INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN, ICED'07
28 - 31 AUGUST 2007, CITE DES SCIENCES ET DE L'INDUSTRIE, PARIS, FRANCE

PIEp: PRODUCT INNOVATION ENGINEERING PROGRAM

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ABSTRACT
This article presents the establishment of a large research, education and development program in the area of innovation engineering, the Product Innovation Engineering Program, PIEp. The program is intended as a network of researchers, educators and students in innovation with the purpose of creating a systematic shift toward innovation and entrepreneurship in institutes of higher education and research.
The initial PIEp consortium consists of: Faculty of Engineering at Lund University, Umeå Institute of Design at Umeå University, International Business School and School of Engineering at Jönköping University, Center for Technology and Health, Sweden and is coordinated by the School of Industrial Technology and Management at the Royal Institute of Technology.
PIEp is organized in five activity fields, ranging from research in innovation to product- and business development through education in innovation. The organization is based on a model where the five fields generate knowledge and feed back knowledge and experiences to the other fields.
The program is initially funded by the Swedish Governmental Agency for Innovation Systems, VINNOVA, Innovationsbron AB (a Swedish organization that supports business development through incubators and seed capital), the collaborating universities and a number of private sponsors. The program was launched in late 2006 and is intended to run for ten years. The first research projects and educational activities have started, and the PIEp program is now inviting more national and international partners.

Keywords: Product innovation engineering, Research program, Entrepreneurship, Engineering education

1 INTRODUCTION
The aim of this paper is to present an ongoing attempt to create a systematic change toward innovation, innovative product development and innovation engineering research in companies, universities and research institutes.
The Product Innovation Engineering Program, PIEp, is a national program with the purpose of strengthening the ability in innovative product- and business development. PIEp encompasses the fields from theory to practice, from research in innovation to pro-active work to strengthen innovative research and development and reach a systematic change within research, education and development.
PIEp is intended as an injection of inspiration for innovation in the existing system. PIEp results, for example, in increased innovation capacity, in better utilization of academic research, in increased mobility between industry and academia, which will lead to new products, new companies and businesses. The program involves higher engineering education institutions, with the purpose to influence courses and entire programs to stimulate and train students in innovation.

Structure of the paper
The structure of the paper is as follows: In section 2 we describe the background of the research and development program in perspective of Swedish history; the industrial need, the academic possibilities and the idea of a systematic change. In section 3 we describe the program with activity fields, research areas, educational aims and organization. In section 4 we present a number of early projects, activities and results of these. In the final section we conclude with experiences and conclusions from the first phases of the PIEp program.

2 BACKGROUND

The PIEp initiative was taken by KTH, the Royal Institute of Technology, in unison with a number of industrial partners in 2005, and the program was developed in one year's time by a consortium of researchers, representatives from companies and in close dialogue with VINNOVA (The Swedish Governmental Agency for Innovation Systems) and other funding bodies.
The final decision to launch the PIEp program was made in the summer of 2006, when VINNOVA decided to fund the first three years of the program. A second financier soon followed, and discussions are ongoing with more financiers. Also, grants from two private companies have enabled the establishment of two new chairs at KTH, in innovation engineering and product design related areas, and two new professors are being recruited.

The initial PIEp consortium

The PIEp consortium consists in the starting up phase of members from a national PIEp network spanning relevant research groups and representatives of application specific areas. The network consists initially of the following five nodes, each bringing its respective specialties to be utilized in the PIEp network:

- Faculty of Engineering, Lund University.
    - Research and education in the design sciences with need analysis, design methods and design principles. Also, ergonomics and industrial design.
    - Innovation research.
    - Ideon Science Park, with extensive experience from utilizing academic research and from several success stories.
- Umeå Institute of Design, Umeå University
    - Extensive experiences from research and education in user-oriented design, interactive design and product design in general.
    - Industrial collaborative research and educational projects with partners such as ABB, Ericsson, Telia and Volvo.
- International Business School and School of Engineering at Jönköping University
    - Jönköping Science Park, with extensive experience from SMEs.
    - School of Engineering, Jönköping University, educating directly to and for SMEs.
    - International Business School with research and education in entrepreneurship, business renewal and internationalization.
- KTH, Royal Institute of Technology, School of Industrial Technology and Management
    - Research and education in innovative and integrated product development, and industrial engineering and management.
    - Research and education in complex, knowledge intensive products and systems development, in particular related to medical engineering, mechatronics and embedded systems.
- CTV, Center for Technology and Health
    - Multidisciplinary research and education in innovation and entrepreneurship in medical engineering

The five nodes are each chosen to contribute to the overall goal of creating possibilities for a systematic change of abilities in innovative product development. The area of design is identified as one of the most important factors in product development, and the partner Umeå Institute of Design is the leading institute in Sweden. The roles of SMEs are equally identified as important for entrepreneurship, and the Jönköping University node is situated in the midst of the most famous SME region of Sweden. Ideon Research Park in the vicinity of Lund University is a meeting place for researchers, entrepreneurs, innovators and educators suitable for studies of start-ups, incubators and business mentoring. CTV provides the platform for the application specific domain – medical technology, with extensive experience from innovation and entrepreneurship in this area. KTH provides both research groups in innovative product development and in the application specific domain, related to development of complex, knowledge intensive products (mechatronic products). KTH also has strong links to STING (Stockholm Innovation and Growth) which provides a well established and efficient environment for new entrepreneurs and start-up companies.

PIEp Innovation network – PIEp Innovation Friends

In the development phase of the PIEp program a number of national and international partners have contributed in the design and establishment of the program and consortium. These nodes together with a few partners from previous collaboration with members of the consortium constitute an interim PIEp innovation network, sometimes referred to as belonging to the PIEp Innovation Friends. Examples of these partners are:

- Stanford University, USA
  - Center for Design Research and Design Division both perform excellent research in the areas of design thinking, creativity and collaborative design.
  - d.school, the Hasso Plattner Institute of Design at Stanford, where design thinking is explored and integrated all across the Stanford campus.
- Boston University, Harvard Medical School and MIT, USA
  - The NeuroMuscular Research Center and research groups at Massachusetts Eye and Ear Infirmary together with associates at MIT provide a platform for entrepreneurial student collaboration.
  - MIT Sloan School of Management and the MIT Entrepreneurship center.
- TU Delft, The Netherlands
  - Department of Industrial Design Engineering, with research focus on products and product design.
- Zhejiang University, China
  - The Chinese "Silicon valley", with education in entrepreneurship with global setup.
- Technical University of Denmark together with other Danish Universities
  - Center for Innovation in Product Development, CIPU, a national center of excellence in research and practice.
- Swiss Federal Institute of Technology, Zurich
  - Department of Management, Technology, and Economics performs research in technology management and entrepreneurship in conjunction with the University of St. Gallen.

The purpose of this network is primarily to provide global expertise and competence to PIEp but also to provide discussion partners and quality assurance. The network will also be used for the exchange of students and as a platform for collaborative research and educational projects [1,2,3,4].

Innovation engineering and Swedish industry

Innovation Engineering can be interpreted both as an ability to create conditions for innovation, and also as innovative power in developing engineering products. Sweden has an industrial history with a number of companies that have grown to multinational corporations based on technical innovations. The position is though challenged, the capacity to develop innovative products has not increased, several of the major companies are today acquired by international actors, and the business possibilities are all in a global context. It is also a fact that many of the larger Swedish corporations stem from innovations made many years ago, companies like Ericsson, ABB, Scania and others [5]. According to the Swedish Patent and Registrations Office [6] the number of patent applications decreased in Sweden with 42% between 2000 and 2006. No clear explanation to the decrease is found, and the need to investigate further is apparent.

The potential to develop new businesses is closely related to an increased ability in innovative product development, and to develop innovative organizations, processes and people with capacity in creating value through new products and services [7,8].

3 PRODUCT INNOVATION ENGINEERING PROGRAM

PIEp is implemented with a series of activities: research efforts, educational efforts and development projects. The research efforts are necessary to gather existing, and generate new, knowledge about the innovator, the innovation process and the innovation system. Further, PIEp will contribute to technical research efforts which are governed not only by the scientific questions, but also more directly from a product and innovation oriented perspective. The innovation climate in participating companies is developed through research, development and directed activities such as creative sessions and the building of networks.

The program spans the area of product innovation engineering, from theory to practice and from research to innovative product development. The program is organized in five fields; two with a focus on process and organization oriented research (Innovation Knowledge and Innovation Management), two related to product- and business oriented research and development (Innovation Experience and Innovation Business) and one related to education. All five fields generate knowledge and feed back knowledge and experiences to the other fields.
The engineering students today are the innovative engineers of tomorrow. Influence on education in innovation is performed within undergraduate, graduate and postgraduate education. Influence on education and the enhanced innovation climate will together with leading high technology research and development lead to new products and new businesses. This process is further strengthened by means of a series of catalytic activities such as a trainee program, projects for increased mobility between academy and industry as well as entirely new courses and programs in innovation engineering.

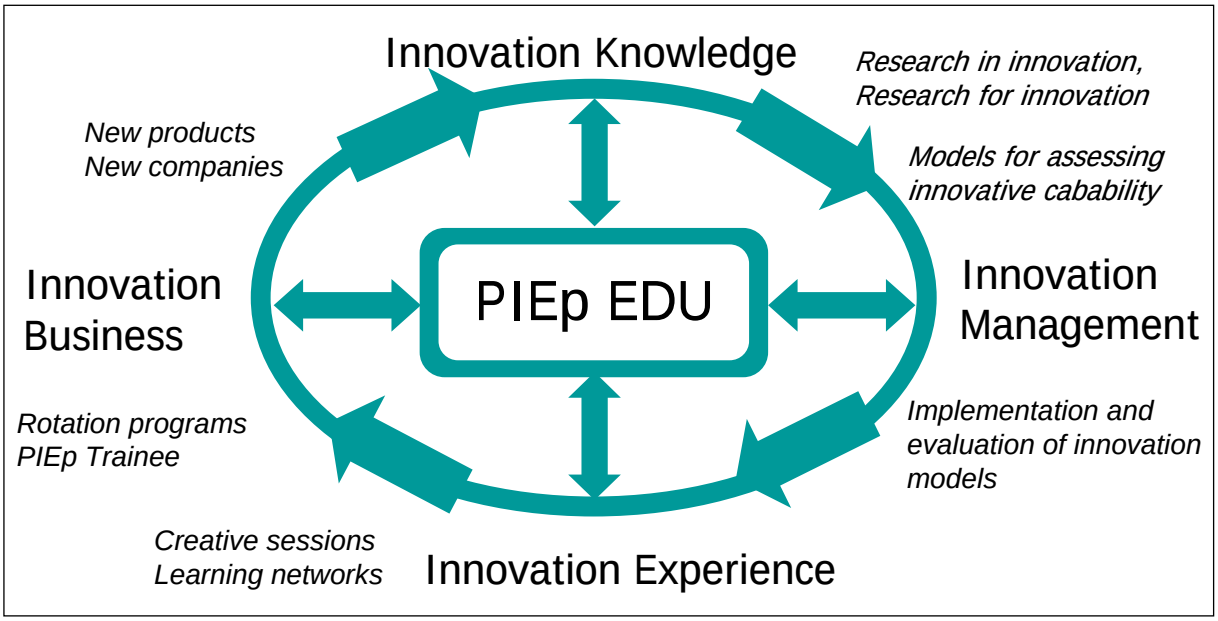

Figure 1. PIEp is illustrated with a 'learning cycle' to show how the five fields are related, with PIEp Education as the central activity – nourished from the outer five fields and providing ideas, material, students etc. to the other fields.

Innovation Knowledge constitutes the kick-start of the entire program; a massive research effort with the purpose to create a base for the rest of the program. Innovation Management involves mainly action research aimed at performing change and effect upon participating companies, and to utilize research performed in Innovation Knowledge. Innovation Experience is built on a forum where knowledge and skills in innovation are utilized for participating partners; where innovators meet and where companies find a creative ground for innovative sessions with creative people. Innovation Experience also involves rotational programs between industry and academy and international collaborative programs. Innovation Business is built on activities aimed at utilizing research results, student projects, ideas etc. into products and businesses. Further, Innovation Business feeds back into Innovation Knowledge where new knowledge is gathered based on experiences and results from all other fields.
Finally, PIEp Education is the fifth field that utilizes and feeds knowledge and skills to and from all other fields. Innovation Business, for example, utilizes student ideas and creates products and businesses from student projects. PIEp Education is nourished from the activities in Innovation Experience, Innovation Knowledge and Innovation Experience that provide information for courses in innovation. Activities in PIEp Education involves new courses in innovation, a network for doctoral students, exchange programs for students, rotational programs for faculty, better utilization of all existing mechanisms for bringing an idea to the market, and technical research education driven by

scientific and business oriented merits in symbiosis. Figure 1 shows an illustration of the 'learning cycle' of PIEp together with some keywords and key activities of the respective activity fields [9,10].

Product focus

There are many examples of good technical inventions that so far have not lead to a considerable commercial activity. In Sweden, we have seen a recent example with the communicational standard STDMA. There are also many examples where successful companies and economic growth appeared in other countries than where the invention originated.

There are always ideas, concepts, initial experiments and prototypes with the potential of becoming products that generates work, employment and growth. These ideas should result in an increased number of products or product concepts within companies, undergraduate and graduate education, leading to sustainable business and growth. PIEp should also contribute to the satisfaction of known needs by way of new products and companies, and that unknown needs are identified and fulfilled by appropriate solutions, e.g. with new products for elderly and disabled. The industry-specific strategic programs defined by government bodies that have been developed within different fields are important, and PIEp is an urgent complement that addressed cross-industrial innovative capability.

The knowledge in innovative development that will be gathered, developed and used in PIEp should be applicable in a wide range of products and markets. Innovation engineering is a generic and strategic competence. Knowledge, methods and instruments will be useable for both small and large companies, and the implementation will be adapted to the varying needs of the different companies. PIEp focuses on the development of complex, knowledge-intensive products. Within the PIEp framework, research and development will be performed both within the areas of health and medical technology, as well as within activities and businesses related to Swedish advanced technology companies, both existing and new.

PIEp is focused on innovation in the development of products and services with a physical carrier. Possible innovations could be found in technical development, in how to utilize academic research in product development, in service design and in business development. It is most necessary to address the entire product life cycle in an integrated perspective, even if the research efforts in PIEp mainly addresses the early phases in the product development process. Knowledge that is generated in PIEp will typically be applicable also in development of pure service products [11,12].

Special prerequisites for SME

For large companies, PIEp is an arena for their own development through collaborative projects. Smaller companies have a different situation, the need for competence development are harder to satisfy in the daily activities. PIEp contains several instruments to support innovative development within smaller companies. There are positive examples within programs of the Swedish Knowledge Foundation [13], for example the program teknIQ [14] which shows a 25-fold outcome on invested means, by joint idea development between companies, universities and research institutes within the area of intelligent products. PIEp creates learning networks related to product innovation in collaboration between companies and universities, offers students and researchers as catalysts for development and possibilities for employers to spend time in a different environment. Key factors are the removal of obstacles for collaboration between companies and universities as well as an offensive strategy from the universities and a focus on the need for small and medium sized companies.

The participation of Jönköping University in PIEp provides an existing network for SME, as well as the activities related to University of Lund and similar SME-projects. Another urgent task is to create continuous educational activities that aim toward product innovation ability.

Apart from existing SMEs a major goal of PIEp is to be a catalyst for the creation of new SMEs based on PIEp innovations. Those and existing SMEs should when appropriate be supported by PIEp instruments and results in their ambition to grow and become larger global actors.

Program organization

The Product Innovation Engineering Program has a matrix organization with horizontal field responsibilities and with vertical local node activities at each participating university. PIEp is organized mainly as a network of actors with common visions and goals. Overall leadership for the program is managed by a board, a director, scientific and industrial advisors and a process for

initiation, planning, selection and quality review of projects and activities. Figure 2 shows the formal organization of PIEp.
Ideas for projects and activities within PIEp can be initiated in all fields and on all levels, both ad-hoc and in planned workshops or creative sessions. Projects are not initiated through a call-process. Common for the handling of project ideas and larger proposals are that these are handled in a preparatory committee, reviewed and is subjected to alternative approaches and constellations of actors. It is central for PIEp that this preparation is made with a holistic point of view in each research field and that it is clear how the proposed project complements and are expected to collaborate with other activities in the program. Decisions to start activities prepared in this manner are made by the board.

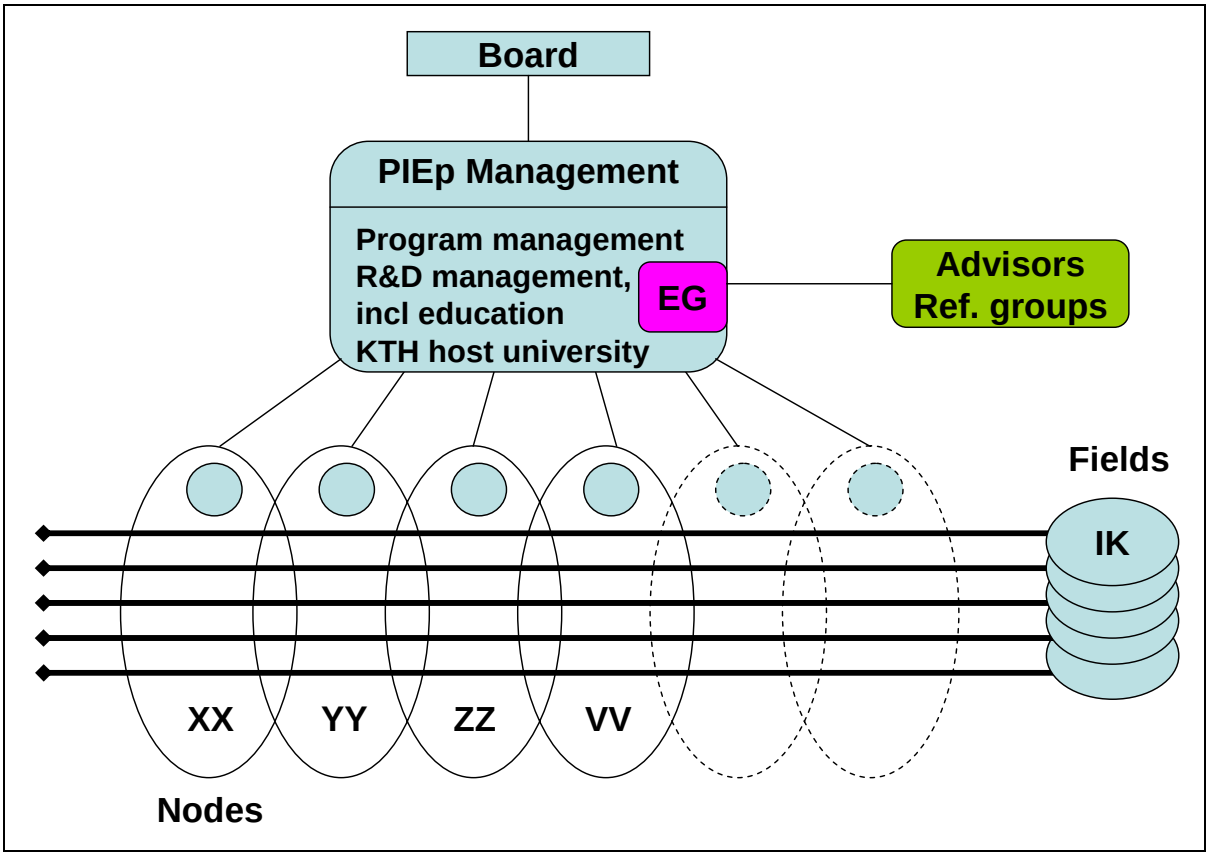

Figure 2. The PIEp organization. Currently five activity fields and five nodes exist, with the ambition to increase the number of nodes. EG means executive group.

4 RESEARCH- AND DEVELOPMENT ACTIVITIES

Innovation Knowledge, IK
The field of Innovation Knowledge aims at creating basic knowledge in innovation through cross-disciplinary research in collaboration with Swedish and international companies and organizations. The research results in knowledge in innovation processes, innovation management, about the innovator and in models of generation of improved innovation models. Areas in focus are those where the potential is strong, for example medical engineering and technology, where the entire chain of actors are represented in Sweden; from start-up companies to large companies with focus on both products and services. Relevant questions are best-practice in innovation, methods for assessing and valuing innovation capacity and models for generating innovation ability.
The research activities in Innovation Knowledge were started in late 2006 with a large state-of-the-art study of Innovation Engineering with the intention of defining and creating a base for further research in the area.

Innovation Management, IM

Innovation Management aims at creating effects on innovation capacity with participating companies and organizations. The innovation models from IK are implemented, verified and fine-tuned in industrial environments. The companies are organized in learning networks with researchers, product developers, technology specialists and process owners as actors, with the aim of creating change. The researchers are bridging theory and practice; manage reflection and analysis and exchange knowledge with IK. Methods for disseminating results are applied both within the specific methods and explicit through interchanging activities and information with other fields.

Methods to develop innovation capacity might prove to be different in small, medium-sized and large companies. The intention is to develop methods within PIEp that are directly useable in small and medium-sized companies as well as in large companies, which allows assessment of innovation capacity and its change over time.

Most research performed within Innovation Management will be coordinated with the field of Innovation Knowledge and the initial research projects are expected to start during 2007 when the state-of-the-art study of the field is concluded. These projects are intended as empirical action-based research activities with the purpose of better understanding the research field and the prerequisites for innovation engineering.

Innovation Experience, IE

Innovation Experience aims at enhancing innovation and innovative development through meetings with new constellations of people from companies, universities and research institutes in new forms for effective collaboration, learning and direct development. Innovation capacity in participating companies is strengthened through programs for exchange of experiences between industry and university, possibilities for work rotation, through structures for fruitful exchange and special functions like “creative sessions”. This also serves to enhance the possibilities of commercialization of research results. Direct examples of activities are programs for participation of researchers in industrial product development processes, to create directed activities for SME to utilize academic research and development, and to better utilize students as agents of change and the results of student work. Activities within Innovation Experience are planned to start in 2008.

Innovation Business, IB

Innovation Business aims at creating better conditions for commercialization of research results. The field will give knowledge and experiences of advantageous factors for an innovative climate; for example studies of incubators and their effects, the importance of the VC-market on scalable technology companies etc.

Within Innovation Business, researchers will be able to more easily commercialize the research performed at Swedish universities. These will be an attractive (and cost-efficient) environment for cooperation in research and product development. The universities have a unique environment for innovation bearing in mind traditions and the academic freedom that gives possibilities for engaged researchers, a fact which is shown e.g. in the report “The entrepreneurial faculty” [15].

The field Innovation Business will result in new companies based on research, innovation centers and incubators, in new products developed by students as well as employees of companies and universities.

Innovation climate is defined as requirements for, and the ability to create, nurture, develop and transform ideas to products. Product development in Swedish industry has for some time been characterized by rationalization and effectiveness, outsourcing and highly competitive economical climate. In the aftermath of making the product development process more and more effective a decrease in creativity has been seen; the more rational and effective the product development process, the more difficult it gets to create an innovative climate for new ideas.

PIEp Education

The basic idea of PIEp Education is to view students as ‘agents of change’, both in universities and in companies. Newly graduated students working in companies can be bringing a fresh mindset and the possibility to inject unconventional ideas. Students, and fresh graduates, have an advantage of not carrying a load of implicit knowledge and preconceived notions about how things are usually done. A program for ‘students as agents of change’ will attract students in the final years of their education and

organize mentorship networks, a lecture series and basically the transfer of knowledge and experience between these students and all other activities of the PIEp program. The 'agent'-program can also be seen as a network of interested students, where the network provides and establishes the roles and interests of these students, and creates a feeling of participation, membership and responsibility for the issues.
The role of PIEp Education is to create awareness in Swedish engineering educational programs about product innovation and entrepreneurship. In most engineering programs students take courses in business administration and sometimes also entrepreneurship, but in small numbers and not correlated to the other engineering courses. The purpose of the PIEp program is therefore both to integrate new courses and educational programs in product innovation engineering, but perhaps more important to find mechanisms to entice students to constantly be on the lookout for new ideas, and to be prepared to take these ideas one (or many) steps further, rather than keeping the idea as 'only an idea'. This systematic change of mindset that PIEp is striving for will be facilitated on all educational levels – from undergraduate to postgraduate [16].

A first course in innovative product- and business development

This course is presented here as a more explicit example of activities within PIEp Education. The basic idea of this course is to provide students with an attractive alternative to the traditional way of applying for a job immediately after graduation – to provide students with guidance in and toward entrepreneurship.
Students are recruited during their final year of studies, before the process of searching for a job has commenced. Typically, the students aimed for are either finishing their final courses, searching for a thesis project or currently undertaking a thesis project.
The students are recruited from areas related to product development. The students are asked to present an idea for a product or a business. This idea is put in front of a jury consisting of representatives from the university, from industrial companies, from business coaches and seed capital representatives. Students are then accepted on basis of the potential of their respective ideas, and the course is based on the process of taking the ideas into products and onto the market.
The students are required to put forward an idea that correlates to his or her specialization, and the idea is required to be built on knowledge and skill within this field. The field is also required to correlate with the fields of the faculty, meaning that the faculty must be able to provide guidance within this field. Typically, the ideas are expected to have sprung from student projects related to capstone courses, master thesis projects or student projects in general.
The course is currently aimed for students within the two specializations (M.Sc. programs) of Mechatronics and Integrated product development, specializations which are open to students mainly from the programs (B.Sc.) of Mechanical Engineering, Industrial Engineering and Management or Vehicle Engineering. The course is offered to these students as a complement to previously taken capstone courses. The course is also given by basically the same faculty, within the same context both related to the subject and the environment. Therefore, when faced with the option of taking this new course, the choice to take the course can be easier to make than choosing not to take the course, which would imply leaving the university and start searching for a job. Naturally, most students chooses the path of graduation and search for a job, but still the threshold of choosing an entrepreneurial path after graduation has suddenly been reduced to something which is mainly a question of having a good enough idea and initially leaving everything else to the course organizers.
The course, Innovative Product- and Business Development, runs over a period of one year with a student engagement of 50%. Students are encouraged to take the course either in parallel with a master thesis project, with other courses or with a regular job. The students also have the option, however discouraged from this, to study full time and finish within six months.

5 CONCLUSIONS

This article presents an attempt at taking the first steps toward a systematic change toward innovation, innovative product development and innovation engineering research in companies, universities and research institutes. The PIEp program, for Product Innovation Engineering program, is intended as a network for product innovators, innovation researchers and innovation educators.

The PIEp program will further serve as a platform for international collaboration and we are looking forward to inviting partners in product innovation in research projects, educational collaboration and reciprocal learning and exploration.
The program officially opened in late 2006 and a number of research projects and educational activities have started so far, even if the majority of activities are in the process of getting started. The funding for the program has been received from a number of sources, both governmental funding bodies and private sponsors.
Early experiences from the establishment of the program and the first projects and activities show that the timing was absolutely right and that the interest is as large as ever. The first research project is gathering many researchers in Sweden active in product innovation engineering, with the promise of future research results and publications in the area.

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