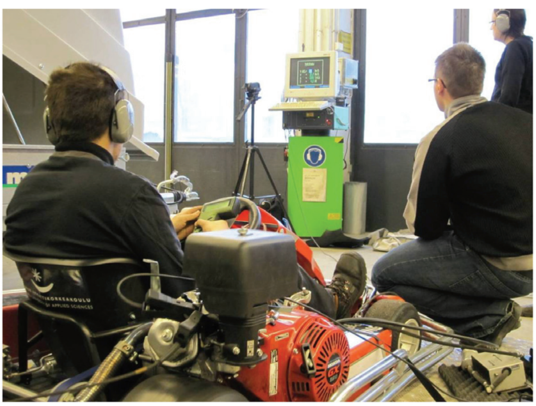
Diminishing the energy consumption of passenger cars

Diminishing energy consumption results in lower amounts of carbon combusted and reduced amounts of carbon dioxide emitted. The study concentrates on analysing the factors contributing to the need for kinetic energy for a vehicle. Another key issue is to study how to increase the efficiency of the energy conversion process when transforming the chemical energy of the fuel into kinetic energy of the vehicle via the mechanical energy of the engine. The possibilities to save energy are studied and pointed out.

PICTURE 4. *An engineering student presenting an economical hybrid vehicle in an auto show. Photo by Markku Ikonen.*

Converting a go-kart to electric propulsion

The aim of this project is to measure the performance of the car with original powertrain and to find out how to convert a vehicle equipped with an internal combustion engine into a more environmentally-friendly vehicle with electric propulsion. The performance with electric powertrain will be recorded and compared with the original condition of the vehicle.



PICTURE 5. *Students testing their go-kart car on a chassis dynamometer. Photo by Markku Ikonen.*

Converting a small passenger car into a battery-electric vehicle and possibly ultimately to a range-extender equipped series hybrid vehicle

In the future, electric powertrain will be utilised in many types of vehicles in addition to gasoline and diesel engines. The future engineers being educated at the university need knowledge and understanding about electric propulsion systems. This project has been implemented in order to increase the knowledge of both students and teachers relating to electric powertrain.

CONCLUSION

The examples given above reflect the ways innovation pedagogy has been implemented in the Degree Programme in Automotive and Transportation Engineering. The learning outcomes of the new student-activating methods have been promising. We are positive that students exposed to such education will end up with more innovative working skills. As mentioned earlier, every innovative method cannot be utilised in all teaching, but by implementing the approach as supplementary methods in selected fields, the learning outcomes and the competences of the students for meeting the challenges of working life can clearly be improved. In conclusion, there seems to be no reason, at least in case of the described example cases, to return back to traditional lecturing and teacher-focused teaching.

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NEW WAYS OF LEARNING IN THE ENGINEERING STUDIES OF ENERGY AND INTERNAL COMBUSTION ENGINE TECHNOLOGY

Tommi Paanu & Pekka Nousiainen

INTRODUCTION

Traditionally, learning has been based on the transfer of knowledge from teacher to students. This kind of education does not offer enough skills and competences required in working life any more. (Pedagogical plan at TUAS, 2010–2013) Due to the intensively changing nature of today's working life, a large proportion of the information offered during education becomes outdated by the time the students graduate. This presents new challenges to the education of engineers (Bachelors of Sciences in Technology). (Paanu, 2005) New pedagogical approaches are needed, including methods like project-based learning and problem-based learning. These methods should not be discussed only as separate tools for teaching, but as parts of a larger whole of innovation pedagogy. The methods in question support innovative actions and solutions during studies, and create environments that produce competences required by working life.

LEARNING METHODS

In project-based learning, the aim is to connect theory and its implementation to the practical project at hand. Project-based learning is quite close to inquiry learning as it is based on the same pedagogical principles (Figure 1). (Edu 2009)

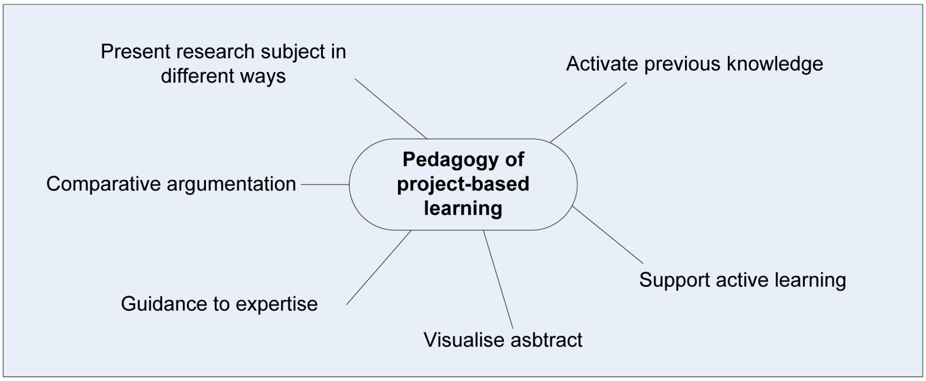


FIGURE 1. *Pedagogy model of project-based learning after Edu (2009).*

Projects have always been a part of engineering studies. The essential point to be considered is how the project work should be approached as a whole. In the behaviouristic approach, the teacher-led classroom activity comes first, and project work is only a secondary aspect. In the cognitive approach, the project work comes first; the previous knowledge and experience of the students and their ability to generate new information are utilised in addition to the teacher's expertise. (Kettunen, 2009). Project-based learning can also be seen as a key method for merging research and development work to studies in universities of applied sciences.

In problem-based learning, solving practical problems is the basis for learning. The problems themselves are recommended to be selected in close co-operation with working life. The students are expected to be very self-directing and capable of autonomous learning. The student is an active doer, searching and processing information, not just passively receiving it. Learning is supported by tutorials (group meetings) and short lectures. (Paanu, 2005; Poikela & Poikela, 2005; Poikela, 2003) There is a wide variety of literature relating to problem-based learning and its variations. One manner of describing problem-based learning processes is shown in Figure 2.

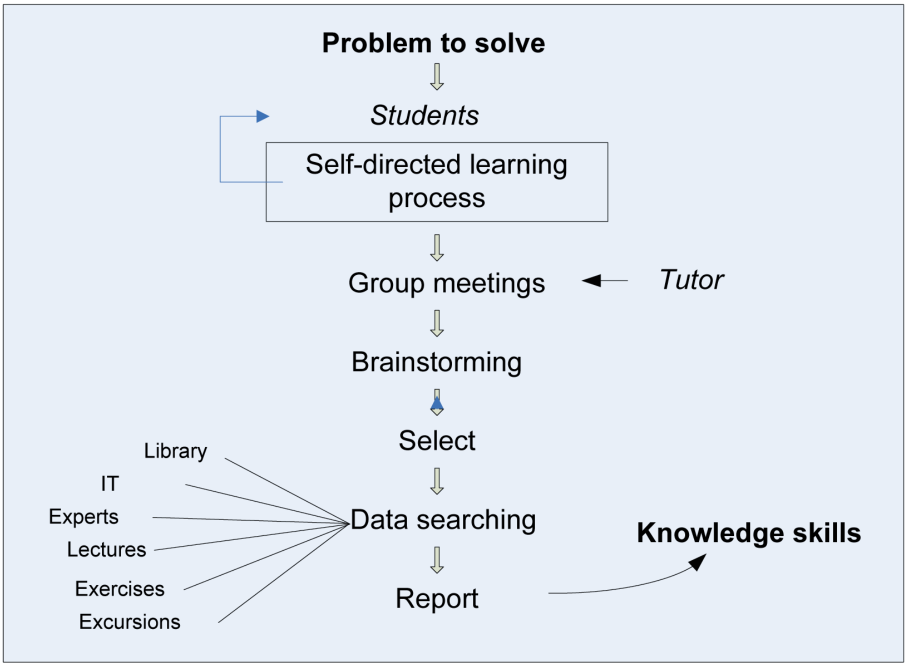


FIGURE 2. *Problem-based learning process after Malmfors (2009).*

As a part of engineering studies, project-based learning and problem-based learning create new possibilities for facing the challenges of future working life.

APPLICATIONS

Thermal and Flow Machines study unit

The principles of project-based and problem-based learning are applied in the laboratory works of the study unit Thermal and Flow Machines. Instead of having specific instructions on how to conduct the process, the students get a problem to be solved. They work in small groups, searching and processing information required for solving their problem. The students also attend lectures and do exercises supporting their problem-solving. For example, the students might have to produce material for an assignment consisting of a test run of a diesel engine. Instead of having detailed instructions on how to manage the test run and what to report (diagrams, tables), they have to sort out what kind of information and measurements are required. They also plan the test run, take notes of observations and draw up the final 'customer report'.

The feedback from students has been very positive, and they find this kind of approach challenging and educative. Problem-solving has also motivated them to learn and understand the involved theoretical background in a deeper way.

Study units related to internal combustion engines

The internal combustion engine studies consist of three study units during the school year: The Basics (autumn), Combustion & Emissions (autumn) and Measurements & Adjustments (spring). These studies were carried out in project groups. The studies were offered for the first time in their new form in the autumn of 2009. There were three student groups with five or six students in each. The project work lasted the whole school year; the boundaries for the work were set and the groups formed already in the beginning of the first course. The actual implementation of the project work itself took place during the final course, but both earlier study units, including lessons and laboratory exercises, supported the students in pursuing the goal set for the whole of these three courses. The practical part of the project work was carried out at the internal combustion engine laboratory at TUAS.

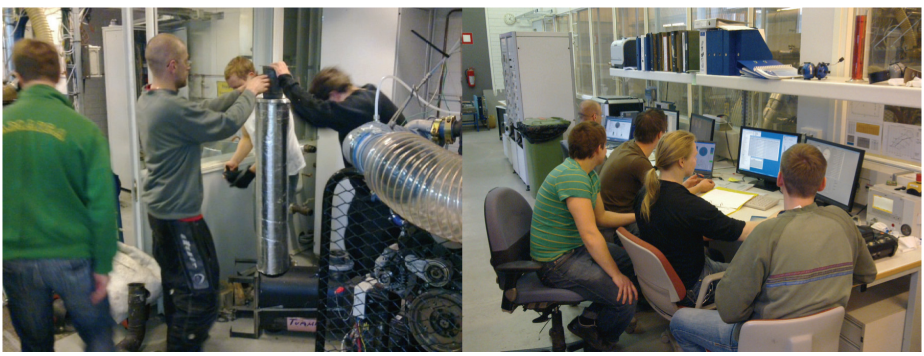
The heading for the project work, "Reduction of the fuel consumption of the nonroad diesel engine", was the same for each group. The target was to reduce the fuel consumption of a real engine a minimum of 3% without increasing exhaust emissions. Each group was free to choose the methods for reaching the target. The idea was that during the autumn period, the groups explored suitable solutions and they would put them into practice in the spring by building, measuring and finally by presenting their results.

The project work was supported by a Finnish nonroad diesel engine manufacturer Agco Sisu Power. Sisu supported the project mainly by delivering engine components and guiding the students in special technical issues. The contents and operational boundaries of the project were defined in co-operation with the company.

All groups chose a slighly different approach to reach the target: one decided to build a so-called 2-stage turbocharging system, the second concentrated in optimising basic turbocharging technologies and the third group decided to install a special NOx reduction catalyst system (SCR) on the engine.

While other groups succeeded in reducing the fuel consumption by no more than 1%, the third group with the SCR system achieved a fuel consumption reduction of more than 10% and also a 70% reduction for particles. This was an excellent result, although the third group also had to consider more carefully the possible installation issues and make payback time calculations. According to those considerations, its installation to the vehicle would be challenging, but not impossible. The payback time for an SCR system was 2.5–3 years, which is acceptable.

Even though all groups did not reach the original target, an even more important goal was reached as all students got to participate in the practical work: designing, machining, welding, installing, running and adjusting the engine, measuring exhaust emissions, writing reports and presenting them to others. The results were presented at the end of the last study unit with the representative from Agco Sisu Power in attendance.



PICTURE 1. *Students installing a SCR catalyst (left) and running the engine (right). Photos by Pekka Nousiainen.*

After the project, feedback was collected from the students. It showed that the first project set was successful. The students especially liked the planning and implementation part of the project, although they criticised the total workload to some extent, particularly because the project was implemented in parallel with other studies.

The co-operating engine manufacturer was also pleased with the results, and the plan is to develop project work even further in the future. For the teacher, this first trial was challenging, but also rewarding.

Passenger car projects

Exhaust emission legislation will be gradually tightened, which will increase the demand for new technical solutions. Researching and testing these solutions, which are usually very complex systems, has to be carried out not only in a laboratory conditions but also in the field. This need applies to all engine and vehicle sizes: small passenger cars, heavy duty vehicles, even ships. The field testing is implemented by utilising different kinds of data logging systems. In parallel with emission testing, these systems can also be used, for instance, for fuel consumption measurements in different load and ambient conditions.

In the end of 2009, the internal combustion engine laboratory at TUAS acquired a Euro 4 emission level passenger car, registered for as a van. The aim was to start improving the car in the areas of noise reduction, particle reduction and especially energy efficiency (fuel consumption). Another aim was to use the car as a platform for project-based learning by offering the students real-world problems to solve. Again, the project consisted of planning, implementation, measurements and reporting. The report is typically produced as the thesis of the project leader. Project assistants typically get "training points" for their contribution. Two such projects were carried out during 2010.

Reduction of interior noise

The average noise level of the researched car was too high, so the first project focused in noise reduction. The target was to decrease the interior noise at least by 3 dB, measured with a sound-level meter. The project team comprised three students; the project leader studied in the Degree Programme in Automotive

Engineering and the two assistants were students in the Degree Programme in Mechanical and Production Engineering.

After being briefed on the target of the project, the group were allowed to choose their methods. freely. Every now and then the teacher and the group arranged meetings for ensuring that everything was on the right track.

The group compared different insulation principles and materials. Based on the results, the noise reduction project was implemented in two steps. During the first step, the back of the car was insulated by using special insulation mats and plates. During the second step, the front doors of the car were insulated with similar material.

PICTURE 2. *Insulating the front door (left) and the back of the car (right). Photos by Pekka Nousiainen.*

The group agreed on the noise measurement area, route, measuring technique and device mainly by themselves. After analysing the measured data, they were happy to discover what they thought they had heard in the first place: the sound level of the car had really dropped below the original target.

The project was executed during the spring 2010. The project was successful, the target was easily reached and during the project some additional ideas for further development were conceived. The students thought that the project was a nice change as opposed to the usual lectures.

Designing and assembling of a data logging system

Another project was also carried out regarding the same passenger car, as it was deemed that a suitable data logging system, to be utilised in future work, should be installed to the car. The system collects data from the car's own data network (CANbus) and also from additional, self-installed sensors. This helps in forming a clearer picture of the reference situation and the effects of further development steps.

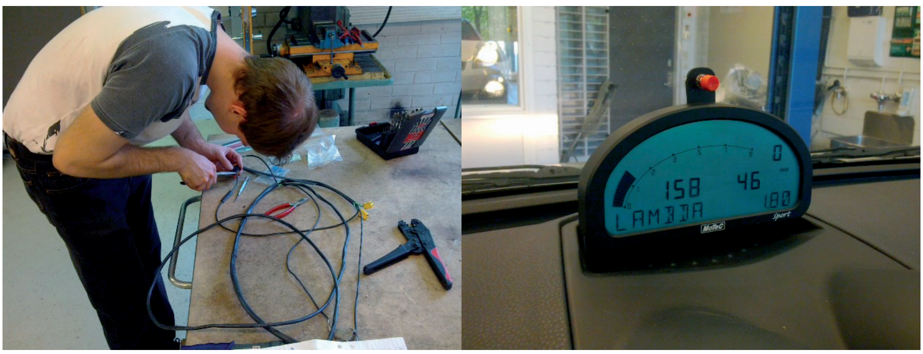
The target of the project was to design the whole layout for the data logging system, install it, and fine tune some basic settings for providing reliable data logging. The project team comprised four students; the project leader was from the Degree Programme in Mechanical and Production Engineering and the assistants from the Degree Programme in Automotive Engineering. The teaching and the working principles were similar to the previous case.

The most important development and action steps for the project were as follows: study of the functions of the car's own CAN system; assembly of data logging system's monitors and modules: design and fabrication of wiring harness; design, order and assembly of analog sensors to pipelines; and finally, connecting, testing and programming of required CAN and analog signals to data logging system.

The target was to measure, among others, the following signals: engine speed and load, fuel consumption, oxygen sensor data, NOx content, exhaust gas temperatures and pressures, boost system temperatures and pressures, driving speed and GPS location coordinates.

Some work tasks were divided among the group members while some tasks were done together. Many tasks required different kinds of machining, welding as well as dismounting and mounting abilities, which provided the students with useful practical experience. After the mounting of the system modules, monitors and sensors, the wiring harness of the system was made. The length of all junctions and the main line was carefully designed. The installation of the connectors required the use of some special tools.

PICTURE 3. *Installing boost system pipes (left), peeling connector housing (right). Photos by Pekka Nousiainen.*



PICTURE 4. *Making of wiring harness (left), data logging system monitor installed in the cabin (right). The cabin monitor can be seen showing data of a few measurement parameters; the engine speed, exhaust gas temperatures in the exhaust pipe, lambda value and vehicle driving speed. Photos by Pekka Nousiainen.*

The project was completed during the spring and summer of 2010. The targets of the project were mainly reached; however, some functions of the data logging system were not completed until autumn. This was mainly due to the lack of support from the data logging system manufacturer at some critical moments of the project. The project was very demanding, but the students enjoyed it, and maybe especially so because of the challenge. The mix of automotive and mechanical engineering students worked well together.

CONCLUSIONS

Conventional education does not offer enough skills and competences required in today's working life. A new pedagogical approach is needed to give the engineering students a proper readiness to manage themselves in the future.

The engineering world revolves around projects. To meet the challenges working in a project poses, engineering education should be based on project-based learning. To achieve proper results, problem-solving skills are required and problem-based learning helps developing them.

The methods presented in this paper are only some examples of how to develop engineering education in the spirit of innovation pedagogy. In order to apply innovation pedagogy in practice, the whole study curriculum and the educational organisation itself must embrace the approach completely.

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DEVELOPING LEARNING METHODS IN MATHEMATICS

Marko Kortetmäki

INTRODUCTION

A study (Kortetmäki 2009) conducted at Turku University of Applied Sciences shows that of the students that entered the degree programme in mechanical engineering in the autumn of 2005, only approximately 30% knew at the beginning of their studies how to solve the following task:

Simplify the sentence $\dfrac{\frac{1}{3}-\frac{1}{7}}{4}=$

For engineering students, it is a long way from knowing how to simplify a sentence with fractions to having a sufficiently solid mathematical foundation for the advanced studies within their own field, not to mention the many challenges they will encounter in their working life as recently graduated engineers.

The aim of the education is to produce engineers that possess good basic knowledge, skills and attitudes needed in their specialty as well as to equip them with competencies that can contribute to innovation creation. Mathematics, and mathematical subjects in general, play a central part in engineering studies and in setting the foundation for the entire education. Thus, these subjects form an essential part of any engineer's basic knowledge. Learning of more specific professional subjects is only possible when the foundation is solid.

However, in today's working life it becomes obvious that basic knowledge is not enough; one also has to know how to apply and use one's skills to create innovations as well. Therefore, the education itself stands before various challenges. The groups of mathematics students are large and heterogeneous, and the resources for contact teaching are limited, all of which add to the challenges. (Kortetmäki 2009)

Turku University of Applied Sciences applies innovations pedagogy, the aim of which is to help the students develop their innovation competencies during their studies as part of their professional knowledge. To enable the students to reach this goal, new and innovative learning methods are needed to boost the learning of both the core knowledge of any study programme as well as the skills and attitudes needed in the future profession.

This article focuses on studying the student's self-efficacy, which is necessary for the student to develop good, life-long learning skills, problem-solving skills and the ability to start anew after failure, among others. These competencies all belong to the list of innovation competencies. Self-efficacy means the individual's perception of his own abilities and qualities as a learner. Self-efficacy is not a permanent characteristic, but sensitive to changes in the individual's activities and performance. Many studies show that a student's success in different subjects is widely predictable through his self-efficacy (Bandura 1997). What is an engineering student's self-efficacy like in mathematics? How should the education support self-efficacy? According to innovation pedagogy, the purpose of taking self-efficacy into account in education is to try to enhance learning as well as the application and production of new knowledge (Penttilä et al. 2009).

THE CONNECTION BETWEEN SELF-EFFICACY AND MATHEMATICAL SKILLS

In the 1970's Albert Bandura defined "self-efficacy", by which he means the learner's own perception of his abilities and qualities as a learner. When assessing self-efficacy, a person evaluates his possibilities to perform a task rather than his own personality. Life experience, social interaction and the person's own feelings work as sources of self-efficacy. Only with the cognitive process these beliefs become part of the person's perception of himself (Bandura 1997, 3, 11, 79). According to many researchers of educational psychology, the students' prejudice is the factor that influences the learning process the most (Batanero et al. 1994, Rautopuro 1999, Thomason et al. 1995).

According to Bandura (1997), the evaluation of students' self-efficacy may vary quite a lot, depending on the activity to which the assessed self-efficacy is linked. The experience of self-efficacy influences the degree of difficulty of the tasks performed, as well as the choice of tasks by an individual. People tend to choose tasks that they believe they can perform and avoid tasks that they feel are too demanding. An evaluation of self-efficacy is then a good way of predicting the activity that an individual will aim at (Zimmerman 2000). Also, self-efficacy very accurately predicts the quality of a performance, and it is linked both to the motivational process and the decision-making process. In Pajares' (2003) meta-analysis the evaluations of self-efficacy strongly correlate with the performance of a task. Especially in situations where the student encounters difficulties, evaluations of strong self-efficacy have correlated with high perseverance (Bandura 1997).

The perception of the future is highly dependent on the students' experiences of their own capabilities. The school plays a big part in creating a feeling of self-efficacy. In fact, one standard of the teaching should be the success in creating a strong feeling of self-efficacy in the students. (Bandura 1997, 174, 176, Pajares 2003)

BUILDING UP SELF-EFFICACY

Bandura gives four sources of self-efficacy. The first one consists of significant experiences. Succeeding increases the sense of one's own abilities, and failures decrease the feeling of self-efficacy. Failing especially decreases self-efficacy when a student has not yet had the time to develop a strong feeling of efficacy. Another factor that creates and enhances efficacy is the indirect experiences obtained from social models. This means that when a student sees a successful person that he can compare himself to, it gives him the feeling that he also has a chance of succeeding. The third factor that enhances self-efficacy is social encouragement. If an individual is encouraged and convinced that he can perform a challenging task, he is more likely to try harder. Thus, the building up of self-efficacy supports innovation pedagogy, in which communality and the learner's activity are emphasised (Penttilä et al. 2009). The fourth factor influencing self-efficacy is the improvement of the individual's physical state as well as decreasing stress and negativity. (Bandura 1997)

RESEARCH METHOD

All students that initiated their studies in mechanical engineering at Turku University of Applied Sciences in the autumn of 2005 participated in Kortetmäki's (2009) research. At that time 86 students were accepted to the degree programme. The material was collected from 76 of the accepted students.

After the presentation of the course content and the test that was held at the beginning of the Mathematics K1 course the students were offered the possibility to do the course online. At this point the online course was marketed to be done without any contact teaching. A total number of 80 students were offered this possibility. Eight students signed up for online studies.

Even before the actual studies began, three of the online students realised that studying online did not suit them. Afterwards all of them said that they had thought they would have it easier through online studies than in a traditional course. However, they found already at the beginning that their self-discipline would not be strong enough to do the course online, since there would be no teacher to continuously push them forward in their studies. As a result, they moved over to the group that would get traditional teaching.

Before the mathematics studies began, the students that started the degree programme in mechanical engineering were tested with an initial test. At the same time, they were asked to fill in a questionnaire, where they were asked to evaluate several different statements using a scale (1 totally disagree… 5 totally agree). After having finished their mathematics course, the students filled out the same test, now as a final test, as well as another questionnaire. The aim of the initial and final tests was to chart the students' basic mathematical skills.

The Mathematics K1 course is the first mathematics course of the degree programme in mechanical engineering and it yields 3.75 credits. For an average student the course takes about one hundred hours of work. The Mathematics K1 course lasted 14 weeks. The groups that took part in the traditional teaching had 3-4 hours of contact teaching per week. The total amount of contact lessons per group was 48. At the end of the course all students took the same test in a traditional classroom.

FORMING FACTORS

Based on the material collected with the questionnaire at the beginning of the course, the statements were grouped into five factors with the help of principal component analysis, where Oblimin rotation was used. Each of the variables loaded on several factors was observed in the context of one factor only. The specific value of all five chosen factors was over one, as can be seen in Table 2. The reliability of the chosen factors was tested with Cronbach's alpha test and the value of the alpha coefficient of each chosen factor was over 0.8.

In accordance with Table 1, factor F1 is formed by variables X12-X16. The number after the variable refers to the order in the questionnaire. The letter K in front of the variable means that the variable has been changed. In the correlation matrix of the factor analysis, variable X12 was loaded with a negative correlation to factor 1, whereas the other variables were loaded with a positive correlation. By changing variable X12, the correlations of the variables loaded on factor 1 were made positive. The change is also seen in the statement of variable X12 – *I am good at mathematics*. In the original questionnaire the statement was – *I am simply not good at mathematics*. Variables X23 and X25 have been changed as well. Factor 1 has been named as mathematical self-perception. The value of factor F1, as well as the values of the other factors, is the average of the variables belonging to that factor:

$$F1 = \frac{KX12 + X13 + X14 + X15 + X16}{5}$$

Factor F2, self-efficacy in using computer technology, is formed by variables X22-X26. Factor F3 has been named mathematics anxiety and it entails variables X17, X19, X20 and X21. Factor F4, interest in mathematics, consists of variables X8-X11. The fifth factor, factor F5, opinion on on-line studies, is made up of variables X28-X31.

TABLE 1. *The variables loaded on the factors and their names.*

F1 (mathematical self-efficacy)
KX12 I am good at mathematics
X13 I get good marks in mathematics
X14 I am a quick learner of mathematics
X15 I have always believed that mathematics is one of my best subjects
X16 In mathematics class I understand even the most difficult things
F2 (self-efficacy in using computer technology)
X22 I feel confident when working with computers
KX23 Using computers is quite easy for me
X24 I mostly know how to help others solve computer related problems
KX25 I am the type who can manage computers
X26 I believe that I can learn new computer skills quite easily
F3 (mathematics anxiety)
X17 I often worry that mathematics will be difficult for me in the future
X19 I get very anxious when doing mathematics exercises
X20 I feel helpless when doing mathematics exercises
X21 I worry about getting bad marks in mathematics
F4 (interest in mathematics)
X8 I enjoy reading books about mathematics
X9 I very much look forward to mathematics class
X10 I study mathematics because I enjoy it
X11 I am interested in the things I learn in mathematics
F5 (opinion on on-line studies)
X28 I am interested in the possibility to study mathematics on-line
X29 On-line studying suits me
X30 On-line studying goes well with mathematics
X31 The possibility to study on-line should be increased

Factors F1 and F4 are the same that were used in the Pisa 2003 study (Kupari et al. 2005) when studying the knowledge of mathematics among comprehensive school pupils. In addition, factor F3 is almost the same as in the Pisa study. The difference is that variable X18 of factor F3 was included in the Pisa 2003 study, but not in this study.

Table 2 shows the central key figures of the factors. The specific values of the factors vary from 1.050 to 7.143. The cumulative coefficient of determination of the factors is 62.017%. Factor F1 has the highest coefficient of determination at 28.574%. The values of Cronbach's alpha coefficient vary from 0.804 to 0.873. Factor F2 has the highest average at 3.639 and factor F4 has the smallest average at 2.847.

TABLE 2. *Central key figures of the factors.*

	F1	F2	F3	F4	F5
Specific value	7,143	3,664	1,334	1,050	2,313
Coefficient of determination [%]	28,574	14,656	5,335	4,200	9,253
Cronbach's alpha	0,869	0,873	0,812	0,858	0,804
Average	2,941	3,639	2,585	2,847	3,056

STUDY RESULTS

What is the students' self-efficacy like?

As can be seen from Figure 1, the students have a firm belief that they are good at mathematics. More than 60% of the students that answered the questionnaire at the beginning of the course marked the statement *I am good at mathematics* with a four or a five (totally agree). Only one person totally disagreed with the statement. Although the students think that they are good at mathematics, they do not think that they will get good marks or that they will be fast learners of mathematics. In addition, they admit that they do not learn the most difficult concepts in mathematics class. Approximately 85% of the students answered with the numbers 1-3 on the statement *I get good marks in mathematics*. Only 22.6% of the students think that they are fast learners of mathematics. About 35% of the students consider mathematics to be one of their best subjects. A slightly larger group, i.e. about 40% of the students, thinks the opposite. Only 6.5% of the students believe that they understand also the most difficult concepts in mathematics class.

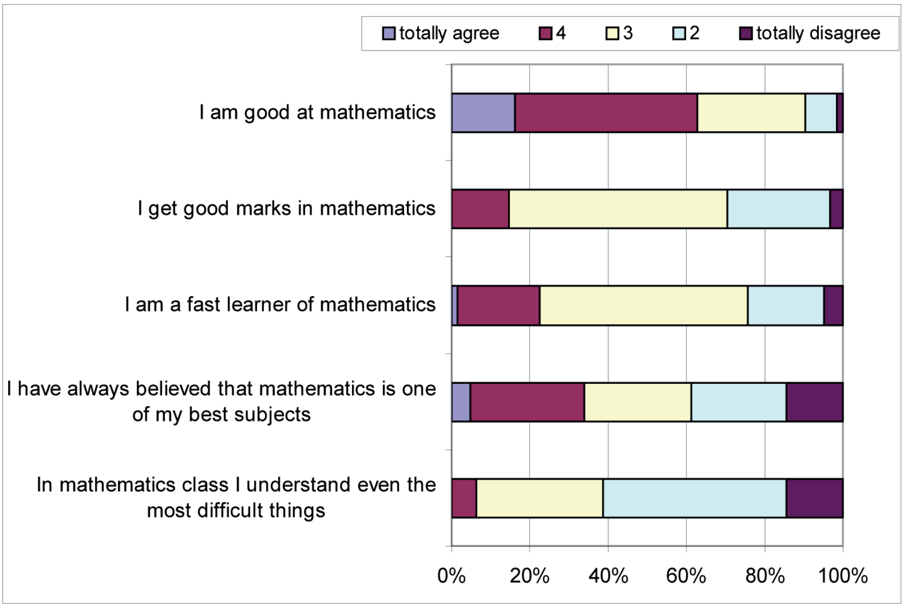

FIGURE 1. *The distribution of the answers to the different statements relating to factor F1, mathematical self-efficacy.*

The students seem to have an even stronger belief in their computer skills than in their mathematical skills (Figure 2). Nearly 80% of the students feel that computers are manageable, quite easy to use and that it is fairly easy to learn new computer skills. Some 47% of the students feel confident when working with computers while about 23% of the students feel insecure. The students feel the most insecure regarding the statement *I mostly know how to help others in solving computer related problems*. Almost 40% of the students feel (answers 1 and 2) that they mostly do not know how to help others with IT related problems.

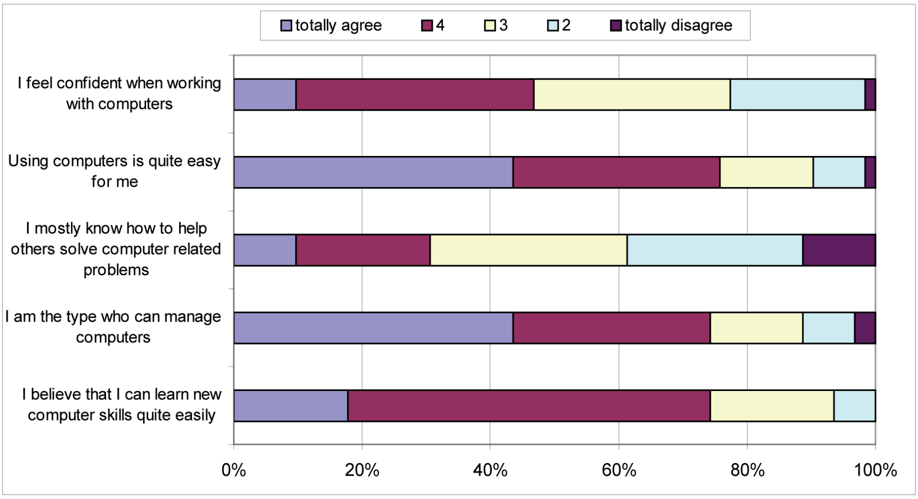

FIGURE 2. *The distribution of the answers to the different statements relating to factor F2, self-efficacy in using computer technology.*

Table 3 presents the averages of the answers to the different statements relating to factor F2 both at the beginning and at the end of the course. Table 3 affirms the notion that is already implied in Figure 2, i.e. the students believe quite strongly in their own computer skills. During the course, no great changes occurred in the averages of the different statements. As for the statements *Using computers is quite easy for me*, *I mostly know how to help others solve computer related problems* and *I am the type who can manage computers*, the students' confidence in their own skills grew stronger during the course. However, for the statements *I feel confident when working with computers* and *I believe that I can learn new computer skills quite easily* their confidence somewhat weakened. The students' self-efficacy in using computer technology was very strong both at the beginning and at the end of the course.

TABLE 3. *The averages of the statements relating to factor F2, self-efficacy in using computer technology, at the beginning and at the end of the course.*

	At the beginning of the course	At the end of the course
I feel confident when working with computers	3.32	3.25
Using computers is quite easy for me	4.08	4.24
I mostly know how to help others solve computer related problems	2.90	3.07
I am the type who can manage computers	4.03	4.15
I believe that I can learn new computer skills quite easily	3.85	3.81

The most central statistical quantities of factors F1-F5 are illustrated in Table 4. As stated before, the table shows that the students' self-efficacy in using computer technology is even more positive than their mathematical self-images. The average of 2.58 for factor F3, mathematical anxiety, indicates that students are not particularly distressed by mathematics. Some 40% of the students are worried that in the future mathematics will be difficult for them. Nearly as many feel completely the opposite. About 30% of the students fear that they will get poor marks in mathematics. The average of 2.85 for factor F4, interest in mathematics, reveals a mild interest towards mathematics. Around one third of the students look very much forward to the mathematics lessons and some 45% are interested in the concepts that you learn in mathematics. 14.5% of the students have no interest whatsoever in the concepts that you learn in mathematics. The view on online studies, factor F5, is quite positive, as can be seen from Figure 3.

TABLE 4. *Other central factor related key figures.*

	F1	F2	F3	F4	F5
Average	2,94	3,64	2,58	2,85	3,06
Median	3,00	3,50	2,50	3,00	3,13
Standard deviation	0,71	0,83	0,88	0,78	0,85
Variance	0,51	0,69	0,78	0,61	0,72

Is there a connection between possessed skills and the evaluation of self-efficacy?

Table 5 demonstrates the average of each factor and the standard deviation for each mark. The rows in grey show the average. Cd means course drop-outs. Six students dropped the course. According to Table 5, the course drop-outs have clearly the weakest mathematical self-image with an average of 2.50 for factor F1. The better the mark a student gets for the course, the better is the mathematical self-image, except for the mark four. The average mathematical self-image with the mark 4 is clearly lower than with the marks 3 and 5. The students that got the mark 5 for the course had the highest self-image in mathematics with an average of 3.33 for factor F1.

TABLE 5. *The average for the factors and the standard deviation for each mark.*

mark/factor	F1	F2	F3	F4	F5
cd	2.50	3.77	2.63	2.50	3.00
	0.77	0.75	0.97	1.11	0.85
0	2.82	3.64	2.83	2.63	3.13
	0.78	1.03	1.07	0.52	0.65
1	2.94	3.60	2.60	2.85	2.65
	0.67	0.86	0.78	0.67	0.90
2	3.04	3.72	2.63	3.15	3.48
	0.76	0.53	0.90	0.67	0.87
3	3.09	3.53	2.33	3.00	3.31
	0.83	0.46	0.79	0.86	0.72
4	2.85	3.82	2.45	2.70	2.70
	0.43	1.04	0.93	0.93	0.93
5	3.33	3.27	2.67	3.08	3.25
	0.84	1.11	0.94	0.77	0.89

The averages of Table 5 are illustrated factor-wise in Figure 3. The students that dropped the course had clearly the weakest mathematical self-image and their interest in mathematics was also low. These drop-out students did not get particularly distressed (F3) by mathematics and they considered themselves to be quite good at computer technology (F2). Apart from the mark 5, the students had a more positive self-image in computer technology than in mathematics. The students that got the mark 5 for the course had a slightly weaker self-image in average in computer technology than in mathematics. These students had a strong mathematical self-image and they were interested in mathematics (F4). The students with the mark 5 related in a positive way to online studies and they were not particularly distressed by mathematics, even though their average for factor F3 was the highest of all the students that passed the course. However, the average for the factor describing mathematical anxiety was quite low at 2.67. There were no major differences in the average for factor F3, as can be seen in Table 5 and Figure 3.

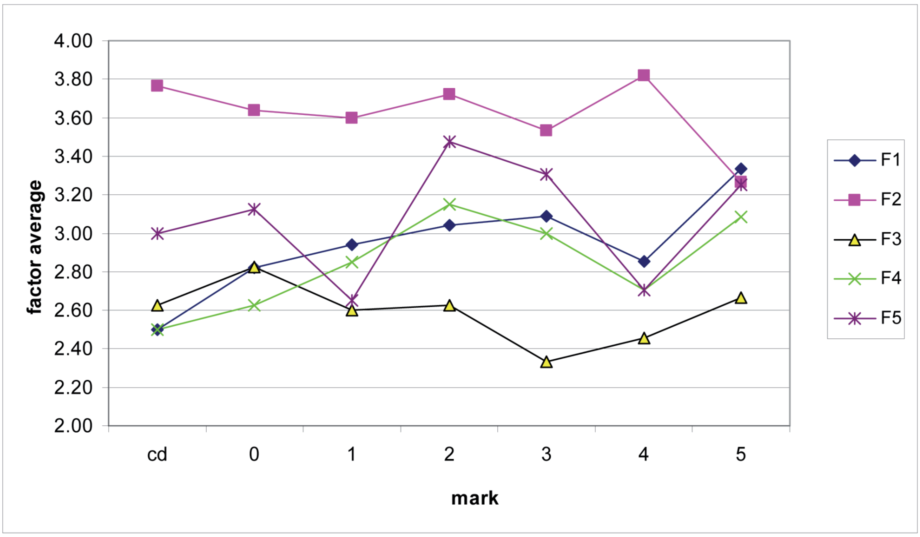

FIGURE 3. *Factor-wise averages.*

The shapes of the lines for mathematical self-image (F1) and interest in mathematics (F4) more or less follow one another. A student with a strong mathematical self-image is also interested in mathematics and vice versa.

The analysis of variance shows no significant statistic connection between doing well in the course, i.e. the mark for the course, and factors F1 and F2. This also means that the mathematical self-image, i.e. self-efficacy, has no significant statistic connection to doing well in the course. The level of significance of the analysis of variance was 0.05.

CONCLUSIONS

The Pisa study

In Pisa 2003 study (Kupari & Välijärvi 2005, 151–182) young Finnish people belonged to the average among the studied countries regarding mathematical self-images. As much as 40 per cent of young Finns felt that they are not good at mathematics and only one third regarded mathematics as one of their best subjects. According to the study presented here only 10% thought that they were not good at mathematics and some 35% considered mathematics to be one of their best subjects. In the Pisa study two thirds felt that they do not understand the most difficult concepts in mathematics class. In this study a little more than 60 percent of the students felt the same way. The students in this study, who were all engineering students, had a stronger self-image than the students that took part in the Pisa study. In all other respects the results above are very similar in both studies.

The country-wise results of the Pisa 2003 study (Kupari et al. 2005, 151–182) showed a strong connection between mathematical self-efficacy and mathematical skills. The students with a strong mathematical self-image had significantly better mathematical skills than the students with a weak self-image. According to this study conducted with the engineering students, there is no significant statistic connection between self-efficacy and mathematical skills. However, according to Figure 3, the mathematical self-image is stronger the better course mark the student has, except for the mark 4. The graph for factor F1, mathematical self-image, is very similar to the Pisa study, except for the mark 4.

When comparing the study results, it must be noted that the Pisa 2003 study covered the mathema- tical skills of 15-year-olds in 41 different countries. From Finland alone, 6000 students took part in the study. This study covered 76 people, of whom the youngest were 18 years old.

How mathematics teaching could be developed

A versatile education alone is not enough to guarantee excellent learning results if the student does not believe in his own abilities. An engineer with average skills and a strong but realistic self-image may be an excellent employee for a company.

According to both Kortetmäki's study (2009) and the Pisa 2003 study (Kupari et al. 2005), the building up and supporting of mathematical self-efficacy should play a central part in mathematics teaching. By improving the students' mathematical self-image, it is probably possible to decrease the number of drop-outs, improve study results and especially make studying more interesting.

More elements by which the student's thinking processes can be further emphasised should be added to the current, already versatile mathematics teaching. By getting inside the thinking processes, it is easier to steer the thinking in the right direction and, at the same time, correct possible errors of thought. The thinking processes can be made visible by both talking about and writing down the thoughts that come to mind during exercises. Making thinking visible, also called languaging, helps the student to create a more realistic image of his own skills and the points to develop. This is also the way innovation pedagogy directs the development of mathematics teaching as the approach emphasises offering the students a chance to develop their knowledge, skills and attitudes in a comprehensive manner in addition to their own substantial know-how (Penttilä et al. 2009).

It is crucial for the reinforcement of self-image to give the students positive feedback on their success. Negative feedback should be given in a very constructive and developing way. Negative feedback that is presented the wrong way might radically weaken a person's self-efficacy. In addition, the entire learning situation should be made as pleasant as possible. Sociability should be added to the studying of mathematics. In learning situations, discussions on the exercises could be increased amongst the students. This way the mathematical thinking processes would become visible. The students could influence each other's thinking processes as peer support. At the same time, the teacher would have the possibility to steer the thinking processes in the right direction.

Overall, the studying of mathematics should focus more on the quality of the learning and less on the quantity. It is only through profound learning that students or recently graduated engineers can apply their skills to the many challenges in the working life. With the help of an innovation pedagogical frame of reference it is possible, also within mathematics teaching and learning, to observe and develop such teaching and learning methods that not only support the students' professional growth, but also give them better social skills and a chance to develop as human beings (Penttilä et al. 2009).

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PANOSTE FROM START TO FINISH

Tero Reunanen

The aim of this article is not to present every little detail of Panoste. The aim is to give an example of a real-world R&D project based on the principles of innovation pedagogy and how those principles become visible in day-to-day surroundings. During the project, students were involved in real-world multidisciplinary work thanks to their modified curriculums, which enabled them to take part in the project. This text is hoped to offer new ideas for those whose work revolves around teaching and R&D in universities and to bring forth the pedagogical benefits of functioning in innovative learning environments.

PROJECT PANOSTE

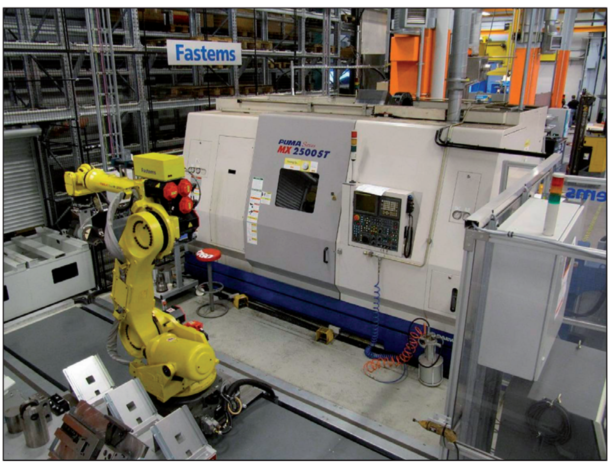
Panoste is an acronym derived from the project's Finnish name *koneistettavien aihioiden uusien panostusmenetelmien käyttöönotto*, which, freely translated, means *deploying new methods in loading machined blanks*. The project was a part of a technology programme called SISU 2010 funded by TEKES (Finnish Funding Agency for Technology and Innovation, www. tekes.fi). The programme's aim was to develop innovative practices for the manufacturing industry by developing new production methods and manufacturing technologies. The programme had a total volume of 93 million euro and it was scheduled for 2005–2009.

Panoste was coordinated by Turku University of Applied Sciences (hereafter TUAS). It had 14 partner companies from all over South-West and West Finland. The project's budget was 434 697 € and it was carried out between May 2008 and December 2010. The project had two priorities. The first was to develop a new robotized, cost-effective and flexible manufacturing cell for machining industry. The second was to disseminate information and knowledge relating to new technologies and applications as well as project results. The primary target group for the developed cell were small and medium-sized companies having a wide variety of products.

According to these guidelines, the technological targets for research and development became

1) zero point clamping system applications and robotized loading,
2) robotized deburring applications,
3) robotized marking applications,
4) robotized optical and mechanical based measuring applications.

The primary location for the studies and for the building of the cell itself was the facilities of Machine Technology Centre Turku Ltd (hereafter MTC). MTC is a joint education and development centre utilised by the educational institutes and enterprises having to with mechanical engineering in the Turku area.



PICTURE 1. *Practical learning environment in Panoste. Photo by Sakari Koivunen.*

The personnel of the project consisted of teachers, R&D personnel and students from TUAS as well as personnel from partner companies. The work was distributed so that the teachers were used as specialists and guides for students, the students themselves as the main working force and the companies' personnel as observers and in keeping the challenges and problems of the project as realistic as possible.

Panoste was not initially planned to be executed with so much student participation. Because of the project's slow progression and problems relating to staff changes, half-way through the project it became more student-oriented in its execution style. This article concentrates on the latter half of the project between October 2009 and July 2010. Students participated in the project in numerous ways and all together 28 students carried out some of their studies in the project. Although every student participating in Panoste was an engineering student, the degree programmes themselves were different. The students writing their thesis for the project were simultaneously working as paid assistants.

METHODS

Many methods of innovation pedagogy were utilised during Panoste, as the project and its subprojects were executed in close cooperation with working life companies not too dissimilarly from service activities TUAS carries out in general (Penttilä, Kairisto-Mertanen & Putkonen 2009). The possibility of utilising a flexible curriculum was also exploited. The nature of the project being heavily R&D-oriented, it did not include any separate entrepreneurial teaching as such.

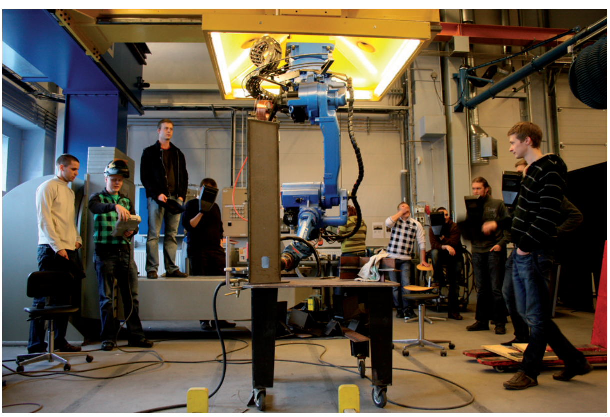
Working order

Because of the project's aim was to provide new applications and technologies for the industry, it was only natural to use the principles of PBL (problem-based learning) and CDIO (conceive – design – implement – operate) when working with students. The project was divided into four subprojects, all of which were led by a member of the TUAS staff. The main idea was to divide the workload in a way that every staff member would have enough time for students. The teachers also coordinated the university-industry interface and the activities relating to other subprojects. Furthermore, they took responsibility of their own subprojects.

The subprojects were divided into separate tasks, for the completion of which the students answered. The tasks varied heavily in scale and range, which was taken into account when students were divided into teams of different sizes. Thesis writers and some others also worked more independently.

Students

Even though most students participating did so to fulfil requirements for obligatory courses, all students who worked in the project were volunteers. The project manager visited some regular classes and introduced the project to the students. After visits to five different classes, there were enough students, 24 in all, interested in the project. (Later, five students discontinued working in the project, four of which did so due to personal reasons.) The students writing their thesis for the project were chosen separately case by case. Because of the voluntary nature of the project, the students were extremely motivated and hard-working. Besides the content of the feedback received from the students themselves, their commendable attitude was plain to see in the extra hours they spent working on the project out of sheer interest in the subject matter.



PICTURE 2. *Students testing robotized welding after the school day. Photo by Sakari Koivunen.*

Teaching and guiding methods

The primary working and teaching methods utilised were problem-based learning (Dewey 1957; Iisalo 1988), teamwork, peer learning and teaching (Gruber & Voneche 1995) and self-guidance (Rinne, Kivirauma & Lehtinen 2004). The main idea was to realise the teaching as tutor-mentor cooperation between students and experts. From the very moment the project was introduced to students, communicating the fact that the teacher-student relationship was going to be similar to a relationship between two colleagues was heavily emphasised. The only real difference between a teacher and a student was that the former had more professional competence.

As far as the tasks themselves were concerned, only the actual goal and the boundaries within which to operate were given to the students. The boundaries varied from task to task while still remaining quite typical for an R&D project; they often had to do with money, scheduling and the applicability of results, to name a few. One of the benefits of this kind of studying is that because there seldom is an absolute right way to do a given thing, students have to combine different theories from different subjects and ponder upon different solutions. After the operating boundaries were issued, every team prepared their own schedules, while personal schedules were made by each individual as well. Thus students, who were from different degree programmes, were able to practice project scheduling right from the beginning.

We attempted to keep students in the zone of proximal development in parallel with the principles of JIT (just in time). This means that students were helped only when the completion of the task was in jeopardy. We found that this was the ideal way to get the students to constantly challenge and develop themselves, and to help the project, as much as they could. It was initially quite challenging for the teaching and project personnel to make estimations about the level of skills and knowledge relating to the teams and individual students, but different skill and knowledge levels and varieties were also an advantage. The students learned very much from each other and the cumulative knowledge of the teams sometimes surpassed the knowledge the teachers themselves possessed even in the beginning stages of the project.

After the tasks were distributed, some teams simply started their work and everything went as we (and they) had planned. Most of the teams did not find the way to proceed right away and we needed to guide them some more. After a bit more help, every team managed to start and continue their work.

In retrospect, the beginning of the project was a very good example of the challenges that lie in finding every team's and student's zone of proximal development without knowing them well personally. (Rinne, Kivirauma & Lehtinen 2004; Vygotsky 1982)

In the kick-off meetings attended by all personnel working on the project, the students were told that one of the goals of the project was that afterwards the students knew more of the specified techniques and applications in question than most of the teachers or the working life representatives. This statement caused more than a little of insecure laughter. In many cases, the target, however, was actually met.

Working styles and locations

Students worked as teams and as individuals in various locations during the project, including their own campus, home, the companies involved and MTC. The students were encouraged to try out working in different places in order to discover their own personal preferences and practices. Although the actual testing and application building had to be done at the MTC facilities, one of the ideas was to show that gathering information, writing report s and other similar work is nowadays increasingly mobile. This arrangement raised the students' self-confidence and self-guiding capabilities. Naturally some students, often depending on how challenging the work was at a given moment, chose to work at MTC, where help was just around the corner.

Surveillance

The surveillance of the students was done by weekly reports. The report was an A4-template with five parts for the students to fill out:

1) progression after the last report
2) occurred problems and how they are going to be (or are being) solved
3) plans for the next period
4) uncategorised issues and ideas
5) tracking of working hours.

(See Attachment 1. Panoste's reporting language was Finnish, but the template has been translated to English for this publication.)

Every student was asked to send this report to the project coordinator and to an internet-based working platform weekly. The benefit of this weekly report, besides keeping track of the working hours in general, was that every student and team had to plan and analyse their own work. We made a gentleman's agreement with the students that there was going to be no cheating and only the actual working hours would be marked and counted. We also needed the real records to plan forthcoming projects and to analyse the efficiency of the project at hand. For counterbalance, we promised to overlook any small deficiencies relating to the working hours and the planned ECTS-points received for those hours. The results of this two-sided fairness were amazing, as many of the students voluntarily used more hours in the project studies than their courses needed.

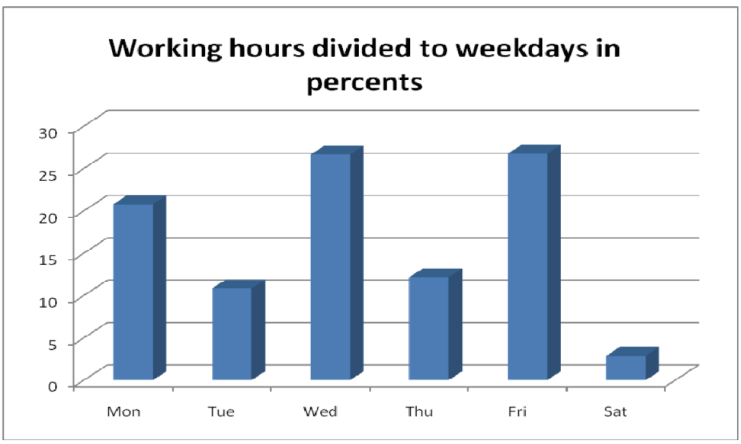


FIGURE 1. *Distribution of working hours according to weekdays.*

As we can see from Figure 1, the working hours were distributed quite equally between Monday, Wednesday and Friday on the one hand and between Tuesday and Thursday on the other. Some hours were recorded even on Saturdays. This distribution, which was a result of the students' own scheduling, enabled efficient working throughout the project without much overlapping on the same pieces of equipment.

Figure 2 illustrates Panoste's hour distribution in terms of weeks. In the figure, week number 1 is the week students got involved in the project, which was just before Christmas break. There is a noticeable correlation in time use between a typical project and Panoste. The project started out a bit slowly, but accelerated towards the end.

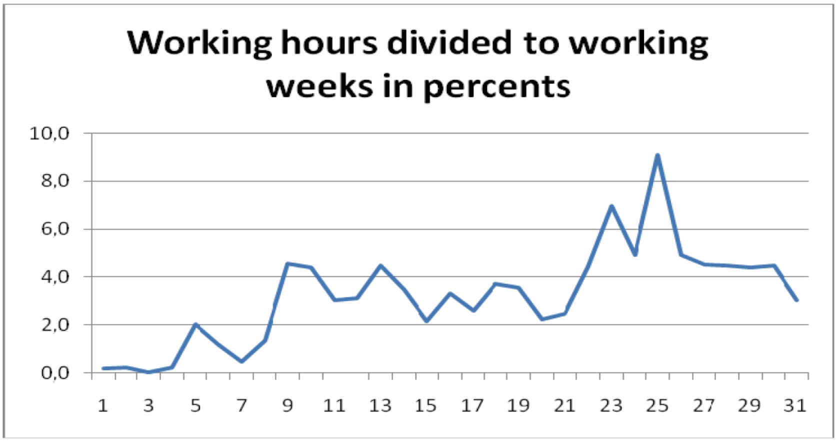


FIGURE 2. *Distribution of working hours according to weeks.*

Gatherings and information dissemination

Weekly meetings

Throughout the project, there was a weekly meeting, to which every student group and all individually working students were asked to participate. During this weekly meeting, typically held at the end of the week, current affairs and problems were discussed among the project personnel. We agreed that one member from every team is enough not to keep the students from attending to other possible study-related responsibilities.

The main idea behind this weekly meeting was to bring everyone up to speed on recent events and solve potential problems together in an organised manner to complement the fragmented nature of the work. This arrangement also cut down needed resources relating to project coordination. After the meetings, the project manager and other responsible persons could also be sure that every announcement and instruction was disseminated for all personnel. Memos kept in the meetings were uploaded to our internet-based working platform.

PICTURE 3. *Weekly meeting. Photo by Sakari Koivunen.*

Documentation and working space

Students were instructed to use, as much as possible, electric memos, sketch plans and other similar aids, but to use only a single paper notepad. The goal was to ensure that everything would be documented, preserved and easily disseminated. To manage this without massive emailing, we created a working space in TUAS's internet-based working platform called Optima. The working space had a general discussion area, a page to submit week reports, document folders for every team and student, common folders for memos and a calendar for reserving machines and cells at MTC.

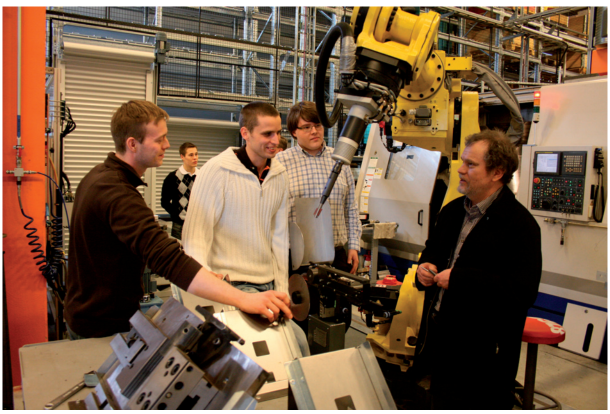
The students were given rights to add and remove their own documents in the working space and everyone could read and download any file. Notification emails were automatically sent to everybody when something new appeared in the general discussion area. All project personnel were instructed to check the working space every now and then.

In practice, the working space primarily functioned as a place to store and share files. The general discussion area remained quiet during the project, because it was felt to be too slow and time-consuming; emails and mobile phones were used for day-to-day communication. A real-time messaging system or a web phone possibility could have complemented the drawbacks, but still these applications would have to be extremely user-friendly to reach the same level of convenience with the traditional email and mobiles.

Students appearances

During the project, the students made many appearances in front of different audiences. For instance, they gave spoken reports in weekly meetings and presented their work to the steering group and visitors at MTC. Students also created demos and small example cases from the project to be presented to other students and staff on the R&D theme day at TUAS.

In addition, the students working in the project took actively part in company visits. According to the spoken feedback from company representatives and the project's steering group, students were outstanding and convincing performers, and they could answer all questions satisfyingly. We believe that this was a result of constant public speaking during the project and, of course, deep understanding of the project in general.



PICTURE 4. *Students introducing production cell to company representative. Photo by Sakari Koivunen.*

Students' economical responsibility

The students were also responsible for communicating with suppliers. In practice, because of TUAS's buying and ordering policies, students were not actually allowed to buy or order anything for the project. However, in most cases, it was the students who were in talks with supplier representatives and made decisions about the needed components and accessories and compared different options to discover the most economical solutions. This responsibility was not limited to simply finding the cheapest component, but in comparing the total cost of different options, including working times, possible alterations, different working principles, the life circle of accessories and so on. After this consideration, the student would present the lists of needed articles and suppliers to the project manager or someone else to whom it was possible to make the order.

Learning from mistakes

In some cases, the students were allowed to make mistakes, even when the expert saw that something was going wrong. Once, a student had done excellent work with an ordering list, but one of the most obvious components was missing from it. The expert asked if the student had rechecked the list, the answer being that everything was fine. After the ordered components were delivered and the supplemental order, for the missing component, was made, the student was sure he would always remember to focus on double-checking component orders from now on. Some could say that this method was irresponsible or even mean, but the lesson is an important one to learn and the environment was still a safe one to make a mistake in. Some components may have long delivery times and careless orders might cause huge scheduling problems.

Peer learning and teaching

At the end of the spring period 2010, the project organised a workshop day during which every team and student presented the tasks they had been working on, their working methods and their results. This workshop, although the expert personnel were present as well, was carried out by utilising the idea of peer learning and teaching. No limits relating to the style, location or method of the presentation were given, but nearly every team used a combination of lectures, showcases and hands-on presentation methods. For example, the robotic deburring team number 1 briefly presented their target within the project and a couple of other main points, after which they proceeded with a demonstration in the manufacturing cell and finally answering questions. Most students used their breaks discussing their tasks and results with other students. Feedback described the day as very enlightening and the concept was seen as an extremely useful one.

PICTURE 5. *Peer teaching during the recess at workshop day. Photo by Sakari Koivunen.*

RESULTS

The pedagogical results of the project, especially in the light of innovation pedagogy, can be summed up as very positive. The implemented methods proved to be quite effective and motivating. Also the students involved in the project themselves felt that learning in this kind of environment was both challenging and rewarding.

Feedback sessions

Although feedback was collected throughout the project, special interview sessions with the students were organised at the end of the spring period. During the sessions, every student was called to have a dialogue with project manager. Each session lasted from 15 to 30 minutes depending on the student. Because the process was so time-consuming, we decided to limit the number of interviewed students. Finally, a total of 17 randomly selected students were interviewed. The idea was to give students a chance to free speech and gather information for future projects. In the interviews, the project manager steered the conversation as little as possible. There were, however, some issues that warranted opinions from every student, including the motivation level when working in a real-life R&D project for study points, the student's own estimation of how much had been learned when compared to conventional classes and the level of workload in general.

The sessions were divided into two parts. The first and more essential part concerned the way the project was executed, having to do with methods, facilities, schedule, and so on. Here, the emphasis was on issues that had to be enhanced or changed regarding a project executed with students, opinions on the effectiveness of this kind of work and ideas to develop the overall coordination of future projects.

The second part concerned the personnel. It was the student's task to evaluate the project manager and the people responsible for the subprojects. Every student was more or less forced to come up with at least one negative and one positive aspect relating to every R&D expert. The aim was to collect information on how individual experts, as members of the staff at TUAS, could develop their own performance and what kind of properties students appreciated in them in such a challenging setting.

The first thing taken up at the beginning of a session was why the session was held. At this point, three things were made clear: the session does not affect the grade, only the interviewer will know whose individual opinion in whose and that there are no bad opinions. The occasional joke or anecdote helped in getting the students to relax and speak freely. This was the case especially during the personal evaluations, as it can be very hard for a student to voice an opinion about a teacher or expert.

PICTURE 6. *Feedback session. Photo by Sakari Koivunen.*

Analysing the results

Feedback relating to project

The student feedback from the interview sessions has been collected in Table 1. The bolded items, the items that have more than one occurrence, are interpretations of the answers collected under one heading.

One of the goals during the sessions was to dig up as many negative aspects relating to the project as possible in order to avoid the same mistakes in the future. (Of course, also the positive aspects that came up were interesting for polishing up the best practices further.) This approach is reflected in the collected results of the feedback below, as the negative seemingly outweigh the positive. Furthermore, the difference between a positive and a negative piece of feedback is not always obvious. It is important to keep in mind that some negative statements do not necessarily relate to things that were inconvenient or all wrong, since they can also mean positive issues that should be enhanced.

For example, "workload was challenging" has been positioned under positives. Normally a challenging workload could be seen as a negative thing, but the students who were of this opinion saw it as a good thing to be able to see how time-consuming it really is to, for instance, plan real pieces of sophisticated machinery. Nobody stated that a bigger workload, compared to traditional class teaching, is a negative aspect. It has to be said that it is very enlightening to see that students do not shy away from hard work, when the pedagogical methods are motivating enough. There are also some contradictory items in the answers. For instance, five students thought that spontaneous, free-form problem-solving was a positive aspect, but six students wanted more limits to their working. This is a good example of the challenge that lies in planning R&D projects in the way that every student is positioned adequately to the zone of proximal development, while helping them to learn by self-guidance as much as possible at the same time.

From the point of view of innovation pedagogy as an umbrella approach, it is soothing to see that nearly all negative items on the list concern problems in the actual project management and not the studying method itself. One big issue that lowered motivation in two of the student teams was that some companies did not participate in the project as actively as some others working with other students. This is another good example of a new kind of challenge that those working within the sphere of innovation pedagogy, as opposed to conventional teaching, have to face.

TABLE 1. *Student feedback relating to the project collected from interview sessions.*

Positive aspects	Students	Negative aspects	Students
Very motivating way to learn	**8**	**Accessory shortages**	**10**
Motivating and different way to learn	**6**	**Communication problems**	**8**
Practical way to learn	**5**	**Too open tasks, more limits needed**	**6**
Spontaneous, free-form problem-solving	**5**	**Too little cooperation with companies**	**6**
Free schedule	**4**	**Slow project starting**	**5**
Weekly meetings	**3**	**Schedule problems in ordering components**	**5**
Workload was challenging	**3**	**Unclear responsibilities and rights**	**4**
Concretises formerly learned theories	**2**	**TUAS staff's schedules**	**4**
Atmosphere in project group	**2**	**Intensive theory part needed inbeginning**	**3**
Real-world problems	**2**	**Clearer instructions to tasks**	**3**
Practices during the project		**More peer teaching/learning**	**3**
Student selection style		**More time needed to support and give feedback to students**	**3**
Robot training		**Clearer tasks and responsibilities for staff**	**2**
Connections to industry		**Faster purchasing of parts**	**2**
Learning wide variety of technologies		**Too narrow area to study / learned too little**	**2**
Learning to work in project		**Student commitment**	**2**
Constant support if needed		Fitting the schedules	
Deeper learning		Introduction to MTC	
Peer teaching/learning		Location of MTC	
To see the realisation of plans		Absence of permanent workstation in MTC	
		Too little negative feedback	
		Students need more pressure and tighter schedules	
		Waiting periods (e.g. when accessories needed)	
		Clearer project plans needed	
		Better preliminary work	
		Clearer instructions to documentation	
		Divide tasks to smaller parts	
		More time to react for presentations etc.	
		Cooperation in team	

Feedback relating to personnel

All notes concerning the TUAS staff have been gathered in Table 2, categorised as above. After the feedback was received, the project manager compiled all remarks for each staff member so that each expert got the list of all issues concerning him or her personally. The list was gathered so that nobody would be able to connect an opinion with the student whose it was. The idea was to offer personal and honest feedback to staff members and also to give tips on what kinds of properties are needed when guiding students in R&D projects. In the personal evaluation part, the students were more uniform in their answers.

TABLE 2. *Student feedback relating to the experts involved in the project collected from interview sessions.*

All together positive aspects	pcs	All together negative aspects	pcs
Professionalism	18	Was available too little	12
Willingness and time to help	15	Too busy	11
Easy to approach	12	Promised things late	10
Demanding but fair	12	Confusions between tasks, teams and students	10
Motivating, encouraging	11	More feedback	9
Clear way to teach and mentor	10	Guiding and mentoring was sometimes insufficient	9
Was genuinely interested in students' activities	9	Commitment for project	9
Attitude	9	Uncategorised	5
Taking care of daily routines	8		
Uncategorised, such as "visionnaire" or "says honestly what is thinking"	8		

The most valued property was professionalism. The professionalism of a given teacher is typically highlighted in university studies compared to lower level studies and it is even more the case in real-world R&D-based studies. In R&D-based studies, experts cannot prepare and plan everything like they can (and should) in conventional class teaching and thus the expert's ability to solve problems, apply theories to practice and challenge themselves professionally is heavily emphasised.

Secondly, students seemed to appreciate honesty and genuineness. This may be the result of the fact that an expert in an R&D project cannot play the role of the almighty, all-knowing authority. The work and cooperation with students is too intensive for keeping up unnatural roles. An inspiring, motivating and devoting attitude is also valued, which was very predictable. No student will be inspired or motivated to learn and work hard, if the staff members themselves are indifferent towards the task at hand.

The project Panoste was quite challenging for the students due to its wide variety of subject matter and its approach to the teaching itself. This is clearly seen in the pieces of negative feedback in the personnel evaluations. Students felt that experts did not have enough time to guide students. This is quite surprising, as there were two experts available for guidance nearly all the time during the project in addition to two others who were available roughly 40% of the time. This shows very clearly the fact that students are not necessarily used to uncertainty in their studies and they may find their responsibilities relating to actual results inconvenient. However, the most notable negative aspect of the feedback was that every staff member in the project at one time or another promised something to be done in a certain amount of time that was not realised in the promised schedule. What makes these cases unforgivable is that during the project, the students themselves were continuously reminded of the essentialness of keeping up with promised schedules, as scheduling conflicts always cost money and are bad for the image of the company in question.

ENHANCING PROJECT PROCEDURES

The biggest problems were found from procedures of buying components and accessories during the project. These problems could be diminished by more careful planning, but as long as projects are publicly funded and their coordinator is a public organisation, there will be legislative limits, which often slow down the purchasing process. Projects should also be frontloaded regarding workloads. In other words, more should be done in the beginning stages of a project and the workload should lessen towards the end. This way the end rush could be avoided and students' stress level lowered.

One of the issues that could be improved relatively easily concerns finding ways to enhance communication in a large group. Trying new and better configurable internet-based working platforms could be one of the answers. Also daily memos and project news sent by email might be worth trying. Overall, it is hard to overemphasise the importance of disseminating information.

Limiting the tasks

Offering more limited tasks and subprojects is a precarious way to approach the feedback concerning the overtly open-ended instructions received from some students. The tasks should not be too limited straight away, because then we would lose the possibility for distinctive innovations and eureka moments. With too narrow assignments student participation in the project may transform from PBL into monotonic executing of the task at hand without any possibility to innovate. The answer for the problem may be in offering students more time initially to prepare and familiarise themselves with the project and its targets. Also the project's execution procedures, including documentation on the working order and other similar information, should be brought forth more clearly right in the beginning.

As mentioned before, it seems that students in general are not ready for the uncertainty of real-world industry projects and work. They are too used to being given the 'right' answer or the answer is written in the back leaves of the book. The fact that there are no right answers in R&D projects should be sharpened to students on every turn.

Choosing the experts

When preparing cooperative projects with students, the first thing to do is to ensure that there are suitable experts available. They should all be willing to challenge their professionalism. The experts and the project manager should pay extra attention to keeping their promises and keeping hold of schedules during the projects.

Student backgrounds

In accordance with the principles of innovation pedagogy, to achieve best possible results and to provide the students with a wide perspective on the related subject matter, the student pool used for a given project should be multidisciplinary by nature. It is easy to simply prefer students who are most likely to do a good job, but to create projects more like real working life R&D projects they should include students from different faculties, degree programmes and levels of advancement. Even amongst small companies, it is very rare that all the people working there should have the same education; in fact, typically people working together have very different educational backgrounds.

In Panoste, the students involved were from different degree programmes and years, but only from the field of machine and production technology. The management of the project was naturally easier as everybody spoke the same language, but the perspective was quite narrow. To Panoste's defence, the project focused mostly in the new production automation and thus a strong emphasis on machine technology students would have justified in any case. In retrospect, however, there may have been great benefits if some students from marketing and other economics-related degree programmes would have taken part to the project.

Be that as it may, it is recommended that the nature of the knowledge base required from students for good results is determined before the choosing process itself. In general, it is nearly useless, for instance, for a machine planning R&D project to employ a student who does not possess a basic level of knowledge concerning the strength of the materials involved. In project work, the participating students should be familiar enough with the subject matter to make self-guidance possible. This way, students will not get frustrated and the expert's time is not spent on guiding students whose studies in the project may not prove useful even for the students themselves.

Companies' effect on motivation

For extra motivation for the students, the active participation of companies should be ensured. The best scenario is that company representatives bring clearly forth, especially in front of the students, the reasons why the company is participating in the project, what kind of expectations they have and how the project results may impact the company. Also constant feedback from company representatives is advisable.

Feedback from companies

Because the project had not ended at the time this article was written, it is impossible to make any conclusions from the written feedback received from the companies. As mentioned before, the spoken feedback has been very positive. It seems that the representatives of the companies are pleased with the industry-university cooperation and that the combination of R&D and teaching has been seen both as profitable for every partner and as an effective way to teach. One thing that has been in common in the feedback from all the companies is that students, after participating in an undertaking such as Panoste, have better basis to make the transition to working life than other students. Some students reported that in a summer job interview, it was a great advantage to be able to tell the interviewer that they had been a part of such a practice-oriented project.

CONCLUSION

As we have seen, studying in a working life R&D project is very motivating for students. The approach utilised in the project Panoste, a mixture of many different pedagogic and didactic theories and practices, is a typical example of innovation pedagogy.

Theories and ideas from at least Lev Vygotsky (zone of proximal development and peer learning), John Dewey (problem-based learning) and Jean Piaget (peer learning) were applied in the execution of the project. Most of the main methods of innovation pedagogy were utilised as well. (Rinne et al 2004; Vygotsky 2003; Dewey 1957; Iisalo 1988; Gruber & Voneche 1995; Van der Veer & Valsinger 1994; Penttilä et al 2009) On the other hand, every procedure was not particularly planned according to pedagogic theories. Many of the practices were adopted from standard project managing and the working practices of the industry; many of them were just plain common sense. It is in the nature of a project that as often as everything runs smoothly on its own, the unexpected happens and one has to make adjustments. This is also something students learn while doing project work.

Below, the potential benefits for students from participating in an R&D project have been complied under three broad themes.

- Working procedures and practices used in the industry and project work:
  - To work independently and in teams.
  - To view ideas and applications critically.
  - To take responsibility for results and financial issues.
  - To document and disseminate information.
  - To manage resources and schedules.
  - To meet the requirements of specific working life customs.

- Combining different theories from different fields:
  - To apply knowledge and theories in innovative ways.
  - To recognise the interfaces between theories and practice.
  - To discern the essential in theories from the practical point of view.

- Social skills:
  - To give talks and presentations for unfamiliar audiences.
  - To adapt presentations according to audience.
  - To question ideas of experts in a fruitful way.

Overall, it was easy to see that all actors involved in the project, the students, the working life companies and Turku University of Applied Sciences itself, benefited from Panoste. The companies directly benefited from the work that was done in the project. The partners also found, and got familiar with, promising new workers. Additionally, Panoste served as a stepping stone for several new cooperative projects involving the companies and TUAS. The whole machine technology branch in South-West Finland is indirectly benefiting from the concluded work in the form of publications and the generation of new knowledge.

The benefits for TUAS, however, were the most multilateral. Even though TUAS has a long history in the field of R&D projects and innovative teaching and learning methods, it could be said that Panoste piloted several new practices. The project developed many new procedures for use in forthcoming projects. Relating to machine technology, Panoste was also the first project of this scale for TUAS that had such a prominent number of students participating and taking so much responsibility for the end result. Although the aims of the project were high and diverse from the beginning, they were exceeded on all sectors.

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ATTACHMENT 1

PANOSTE | Week Report 16

Loading, team 1
Eric Example, Ian Instance
23.4.2010
18 h

Proceeding after last report

- We continued robot programming
  - Edited and enhanced programmes
- We created Loading-main program, where every subprogram is combined to whole.
- Debugging of Loading-program
- Testing and observing functionality of Loading-program

Problems and how problems are going to be (or are) solved

- When we run main program we recognized that robot didn´t followed the programmed lines. It went wrong direction and pulled off hydraulic coupling and it´s attachment frame. Luckily we managed to stop robot before it made bigger destruction. Only damage what happened was bending of attachment frame. We managed to, with fairly little effort, bend frame back and attach it firmly. Next day, with Sakari's guide and help, we localized the problem. The problem was that we were used wrong U-tool coordination system in some parts of program.

Plans for next period

- Attaching measuring device´s frame to machining palette
- Starting measuring test in production cell
  - Determining measuring parameters
  - Desining the piece that would be testeted
  - Making the testing plan
- Attaching the piece that will be machined to clamping palette

Ungatecorized issues and ideas

-

Bookkeeping of made hours

Eric Example

Day	Hours	Location	Description
Mon	3	MTC	Robot programming
Tue			
Wed	4	MTC	Combining subprograms to main program
Thu	3	MTC	Finalizing the main program
Fri	8	MTC	Panoste sub-projects presentations, weekly meeting and working in robotized welding cell
Sat/Sun			
Total	18		

AFTERWORD

Taru Penttilä

This publication introduced the concept of innovation pedagogy adopted by Turku University of Applied Sciences by outlining the approach theoretically as well as by offering practical case examples. The aim of this article collection was not to provide strict definitions relating to the approach, but to open a line of discussion concerning the meaning of innovation pedagogy especially in the context of universities of applied sciences: why it is needed, what new possibilities it offers and how it can be utilised in practice. The articles dealing with the practical side of the concept were not assembled here as an exhaustive collection of good teaching and learning practices, but as excerpts shedding some light on the practices utilised within the framework of innovation pedagogy at the Faculty of Technology, Environment and Business. There are many other successful learning and teaching methods that fall under innovation pedagogy even within our own organisation. In other words, this publication was intended to further activate the ongoing discussion on sharing the best teaching and learning practices in general and to develop the pedagogical dimension as a whole in all universities of applied sciences.

Innovation pedagogy, as a framework, is a subject that has not yet been extensively studied or defined. Thus it offers a large variety of topics for further study. The need for innovation pedagogy and the innovation competences it produces is great, as the Director of Education Kairisto-Mertanen points out in the introduction for this collection. In order to support businesses and the creation of innovations, the universities of applied sciences must offer a learning environment that enables the growth of multidisciplinary professionalism. This goal is pursued with innovation pedagogy, which defines in a new way how knowledge can be absorbed, produced and used to create innovations.

It is hoped that this article collection generates discussions and evokes research projects on further development of innovation pedagogy so that the competences produced by all universities of applied sciences continue to maintain their competitiveness also in an international setting. To support this work, a working group for innovation pedagogy has been established at Turku University of Applied Sciences. The group oversees the development process at the level of the university and strives to rouse discussion at the national level as well as in the international cooperation networks.

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