FACILITATING THE LEARNING ENVIRONMENT: INITIATIVES WITHIN THE PIEp RESEARCH SCHOOL

Vinit Parida
PhD Student, Luleå University of Technology (LTU), Sweden

Anders Berglund
Lecturer, Royal Institute of Technology (KTH), Sweden

Dennis Sturm
PhD Student, Royal Institute of Technology (KTH), Sweden

Martin Grimheden
Associate Professor, PhD, Royal Institute of Technology (KTH), Sweden

ABSTRACT

Research schools have become common phenomena in the academic world. However, we find lack of studies investigating their influence and role in the academia. This study attempts to address this gap by describing how a specific research school has evolved into an effective learning environment for the enrolled PhD students. The Product Innovation Engineering program (PIEp) is currently the largest research initiative in Product Innovation in Sweden. The PIEp research school is a part of this program, with the aim to increase innovation capabilities in the Swedish industries. Through an action-based research approach the authors, who are research school participants themselves, present the processes and the chain of events to offer knowledge transfer and to give insight into this special research environment. In this pursuit, the findings are presented in three different themes,1) the role of common interest groups, 2) common interest group activities, and c) a tiger team workshop. This paper holds major implications for other research schools and funding organizations.

KEYWORDS

Learning environment, product innovation engineering, research school, common interest group, tiger team

INTRODUCTION

Student Centred Learning Environments (SCLEs) is a generic description of different learning methods that strive for improvements (e.g. problem-based, project-based, open-ended learning environments, constructivist learning environments) [1]. Instead of forcing direct instructions, SCLEs focus on how information can more effectively be conveyed by teachers and understood by learners (i.e. students). Fundamental to these learning environments is the affordances they provide learners for effecting their environment and making meaning. To become efficient learners, it is important that the design of a learning environment pay attention to four basic issues: the role of context, the role of content, the role of facilitation, and the role of assessment [2]. This paper will try to address these four pillars as the evolving learning environment of PIEp is presented.

In the last decade, it could be seen that there is an increased focus by national and international funding organizations for promoting graduate research schools. Their popularity has grown due to an increased focus on effectively handling national and international problems. Many would also argue that the research schools' unique organizational structure and revolutionary role in promoting learning makes them an attractive consortium. However, until now there is hardly any official consensus regarding the characteristics or definition of a research school [1]. In the authors' opinion a research school can be regarded as a collaborative learning environment where researchers from different disciplines and universities work together for a common purpose. These individual researchers are the core of such a research school and the outcome from the research school largely depends on their initiatives. These individuals can be PhD students, under-graduate students or even senior researches. However, this study mainly focuses on the PhD students and how the research school promotes a learning environment.

In a short time span, Sweden has become renowned for establishing several research schools. For example, a recent program was the Engineering Design Research and Education Agenda (ENDREA) and its research school, the ENDREA graduate school (EGS). This was a part of the ProViking research program, which was financed by the Swedish Foundation for Strategic Research [3]. The EGS program was initiated with the aim of educating licentiates and doctors with certain key capabilities, which were believed to be demanded by the Swedish industry at that time [4]. Although, similar in several aspects, research schools also have differences between them; in particular, the management model, number of universities involved, funding provided to PhD students, and most importantly the goal in focus.

A recent addition to the Swedish research schools has been the Swedish national Product Innovation Engineering program (PIEp) research school, which is the largest research initiative in Product Innovation in Sweden. There were 20 PhD candidates involved in two kick-off meetings in March/April 2008. PIEp follows an unusual management model where individual researchers are enabled to self-determine their contribution and their role in the school. This program aims at promoting innovation driven research as well as the transformation of these research results into commercially viable products and services. Thus the financial investment is returned to society by new value and possibly by newly created companies. As this is the target of the program, which will be outlined in the following sections, we make an attempt to explain how after the first year of its formation, the management model and other initiatives have led to a possibility for a better learning environment for PhD students. It is important to clearly state here that, in Sweden, the higher education is partly adapted to the Bologna system of three cycles (3-2-3). In the last cycle, the PhD level, Swedish doctoral students are employed by the university and, in most cases, also conduct lecturing tasks and supervision of students.

Within the CDIO initiative, the authors have found common ground in terms of focus on functionality: a shift from analysis to synthesis, from the traditional top-down-organization of education to student responsibility. In a previous article [8] describing the overall PIEp program, the utilization of the CDIO framework in the design of PIEp is outlined. This previous article [ibid] focuses on the undergraduate activities of PIEp and the step is hereby made to include the CDIO framework in the graduate education (the research school) as well.

Thus, the purpose of this study is to describe in a narrative form how the PIEp research school has evolved into an effective learning environment for the PhD students. The reason for our focus on PIEp is driven by two rationales: first, its reputation for being the largest research initiative in Product Innovation in Sweden and, second, due to our active involvement in several PIEp activities, we have the possibility to provide detailed insights. The context of the investigation of this study is the research schools, as it is relatively rare

and new in the literature. We have struggled to find similar studies with focus on research schools as an effective learning environment for PhD students.

METHODOLOGY

The study presented is based on the events and experiences from the newly founded research school of PIEp. In an action-based research approach the authors, who are research school participants themselves, present the processes and chain of events to offer knowledge transfer and to give insight into this special research environment. Interviews with other enrolled PhD students and board members, focus group discussions and archival analysis further add to the foundation of the study.

PRODUCT INNOVATION ENGINEERING PROGRAM – PIEp

In 2006, a large scaled, long-term national program was launched to enhance product innovation engineering capabilities in Sweden. Its roots had already been planted the year before by representatives from the Royal Institute of Technology (KTH) in Stockholm, Sweden together with a number of other universities. With confirmation of government funding in 2006 [5], the program was named Product Innovation Engineering program, abbreviated PIEp [6]. Today six universities or nodes participate in the venture: Luleå University of Technology (LTU), The Design Institute, Umeå University, the Centre for Technology Medicine and Health (KTH and the Karolinska Institute), Jönköping University and Faculty of Engineering, Lund University.

PIEp's management, and the enrolled researchers, are committed to a system change towards innovation and entrepreneurship in institutes of higher education and research [7]. An organized network of senior researchers, PhD students, lecturers and students is seen as the seed for this change. In three areas of activity, namely research in product innovation, education for product innovation and industrial collaboration for product innovation [8], the development of new innovative products and/or new businesses is promoted. Therefore the program spans from theoretical to practical aspects, from research in innovation to directed activities aimed at strengthening Swedish innovative product development. PIEp's implantation embraces efforts in research, education and development projects. The first mentioned will help to understand and make use of the innovation process in a scientific environment. In educating students and PhD students, this knowledge is transferred to the next generation. Creative sessions and the building of networks promote the innovation climate towards participating industrial partners. This study focuses on research and education and will therefore only briefly return to the involvement of participating companies.

PIEp Education

PIEp's structure comprises five activity fields. Two fields focus on process and organization oriented research for innovation (innovation knowledge and innovation management). Two further fields relate to product and business oriented development (innovation experience and innovation business). The core, however, merges the fields above and focuses on education (PIEp Education). Feedback, knowledge and experiences are communicated all across and between the five fields. Figure 1 below illustrates the 'resource system' and learning environment of PIEp together with some keywords and key activities of the respective activity fields [9,10,11].

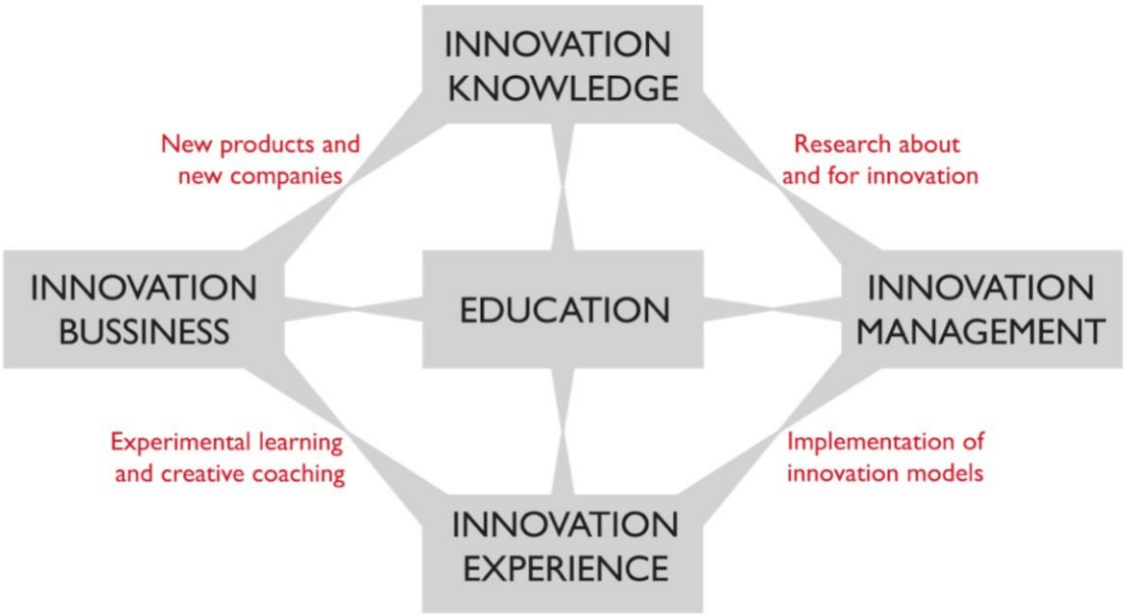

Figure 1. The Learning Environment and Resource Domains of PIEp.

The main activities involved in PIEp Education include a research school for doctoral students, a network for teaching personnel, promotion of new courses in innovation engineering, exchange programs for students, and better utilization of all existing mechanisms to aid the commercialization of new ideas. A bottom-up approach, which ensures alignment with the objectives of PIEp at an early stage, has been selected as the most promising strategy. The whole expertise in the entire PIEp network can thereby closely communicate.

The overall goal of leading and supporting a system shift of higher engineering education toward increased innovation and entrepreneurship depends highly on PIEp Education and the notion of 'students as agents of change'. The structure and all mechanisms in PIEp are primarily designed to achieve this goal.

PIEp Research School

The PIEp research school aims to educate PhD students with distinguished qualities. As a PIEp-student, you act as an ambassador equipped with a new thinking that embraces innovation experience and innovation management [12]. Creating a changed mentality is an important change mechanism as competent and growing networks ease the entry of innovative businesses. Each PhD student is responsible for making use of the activities that are posted and circulated within the research school. With individualization behind the selections made, the PIEp intention is to support and lower all forms of thresholds.

In the planning to stage a new research school program, medical technology was seen as historically important in the Swedish industry. However, without the capability to successfully convert substantially good ideas into products, most realizations have occurred outside of Sweden. Sponsored by governmental funding, one of the first objectives became to find ways of promoting new domestic ventures before losing track of the competences that drive such opportunity [13]. In March/April 2008, the first 20 PhD students were invited to two kick-off workshops at Stanford University and in Minneapolis, respectively. The first addressed engineering and business students and the latter focused on medical technology.
As a result of these two workshops, the milestone of the research school began to take form:

- A financial budget (individual virtual 'backpacks') enables the PhD students in the program to travel to other universities and to meet national and international key players.
- The formation of networks is supported that concentrate on specific problems and bundle competences to find solutions.
- Because of the aim to increase utilization of research results for new products and businesses, creating synergies between innovators, innovation researchers and coaches is named as the third fundamental.
- Finally, every PIEp PhD graduates with an additional certificate stating her/his successful participation in the program. This certificate is introduced as a proof of excellence and of successfully applied research.

Formal meetings within the PIEp PhD research school are held bi-annually; a meeting during the fall, and a workshop in spring. The first has always been held at the KTH in Stockholm whereas the latter is preferably held abroad. These meetings serve as an opportunity for PhD students to communicate, reflect, plan and network. Important decisions are usually made during those meetings when all PhD students are present and able to contribute.

Between the two annual meetings, informal meetings are arranged in Stockholm which, due to its size, is the home to a greater portion of the involved PhD students. The location varies and aims to inspire communication so that the PhD students can stay updated on each others' research. The third opportunity to meet other enrolled PhD students is provided by workshops and events arranged by the common interest groups, so-called CIGs.

Empowering the PhD students

The management model in the research school differs from the traditional graduate research school structure. The participating PhD students are given a great share of influence on the direction of the program but nonetheless they are also expected to take responsibilities for their actions and decisions. For example, the financial "backpack" serving the students in their travel ambitions has to be used carefully as it would not last for infinite journeys to conferences and meetings.

Proactive students can find great support in the research school when they can convince and motivate others towards their vision. Each student is encouraged to make a difference. Every student may influence the next upcoming goal, workshop or any other event. The openness for new ideas and innovation is reflected in the dynamics of the research school. The willingness to test prototypes is not restricted to product design. Driven by pro-activeness, the PIEp research school organization workshop (Hamburg) was the result of three dedicated PhD students. A *loose reigns* management style allowed individual PhD students to take charge of the entire scheduling and planning, which is rare in other research schools.

Common Interest Group (CIG)

During the Hamburg workshop, five areas of specific interest to the participating students were identified, which later were formalized into the formation of CIGs. Existing CIGs mainly have the intention to influence research by sharing, reflecting and producing excellent research. The CIGs at PIEp are also capable of initiating activities within PIEp and thereby create and influence decision-making within PIEp. To provide uniqueness between each CIG, formation is made with regard to the PIEp relevant research areas where dissemination to new and existing members has a catalyzing effect. The currently active CIGs are:

The Medical Technology (MedTech CIG)
This CIG comprises researchers interested in any kind of medical engineering with the purpose of offering new possibilities for cooperation, supervision, feedback and, in general, new ideas. The strong emphasis of the research school on medical engineering is reflected by the size of the group. CIG meetings are scheduled regularly to exploit the group members' various backgrounds and competences for each of the PhD thesis projects. Synergies, such as sharing and borrowing laboratory equipment, have been identified and the first study originating from this CIG's work has just been planned. Furthermore, a paper about medical engineering PhD students' views on innovation education has been submitted to an international design conference and the work will continue. Subjects like this, which are not in the PhD students' research focus, can be addressed and investigated within the CIG, where a single PhD student would neither have the time nor competence to work on such a topic beside the PhD thesis.

The Open Innovation CIG (OICIG)
This CIG mainly focuses on the researchers related to product innovation development at a company level. The CIG consists of eight PhD students and one senior researcher from an engineering and business background. The group has regular phone meetings, writes several scientific papers in collaboration, maintains an internal blog and regularly shares information. Recently, one of their initiatives was to develop a PhD course in open innovation for the PIEp research school, mainly driven by the motive to make other PIEp PhD students better understand the emerging field of innovation. To better understand open innovaitona workshop was put together with Dr. Ulrich Lichtenthaler from WHU - Otto Beisheim School of Management (Germany). As an acknowledged scholar, he is one of the leading researchers in the field of open innovation and technology management. During the workshop heprovided with a detailed review of the research field and gave feedback on PhD students' work-in-progress. These kinds of initiatives can be seen at contributing to the overall research school knowledge.

The Innovation Capability CIG (ICAP)
The focus of this group concerns internal and external factors that influence our innovative capability. The purpose is to enhance participants' interest and research areas, highlighting factors such as creativity, commitment, collaborative skills, team dynamics, user preferences, and business processes. Currently, participant focus has been to stage the prioritized dilemma of promoting creativity in class. An upcoming workshop on creativity and its applicability in education aims to share and increase the collective knowledge in the area. Also, sharing experiences have been achieved with international group members at Stanford. Ongoing plans propose the idea of using a real time interface to share and analyze team projects by peers with different perspectives. About nine people are involved in the CIG, the majority of whom are senior researchers. The common denominator with the active PhD students is an interest in team dynamics, and facilitation of education in NPD projects.

The CIG for Cognitive Aspects of Innovation (CAI)
The purpose of this CIG is to build a network of PhD students and researchers that are interested in learning more about the cognitive aspects of the innovation process. The CIG consists of six PhD students who all have an interest in a better understanding of the cognitive aspects of innovation. That is, those aspects related to how individuals and organizations learn, how people communicate with each other, create concepts and make sense of the world. To give a few example of their focus, the following questions can be used: How do power and trust between people influence the process of knowing? Is innovation an emergent process impossible to be designed and managed? How are practical solutions for supporting cognitive aspects going to be developed? The group stays in contact; especially their 'core group' that consists of three to four CAI members through mail and phone conferences.

The International Relations CIG (IRCIG)
People with extensive personal networks, and those interested in cultivating new and existing contacts, gather in this CIG. Three nationalities amongst the group members represent this intention and the amount of countries they have lived and/or worked in is much greater. The group also has a strong interest in organizing events. So far, two workshops which were organised by the IRCIG have successfully been held and further workshops and meetings are in the planning stage. For instance, an upcoming summer school is planned in relation to the annual ICED conference at Stanford. One detail which differs for the IRCIG if compared to the other CIGs is that membership acquirement requires a higher threshold of participation and active planning processes to ensure a continued high dynamics in the group.

The Management CIG
The Management CIG was the latest addition to the exiting CIGs. During several internal meetings it was felt that the level of internal communication was low and some CIGs were working in isolation. Another challenge was related to decision making: it was not possible to make quick decisions during the usual PIEp workshop, especially when all participants were present. Thus, the management CIG was established involving the CIG coordinators and the research school head. The coordinators represent their CIG's interests and also make decisions on its behalf; these decisions or pieces of information are communicated through them to their respective CIGs at a later date. During December 2008 they had the first meeting near Stockholm and several issues regarding the future were discussed. Also an internal website was launched which was maintained by the CIG coordinators.

Research School Activities

The PIEp research school mainly organizes activities for doctoral students. Most of the PhD students are employed and funded by their node university or an industrial partner. However, the research school provides a nurturing learning environment and complements the respective universities' education by providing national and international networks possibilities, though its mobility programs and funding support. For example, a PIEp doctoral student can utilize the 'backpack' funding support to participate in courses at other universities, or get involved in international/national/industrial rotation, or help the establishment of CIGs among the PIEp network of doctoral students. Activities are held at the local node universities as well as in cooperation with PIEp's international partners. Rather than focusing on explaining how the research school initiatives can be viewed as a learning environment, we will present, in a short historical overview, different activities, which have be fulfilled in the last year.

- Within the first eleven months of the research school, six medium sized (i.e. including 5 to 10 PhD students) or major sized (including 10 PhD students or more) workshops have been conducted. Organised and coordinated by the CIG for international relations, where all PIEp PhD students were invited for a three-day workshop in Hamburg, Germany. Networking opportunities with related researchers from two German universities and two Japanese universities were initiated. The major amount of the time was however spent improving internal networking and working on team building activities. The CIGs, which now form the backbone of the research school's structure, were founded during this period.
- During the fall of 2008, a Tiger Team Writing Workshop (TTWW) was held at the most northern node of PIEp, Luleå University of Technology. A so-called Tiger Team is a group of experts from multiple disciplines cooperating to solve a specific problem at the highest efficiency and effectiveness possible. The TTWW was organized to aid in research and to specifically promote conference articles for the International Conference on Engineering Design (ICED) conference at Stanford, USA, in August 2009. Follow-ups during the next 6 weeks ensured that milestones were

accomplished and that feedback by experienced senior researchers was given to the PhD students working on the various papers. The process was highly dynamic. Eventually 12 papers were intended for submission to the ICED conference, but 13 additional papers were planned and written as well (please refer to Appendix A for a matrix of the papers written). Although the official supervision ended with the deadline for paper submission to the ICED conference, the cooperation started during the TTWW and its appending period. Most cooperation continued beyond the ICED topic. The current study may be considered as a proof.

- In October 2008 the MedTech CIG held a workshop in Stockholm, at one of the PIEp nodes. Joint research activities, and the use of synergies, were discussed while visiting the local laboratories. This activity was followed by a second MedTech CIG workshop at the end of March 2009. This time the environment was the node in Jönköping to provide the possibility of viewing a different lab in order to provide a deeper insight into one another's research possibilities.
- Invited by a senior researcher within biomedical engineering, the CIG for international relations travelled to the University of Strathclyde in Glasgow, Scotland in November 2008. The foundation for collaboration was laid and will be further evaluated during 2009. Several research projects on both sides are liable to profit from a joint effort. Further meetings and discussions have also been scheduled with entrepreneurial researchers from the Hunter Entrepreneurship Centre at University of Strathclyde.
- In November 2008, a two day research school annual meeting was organized. During the first day there was a parallel session where the CIG coordinator used the opportunity to hold an internal meeting. As most of the CIG members are located in different parts of Sweden, this kind of meeting provides an excellent opportunity to meet each other. Later in the day there was joint meeting where the research school participants met with the PIEp board members. The second day was used for exchanging information about each CIG's past events, lessons learned and future plans.
- In addition, other activities scheduled for 2008 concluded with a LEGO workshop held by the CAI CIG. The group invited an external lecturer using their given budget and personal networks. This opportunity was very successful and inspiring to the participants. In March 2009, the CAI group continued with a one-day workshop on psychological aspects of innovation. In May there is an upcoming ICAP creativity event that addresses how to inhibit improved ways in working with creativity in education. As mentioned earlier, the latest workshop has been an internal meeting of the MedTech CIG which will be continued in June. One of the four further activities planned before September 2009 is the summer school which will be held in conjunction with the ICED conference at Stanford, the most prominent one.

PIEp AS A LEARNING ENVIRONMENT

PIEp was established with the aim to foster innovativeness within the Swedish society and this is supposed to be achieved by having several PhD research projects transformed into commercially viable businesses. Thus, the research school was created with the ambition of having the possibility for students from different disciplines to meet, interact and learn from each other. In many ways this was a learning environment, which worked as a support for PhD students with innovative ideas to find other students with business or other background and to try to think about possible ways in which they could sell their idea or business.

In literature 'learning environment' is often mentioned in context with several other terms that give us some ideas about the definition. These terms are interpretation, meaning making, contextualized, authentic, socially negotiated, co-constructed, collaborative, articulation and reflection, emergent, self-regulation, fluid [1]. Being a successful learner, in the case of PhD students, involves a variety of cognitive strategies and self-regulation procedures to plan and

pursue goals. The PhD students are also faced with ability, and motivation to interpret new knowledge, formulation of questions and openness for continuant reorganizing of thinking. These are fundamentals that basically are quite open to everyone that has a desire to learn. However, given the context of a unique CIG, each participant has includes his/her own research interest into the specific group. And based on individual excitement and motivation to participate the first indications have begun to emerge.
In the pursuit of explaining how the PIEp research school has evolved into an effective learning environment for the PhD students. We would like to discuss three different themes, 1) the role of common interest group, 2) CIG activities and, 3) Tiger team workshop.

The role of common interest group: The creation of CIGs was one of the cornerstones in the short history since the establishment of the research school because PhD students have since then been able to work with those students with whom they share similar interests. Further, to enhance the possibility for higher interaction and learning, CIGs have been given freedom to decide independently and to use the assigned funding to support the decisions. This means that they have been able to use their funds to interact with the other CIGs, to meet well know researches and, finally, to arrange workshops/seminars. The role of each CIG coordinator has been pivotal here as he/she has been responsible for the information flow into and out of the CIG towards the rest of the research school. Finally, some challenges which emerged due of formation of different CIGs were resolved by the function of a Management CIG. Thus, we believe that it is not an overstatement to propagate CIGs as a free environment supporting collaboration, interaction, and learning.

CIG activities: In the previous section some of the key activities conducted by the CIGs (e.g. LEGO workshop, creativity in education, etc) have been highlighted. It is important to understand the logic behind having these activities. Usually the activities are organised to eliminate some form of limitation or to satisfy curiosity within a particular CIG, but the impact of such actions have far reaching effects. When students meet during a workshop or other sessions they are given the unique opportunity to learn and reflect on new ideas and thoughts which otherwise would not be possible. There is an additional advantage: Students' perception of belonging to the research school increases and they associate themselves with the research school due to these regular events. Sometimes this has been referred to as the *"PIEp spirit"* within the research school. This shows the type of a comfortable and meaningful environment which the research school has been able to establish within its short lifetime.

Tiger team writing workshop (TTWW): The reason for choosing to elaborate on this particular workshop mainly relates to the ambition to present, in a very academically driven argument, the research school as a learning environment. The TTWW is one of the recent major group events and it should be pointed out that several PhD students had already established their formal and informal ties prior to TTWW. So when the possibility to write a paper together appeared, students could easily and quickly form different groups and start the discussion regarding possible papers. In total twenty-five paper ideas were formulized and discussed by twenty-two participants. Furthermore, each participant contributed by being the reader of other papers. Most of the papers were aimed for the well-known conference in engineering design (ICED09). From the twelve papers which were sent to the double-blind peer review process, nine were accepted. Given that most of these students had not worked together earlier nor had planned for the papers and large numbers of students have background in Medtech field writing paper for engineering conference was troublesome. However, TTWW s shows an excellent example of the nurturing environment of research school. Also when not all papers were accepted for the conference students learned a lot from the paper-writing process they also got a chance for academic recognition.

THE PIEp RESEARCH SCHOOL AND THE CDIO INITIATIVE

PIEp and CDIO share the same ultimate goal – to produce the next generation of engineers based on an increased need for a system change of traditional engineering education. Both initiatives are founded on heavy industrial support and massive engagement from academic institutes and individual educators – all eager to cross the chasm between slow-changing academia and the need for new skills required in real world engineering. By focusing on these skills, the CDIO initiative is also characterized by strong influence of student-driven courses, projects and interdisciplinarity – that all constitutes examples of a teaching and learning reform.

From a PIEp perspective, the CDIO initiative clearly shows 'how it could be done' – as a manual of how to create the reform. Further, the focus on student-driven activities in a PIEp perspective clearly promotes entrepreneurship and entrepreneurial students. By joining forces it is also clear how these two initiatives can help each other reach the ultimate goal and also how the CDIO initiative can be applied to post-graduate education, for doctoral students in a research school.

CONCLUSIONS

We believe that the PIEp research school within its short history has been able to create and maintain an effective learning environment. There are several lesson learned which can be implemented or adopted by other research schools, and also provides valuable feedback to the CDIO initiative. One of them refers to the advantage of having students taking initiatives in the operations and direction of the research school. However, we are also concerned for how this research school is set to be developing as it has only recently begun to take its form. With current global uncertainties, even academia must be prepared for changes. Plausible changes should be able to cut in on management rigidness and inflexibility, emphasizing self-directedness, motivation and commitment by students' initiatives. Finally, we would like to motivate other researches to reflect on our study and present their experiences from other research schools. There is still a lot to learn about how research schools should be organized and managed.

ACKONOWLADGEMENT

The authors would like to acknowledgement the financial support by The Product Innovation Engineering program (www.piep.se).

REFERENCES

[1] Jonassen, D. H. and Land, S. M., *Theoretical foundations of learning environments,* 2000, Lawrence Erlbaum Associates.

[2] Choi, J-I. and Hannafin, M., Situated Cognition and Learning Environments: Roles, Structure, and Implications for Design, *Educational Technology Research and Development*, 1995, 43(2), pp. 53-69.

[3] Frenning, L., and Gustafsson, G., A National Graduate Research School in Product Realization. *International conference on desing education.* University of New South Wales, Sydney. Kilby (ed.), Entrepreneurship and Economic Development, 2007, New York: Free Press, pp. 43–70.

[4] *ENDREA Graduate School, Proposed Program Plan*., June, 1997 [Online] Retrieved November 29th , 2008, from ENDREA Graduate School: http://www.endrea.sunet.se/pren5.html

[5] Vinnova [Online] Retrieved January 15th , 2009, http://www.vinnova.se/.

[6] PIEp [Online] Retrieved January 15th , 2009, http://www.piep.se/.

[7] Grimheden, M., Hanson, M., Norell Bergendahl, M. and Wikander, J. *PIEp: Product Innovation Engineering Program.* In: Proceedings of the International Conference on Engineering Design, ICED 07, Paris, France, August 2007.

[8] Grimheden, M., Norell Bergendahl, M. and Wikander, J. *Product Innovation Engineering Program: A Change Towards Innovation in Engineering Education*. In: Proceedings of the 3rd International CDIO Conference, MIT, Cambridge, USA. June 2007.
[9] VINNOVA. *The Swedish National Innovation System 1970-2003 – a quantitative international benchmarking analysis*, VINNOVA analysis VA 2004:01.
[10] Clark, B. *Creating entrepreneurial Universities: Organizational Pathways of Transformation*, 1998 (Oxford: Pergamon-Elsevier Science).
[11] Bharadwaj, S. and Menon, A. Makin Innovation Happen in Organizations: Individual Creativity Mechanisms, Organizational Creativity Mechanisms or Both? *Journal of Product Innovation Management*, 2000, 17(6), pp. 424-434.
[12] Berglund, A., Sturm, D. and Parida, V., Embracing Entrepreneurial Behavior in a Research School, Accepted to *International Conference on Engineering Design, ICED'09*, Stanford August 2009.
[13] Brodin, L.-Å., Guve, B., Kihlström, L., Norman, B., and Sundberg, C. J., *Action MedTech – Key Measures for Growing the Medical Device Industry in Sweden,* 2007, Publ. report by Centre for Technology Medicine and Health, Stockholm, Sweden.

Biographical Information

Vinit Parida is currently a PhD student at the Division of Entrepreneurship and Industrial Organization at Luleå University of Technology (LTU), Sweden. He completed his Technology Licentiate (Feb 2008) on the topic of *"Small firms capabilities for competitiveness"*. His research interest is focused on the capabilities-based view, entrepreneurial orientation, and innovation. Recently he has also started working on the topic of *higher education in engineering*. He has several scientific publication at *International Journal of Electronic Business, International Journal of Technoentrepreneurship, International Journal of Information and Communication Technology* and several peer revised conference publications.

Anders Berglund is currently finishing his PhD at the Division of Engineering Design at the Royal Institute of Technology (KTH), Stockholm, Sweden. He works as a lecturer at the Department of Integrated Product Development where his research focuses on individual innovation capabilities. He completed his Licentiate (Sep 2007) on the topic *"The Innovation Process in SMEs"*. As lecturer he is examiner and educator for degree projects in 'mechanical engineering'; 'design and product realization'; 'design and vehicle engineering' together with the role as educator in the 'advanced course in integrated product development'. In addition, he is active several research projects focusing on engineering education, and has several peer revised conference publications in the field and reviews for the *European Journal in Engineering Education (EJEE)*.

Dennis Sturm currently works as a PhD student at the Division of Medical Engineering at the Royal Institute of Technology (KTH) in Stockholm, Sweden. His research focuses on wireless sensor networks in sports to measure and monitor athletes' performance. Through his enrolment in the PIEp research school and due to entrepreneurial activities he is furthermore working with innovation and entrepreneurship in academia.

Martin Grimheden works as associate professor at the Division of Engineering Design at the Royal Institute of Technology (KTH), Stockholm, Sweden. He is coordinator of the PIEp research school and PIEp EDU chair. He has several scientific publications at *International Journal of Engineering Education, Mechatronics, and ACM SIGBED Review.* He gives several courses at the Department of Mechatronics. His research focuses on engineering education in mechatronics and product development. He finished his PhD in 2006 on the topic *"Mechatronics Engineering Education"*, and spent his post-doc at Stanford (2007).

Corresponding author
Vinit Parida (PhD Student)
Division of Entreprenuership and Industrial Organization
Luleå University of Technology
SE-97187, Luleå,
Sweden
vinit.parida@ltu.se

Appendix A

		CTMH	CTMH	CTMH	CTMH	CTMH	CTMH	KTH	KTH	KTH	KTH	KTH	MdH	MdH	HiG	HiJ	LTH	LTH	LTU	LTU	LTU	LTU	LTU
		Frida	Dennis	Carl	Nina	Rickard	Xiaogai	Ernesto	Anders	Ingrid	Diana	Martin	Stefan	Joakim	Lars	David	Per	Malin	Vinit	Pär	Christian	Peter	Andreas
1	Further Development of VIPET in Industrial Design Practice **(ICED'09)**																L						R
2	Decision Making in the Virtual Enterprise **(ICED'09)**													R					C	C	L		C
3	Open Innovation Capabilities for Small Firms **(ICED'09)**		R										C		R				L		C		
4	The Design Process in Small Companies **(ICED'09)**							R							L				R				R
5	Best Practice in NPD - A Concept Suitable for the Small Company?														L				R				
6	Open Innovation - Quite Natural for the Innovative Small Company														L				C				
7	"If we are strategic we die"		R	R	R										L							R	
8	The Innovative Idea Generation in Small Companies			R											L				R			R	
9	Selection of Innovation Ideas in Smaller Companies			R				R					R	R	L								
10	Packaging Innovation **(ICED'09?)**				R													L						R
11	Measuring the User Centered Innovation Process			L															R	R			R
12	Performance Evaluation SOTA **(PMA'09)**			R							C		L	R								R	
13	Performance Indicators as Support in Complex Product Development **(ICED'09)**										L		C						R			R	
14	Pushing the Limits of Lessons Learned								R			R	R							L	R	C	
15	Redefining Decision Making in Innovation #1							L		C				C							R		
16	Redefining Decision Making in Innovation #2 **(ICED'09)**							C		C				L						C	R		
17	Redefining Decision Making in Innovation #3							C		L				C									
18	Research Perspectives **(ICED'09)**							L				R		C									R
19	Idea Evaluation and Selection							L					R	C								R	
20	Decision Making in Disruptive Innovation							L															
21	Learning, Knowledge, Decision Making							C						C							C		
22	Learning in a Stage-Gate Process **(ICED'09)**											R	R	C						C	L		
23	CTMH - in Transition Towards Innovation Driven MedTech Research **(ICED'09)**	C	C	L	C	C	C									C							R
24	Embracing Entrepreneurial Behaviour in a Research School	R	C		R				C			R					R		C				
25	PIEp Research School - Educating Innovators	R	C				R	R				L					R		R	C		C	C

NOTE: It is up to the LEAD AUTHOR to discuss with and decide about eventual CO-AUTHORS. READERS can be added without discussion with the LEAD AUTHOR.
E-mail Andreas.C.Larsson@ltu.se if you would like to be added as a READER. Contact the LEAD AUTHOR if you would like to be a CO-AUTHOR.

L = LEAD AUTHOR	L
C = CO-AUTHOR	C
R = READER	R
TEAMS CALLED TO STATUS UPDATES	

Matrix visualizing the papers originating from the TTWW and the authors per paper