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RESEARCH ARTICLE

Engineering Students' Conceptions of Entrepreneurial Learning as Part of Their Education

Marge Täks¹, Päivi Tynjälä², Hasso Kukemelk³,

Abstract

The purpose of this study was to examine what kinds of conceptions of entrepreneurial learning engineering students expressed in an entrepreneurship course integrated in their study programme. The data were collected during an entrepreneurship course in Estonia that was organised for fourth-year engineering students, using video-recorded group interviews ($N = 48$) and individual in-depth interviews ($N = 16$). As a result of the phenomenographic analysis, four qualitatively distinctive conceptions of entrepreneurial learning were discerned. Entrepreneurial learning was seen to involve: (1) Applying entrepreneurial ideas to engineering, (2) understanding entrepreneurial issues in a new way, (3) action oriented personal development, and (4) self-realising through collective effort. These qualitatively distinct categories differed from each other in four dimensions of variation: nature of learning, response to pedagogy, relation to teamwork, and learning outcomes.

Keywords: conceptions of learning, entrepreneurial learning, phenomenography, integrative pedagogy, teamwork

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1. Introduction

Recent reports about engineering education highlight the need for enhancements in preparing future engineers to meet the challenges of the 21st century and to cope with situations that turbulent business environments bring (see Jamieson and Lohmann 2009; King 2012; European Society for Engineering Education (SEFI) 2011). Moreover, having entrepreneurial knowledge and skills as well as an entrepreneurial mindset are often seen as prerequisites to creativity and innovation and as enablers of entrepreneurial actions that are essential in order to prepare students for a successful professional life. King (2012 p. 1) expressed, 'Engineers need to master much beyond the concepts of engineering itself to advance, branch out, and be most effective during their careers'. Similarly, the SEFI report (2011) emphasises the need to 'create favourable conditions to change the attitude and mindset towards creativity, innovativeness and entrepreneurship in general and especially in European universities' (p. 15).

One of the key areas in preparing students to meet these challenges is to help them acquire entrepreneurial knowledge and skills that enable them to address complex problems that they will face in their future work life (Litzinger et al. 2011; King 2012). Rugacia and his colleagues (2000) suggest that the set of acquired skills should include at least communication and multidisciplinary teamwork skills, awareness of social and ethical considerations, and lifelong learning skills. Other reports add that entrepreneurial mindset and effectiveness are key features that allow future engineers to use those acquired skills for the common good (Obama 2009; The Oslo Agenda 2006; The Commission report 2008; The Quality Assurance Agency for Higher Education 2012). Thus, one attempt to meet the challenges of engineering education has been introducing entrepreneurship education into engineering curricula.

In Estonia, the role of higher education in developing entrepreneurial mindsets and enterprising people has been much discussed since 2009, when an official report initiated by the Ministry of Economics and Communication and the Ministry of Education and Research was introduced (Entrepreneurship studies report 2009). This report paid special attention to developing entrepreneurship education in higher education, urging universities to integrate it into curricula not only in the field of economics, but also across disciplines. Despite all of the guidance provided in this report, steps toward set goals have remained modest. This seems to be the case also in engineering and science education, where learning environments have been traditional, focusing mainly on theoretical knowledge and content rather than developing

entrepreneurial mindsets and generic skills. While traditional educational practices have involved the transmission of prescribed knowledge, entrepreneurial learning has been described as being about unplanned and unpredictable events, the creation of new and non-existing ideas, as well as about freedom instead of restrictions (Jones 2011). Pittaway and Cope (2007) add that entrepreneurial learning includes learning by coping, experimenting, problem solving and learning from one's own mistakes; and that overcoming opportunities and difficulties is crucial for entrepreneurial learning. Our understanding of entrepreneurial learning as part of an engineering education coincides with Gibb's (2008) idea of developing entrepreneurial competences among students, not necessarily expecting them to become entrepreneurs, but showing alternatives for future career options as well as preparing them for future working life. Gibb (2008 p. 106) states that learning entrepreneurship in an educational context is about:

[...] behaviours, skills and attributes applied individually and/or collectively to help individuals and organisations of all kinds to create, cope with, and enjoy change and innovation involving higher levels of uncertainty and complexity as a means of achieving personal fulfilment and organisational effectiveness. Enterprise education is the process by which these behaviours are practiced and supported.

Therefore, the aim of entrepreneurship education is not only to be the engine of economic growth through the creation of jobs and new ventures, but also to develop individuals who understand entrepreneurial processes and have entrepreneurial skills and ways of thinking. These entrepreneurial individuals within organisations are sometimes referred as 'intrapreneurs' (Antonic and Hisrich 2003).

In engineering education, entrepreneurial learning can thus be seen as a way to encourage the development of creativity and innovation together with the individuals' ability to see new opportunities, ideally with a special focus on identifying high-potential, technology-intensive commercial opportunities (Byers, Dorf, and Nelson 2010). Entrepreneurial learning is also about making adequate business judgements and making decisions based on real-life situations and problems, as well as requiring the ability to reflect on one's actions and to learn from them in order to become more efficient in future activities. Therefore, the importance of developing entrepreneurship courses for engineering students (and for all higher education students) emerges from the need to develop entrepreneurial attitudes and to introduce enterprise processes for students, as well as to offer transformative learning experiences that enable the students to develop a unique set of skills needed in the complex world of work.

Such a skill set should include, for example, ability of identifying opportunities, creative problem solving, negotiating, thinking strategically, networking, managing business situations holistically, making decisions intuitively in the face of uncertainty (Gibb 2005, 2008; Cope 2005; Pittaway and Cope 2007; Fayolle and Gailly 2008; Rae 2011), being effective on a personal level (Gibb, 2005, 2008), and becoming more resilient to failures (Sarasvathy 2001). In addition, it has been stated that learning these kinds of skills requires combining theoretical and practical knowledge, ethical values, and acquiring life-long learning skills (see Rugacia et al. 2000; Tynjälä 2008; Tynjälä and Gijbels 2012). It has been emphasised that entrepreneurial learning is experiential in nature and applies learning principles through hands-on action in rich contexts, as well as utilising interactive social learning with and from others (Pittaway and Cope 2007). According to Kyrö (2005), the teachers, who are facilitators in this kind of learning, have to provide freedom and create opportunities to enhance students' creativity, allowing the learners to decide how they learn or act. Teachers also have to provide time for reflection and evaluation, which are an essential part of the learning processes (Kolb 1984; Kyrö 2005; Pittaway and Cope 2007; Tynjälä 2008).

The purpose of the present study is to examine engineering students' conceptions of entrepreneurial learning as part of their education. Although practice-based courses have a long history in certain fields of engineering, such as software engineering (Tomayko 1998), a specific focus on entrepreneurial learning has been scarce. In the context of this study—Estonian engineering education—students are not necessarily familiar with active knowledge processing, interaction, collaboration, reflection, and other aspects of socio-constructivist, entrepreneurial pedagogy. So far, there has been an absence of research on how engineering students experience and understand this kind of new pedagogy that is different from their former learning experiences. Therefore, the present study tackles this issue. What follows is a description of the entrepreneurship course tailored for engineering students, and a brief review of earlier studies on conceptions of learning.

2. An entrepreneurship course for engineering students

Entrepreneurship education programmes are often based on the ideas of experiential learning theories (e.g. Kolb 1984) or socio-constructivist learning theories (e.g. Palincsar 1998; Tynjälä 1999), where the main goal is to create real-life learning environments where unexpected events can occur (Cope 2003; Pittaway and Cope 2007; Gibb 2008). The current

study represents ideas of the socio-constructivist view, thereby emphasising active, collaborative learning which differs considerably from the typical traditional learning environments of educational engineering programmes.

The course aimed at simulating real-life activities (entrepreneurial processes and opportunity centred learning; see Rae 2003; Lans et al. 2013) using project-based and interactive collaborative learning approaches and focusing on integrating theory and practice. For this purpose the model of *integrative pedagogy* (see Tynjälä 2008; Tynjälä and Gijbels 2012; Isömöttönen 2014) was used. In the model, the basic idea is to create learning environments and situations where the four basic elements of professional expertise— theoretical, practical, self-regulative, and sociocultural knowledge—will be integrated in problem-solving processes. With the aim to highlight entrepreneurial learning aspects, the original integrative pedagogy model was modified for the course on entrepreneurship in engineering (AUTHOR et al. 2014). Integration of the four forms of knowledge was achieved by applying different pedagogical tools and practices based on socio-constructivist principles (e.g., Palincsar 1998; Tynjälä 1999; Tynjälä et al. 2009). For example, the students were assigned real-life practical problems, and they needed to use theoretical knowledge for solving these problems and to reflect on their thinking and actions with the help of theoretical concepts. In this way, they put theoretical knowledge into practice, reflecting their practical, experiential knowledge in the light of theory. In these processes, students' previous knowledge was activated, and self-regulative knowledge as well as metacognitive skills were used. In addition, learning processes were built in a way that supported negotiations, sharing meanings, discussions and collaborative learning.

A detailed course description, including the specific activities undertaken during the course, is presented in The Journal of Engineering Education (AUTHOR et al. 2014), but the key characteristics that are based on the model and were applied in the entrepreneurship course are illustrated here in Figure 1.

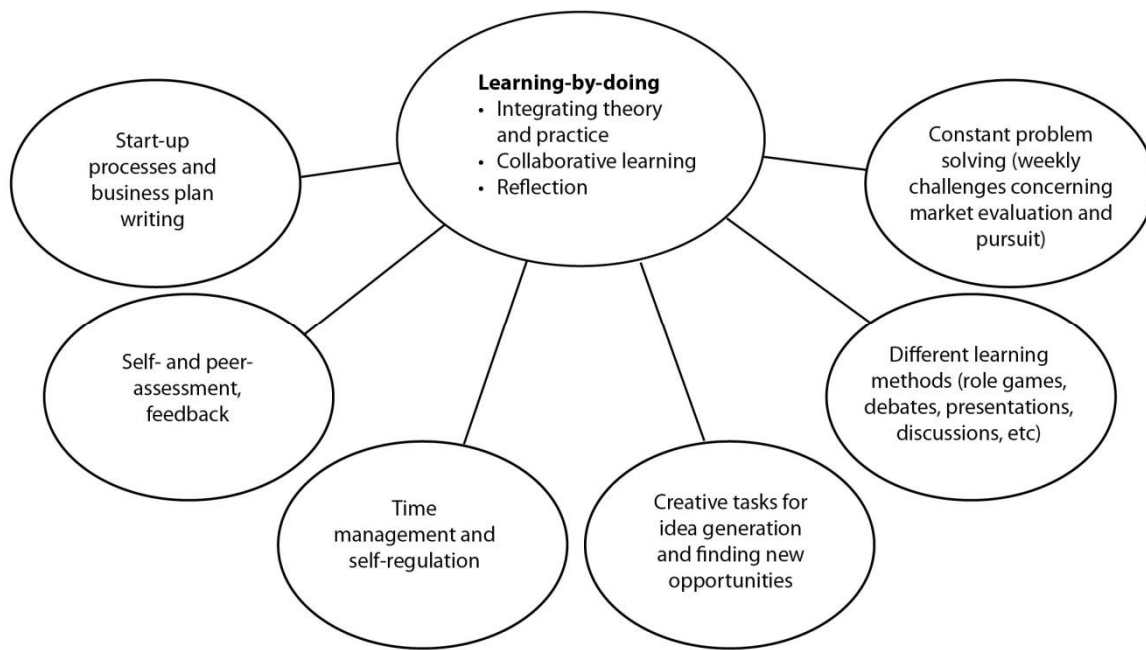


Figure 1. Key characteristics of the entrepreneurship course

Learning-by-doing was the basic principle directing the pedagogical design. In order to create a constant problem-solving learning environment, the course implemented weekly challenges, tight planning, knowledge application, analysis, evaluating accomplished tasks (e.g., market research, possible segments, forecasting, etc.), and reflecting on personal and team performances. All of these activities followed an *enterprise formation* process to give the learners the opportunity to become acquainted with entrepreneurial processes and theories, and to highlight entrepreneurship as an alternative to employment. The learning objectives were related to raising personal efficiency (e.g., better self-awareness and reflection skills), social skills (e.g., teamwork, sharing ideas, networking, etc.), enhancing creativity (e.g., the ability to turn problems into opportunities), strategic thinking, i.e., enhancing entrepreneurial mindsets, and the ability to write a business plan. Students had to learn to orientate themselves in the business environment and were introduced to what it means to be able to act ethically as a nascent entrepreneur or as a manager in a large or medium-sized company. The participants were supposed to acquire the ability to work toward set goals, striving to reach these goals despite the challenges and challenging time frames, constantly aiming to seek out new opportunities. At the end of the course, business portfolios had to be defended. For personal development purposes teamwork, communication, and other skills were monitored and assessed formatively. The assessment methods emphasised the reflective approach, and the

procedures included self-assessment, group assessment, teacher assessment, and feedback. The course was compulsory for all participants (for a more detailed description of the course, see AUTHOR et al. 2014)

3. Conceptions of learning

Conceptions of learning have been examined mainly using phenomenographic research approach, which investigates people's conceptions of different phenomena. The conceptions of learning are reflected in how learners' see learning, how they go about learning, and what they think it is' (Marton and Booth, 1997, p. 34).

The first studies on how students understood learning were conducted at the end of the seventies, when Säljö (1979a, 1979b) identified five qualitatively distinct conceptions of learning among a heterogeneous group of learners (ages 15–73 years: formal education from age 6 to 17, followed by part- or full-time higher education). Since then, students' conceptions of learning have been examined in different disciplines and contexts, such as in the arts (van Rossum and Schenk 1984; van Rossum, Deijkers, and Hamer 1985), education (Tynjälä 1997), engineering (Marshall et al. 1999), business, social sciences, humanities and sciences (Boulton-Lewis et al. 2001), health care, construction and engineering, business, law (justice studies and arts) (Boulton-Lewis et al. 2004), child care (Boulton-Lewis et al. 2008), computer programming (Thuné and Eckerdal 2009), bioscience (Virtanen and Lindblom-Ylänne 2009), international hospitality management (Otting et al. 2010), nursing, medicine and management (Yang and Tsai 2010), health education (Paakkari et al. 2011), and others.

The most cited study on conceptions of learning is the phenomenographic study by Marton, Dall'Alba and Beaty (1993), where Open University students reflected on their own learning and their progress as learners. The analysis of these reflections resulted in six conceptions of learning being defined as follows: (1) increasing one's knowledge, (2) memorising and reproducing, (3) applying, (4) understanding, (5) seeing something in a different way, and (6) changing as a person (Table 1). These results were later confirmed by van Rossum and Hamer (2006) as well as others. In addition, two distinctions were made between the first three (also referred to as traditional or quantitative types of conceptions) and the last three conceptions of learning (referred to as constructivist or qualitative types of conceptions), that is: (1) learning for reproducing, and (2) learning for seeking meaning (see Table 1). The former is seen more as memorising knowledge and as teacher-centred learning,

while the latter is related to constructive, meaning making student-centred learning (Biggs 1999; Biggs and Tang 2008; Ferla et al., 2009; Devlin 2002; Otting et al. 2010)

Table 1. Summary of Six Conceptions of Learning (Marton, Dall’Alba, and Beaty 1993)

Learning as...		
1	... increasing one’s knowledge	learning for reproducing: teacher-focused, traditional learning
2	... memorising and reproducing	
3	... applying	
4	... understanding	learning for seeking meaning: student-centred, constructivist learning
5	... seeing something in a different way	
6	... changing as a person	

As described earlier, engineering education in Estonia has followed traditional, teacher-centred pedagogy, and taking part in an entrepreneurship course involving active problem solving and reflection is an unfamiliar and new experience to students. Therefore, it is important to understand how learning entrepreneurship is experienced by engineering students. Following this line of thought and aiming to understand engineering students’ conceptions of learning as well as to reveal the aspects in conceptions of entrepreneurial learning we addressed the following research question: *What kinds of conceptions of entrepreneurial learning do engineering students express in the entrepreneurship course?*

4. Methodology

This study applied the phenomenographic approach (see Marton 1981, 1986; Marton and Booth 1997; Bowden 2000; Åkerlind 2012). Phenomenographic research is a qualitative research methodology that seeks to find out the different ways in which people understand a particular phenomenon (Marton and Booth 1997; Thuné and Eckerdal 2005; Marton and Pong 2005; Åkerlind 2012), in our case: entrepreneurial learning as part of an engineering curriculum. In other words, like qualitative research in general, phenomenography aims to explore and interpret experiences of group of people in certain context (Braun and Clarke 2013). However, phenomenography particularly emphasises the second-order perspective (Marton 1981), that is, peoples’ perspective. Therefore, the researcher’s task is to interpret and describe peoples’ relations to their experienced phenomenon as realistically as possible.

Åkerlind (2005a, 2012) has pointed out that the validity of qualitative research should be judged by the meaningfulness of its results, which in the case of phenomenography can be seen in the consistency and sense-making of learners’ experiences. The generalisability of the results in the context of phenomenographic research can be considered in terms of

transferability, that is, the extent to which findings can be applied to other contexts (Kvale 1989; Sin 2010). In our study, we assume that the results can be utilised in contexts that apply similar learning principles and aims of learning as were applied in the entrepreneurship course of the present study.

The results of our phenomenographic analysis are presented in a limited number of *categories of description*, which reflect different conceptions people have expressed in the study. The collection of categories of description is called an 'outcome space' (Åkerlind 2012; Collier-Reed and Ingerman 2013; Marton and Booth, 1997). The assumption of phenomenography is that different categories are logically related to one another by hierarchically inclusive relationships (Marton and Booth 1997; Runesson 2006; Marton and Pong 2005; Åkerlind 2012). Thus, the categories vary from less developed to more developed ways of understanding the phenomenon in question (e.g. Marton and Booth 1997; Paakkari et al. 2011; Åkerlind 2012). Categories higher in the hierarchy may include aspects from categories lower in the hierarchy, but not vice versa (Runesson 2006). The focus is on the key aspects of variation, that is, the aspects that differentiate experiences (Marton and Booth 1997; Thuné and Eckerdal 2005). The quality of the categories of description formed can be assessed by three main criteria (Marton and Booth 1997, p. 125): (1) Each category should tell something evident about a particular way of experiencing the phenomenon; (2) the categories should have a logical, frequently hierarchical relationship; and (3) they should be systematised meaningfully (involving as few categories as possible to capture the critical variation in the data). In our study, these criteria were the starting point of our analysis. This means, for example, that we intentionally aimed to produce a combination of categories which is hierarchical in nature. The aspects that distinguish the different categories are called themes or themes of expanding awareness (Paakkari et al. 2010 and 2011) or dimensions of variation (Marton and Booth, 1997). These dimensions reveal the hierarchical nature of categories. It is important to remember that the categories do not represent types of individuals but rather 'different ways of seeing the same thing' (Marton, 1995 p. 166). Thus, the categories describe collective understanding, that is, how the phenomenon in question is understood among a whole group of people.

4.1. The context, sample and data gathering

Present study was carried out in connection with the entrepreneurship course described earlier. The participants were full-time, fourth-year engineering students from three different disciplines (automotive engineering; technical design; textile and resource management), with

the average age of the participants being 24 years and 6 months. All participating students went on to acquire a higher engineering certificate with 240 credit points as a result of their four years of study, as part of which Entrepreneurship was a compulsory course of their curriculum.

The data were gathered in two parts. At the start, four semi-structured group interviews ($n = 48$) were conducted separately with each group (see Table 2) on different days, each time immediately after last teaching session of the course. The four group interviews were video recorded and each one lasted approximately 90–120 minutes. Group interviews were selected in order to achieve more efficient and less time consuming data collection method. However, after conducting the group interviews, it became evident that the information gathered was incomplete (due to the large number of students in each group—17, 17, 6, and 8). Therefore, two to three months later, additional individual in-depth interviews were conducted with selected students ($n = 16$). In order to ensure that the maximum variation among the students was discernable, both high and low achievers were invited. In line with Bowden's (1995, 2000) advice, we started the data analysis only once all of the required data had been gathered. Individual interviews were audio recorded and each one lasted approximately 40 minutes. The students' permission for both recordings was requested before the interviews.

Table 2. Overview of the Semi-Structured Group Interviews and the Individual In-Depth Interviews

The group interviews sample (N = 48, average age 24.6 years)		The individual in-depth interview sample (N = 16, average age 24.8 years)	
Automotive engineering, 2 groups, (N = 34)	Resource Management in the Field of Clothing and Textiles, 1 group Technical Design and Technology of Apparel, 1 group 2 groups, (N = 14)	Automotive engineering, (N = 10)	Resource Management in the Field of Clothing and Textiles, (N = 6)
Male = 33	Female = 14	Male = 9	Female = 6
Female = 1		Female = 1	

The interview guidelines for the data collection phases were prepared beforehand and discussed between the researchers in detail to ensure consistency and smooth flow, and appropriate depth concerning the interviews, which is necessary for phenomenographic research (Åkerlind 2012). Students were asked to explain how they felt about entrepreneurial learning as part of their engineering studies, and what they considered to be the main learning points. They were also asked to describe issues handled during the learning sessions, and to compare the course with other courses in their study program, as well as other questions. In

addition, they were asked to describe themselves as learners during the course and specify how they went about specific learning tasks. If clarifications were needed, additional questions were asked, e.g., *Could you explain that further?*, or, *Could you give an example?* The interview guide is described in more detail elsewhere (AUTHOR et al. 2014). All interviews were audio recorded, transcribed verbatim, and these transcripts were the focus of the analysis.

4.2. Data analysis

At first, the transcribed group and individual interview data were combined; thus, these two sets of data were analysed as a whole. The analysis proceeded with the first author being mainly responsible for the data analysis, consulting (almost daily) the other researcher(s) as part of the process. Thus, categories and their structural relationships were formed collaboratively by the two, sometimes three, researchers.

At the beginning of the analysis, the focus was on identifying and describing the students' ways of understanding entrepreneurial learning in general. For the analysis, the transcripts were read several times by two different researchers, separately, in order to detect similarities and differences in expressions, and later on these results were compared and discussed by these two and a third researcher to ensure their mutual understanding (see Marton and Booth 1997; Bowden 2000; Åkerlind 2012; AUTHOR et al. 2014). Similar quotations were brought together and preliminary categories of description were formed based on their differences (Marton, 1986). Simultaneous horizontal analysis allowed identifying the dimensions of variation, that is, the aspects that vary between the categories. The categories and dimensions of variation were rearranged until they formed the final categories and dimensions (Marton and Booth 1997; Åkerlind 2012; AUTHOR et al. 2014). As described earlier, the assumption of the hierarchical nature of the categories was one leading principle in the analysis. The process of analysing data was iterative and comparative, involving continuous sorting and resorting of the data (Åkerlind, 2012) and lasting approximately six months overall (see Marton & Booth, 1997; Bowden, 1995 & 2000; AUTHOR et al., 2014). The purpose was to ensure the trustworthiness of the findings (Paakkari et al. 2011; AUTHOR et al. 2014).

5. Results

The outcome of the study is presented in Table 3. As a result of the data analysis, the students' conceptions on entrepreneurial learning were grouped into four categories, where learning entrepreneurship was seen as: (1) Applying entrepreneurial ideas to engineering, (2) understanding entrepreneurial issues in a new way, (3) action oriented personal development, (4) self-realising through collective effort.

Four dimensions of variation, that is, themes that differentiated between the categories, were identified: *nature of learning*, *response to pedagogy*, *relation to teamwork*, and *experienced outcomes* (Table 3). The dimensions of variation are shown in italics in the following descriptions of the categories.

Table 3. Engineering Students' Conceptions of Entrepreneurial Learning as Part of Their Education

	Titles of categories			
Dimensions of variation	1 – Applying entrepreneurial ideas to engineering	2 – Understanding entrepreneurial issues in a new way	3 – Action oriented personal development	4 – Self-realising through collective effort
Nature of learning	Reproductive	Transformative	Developmental	Socio-visionary
Response to pedagogy	Confusion	Adjustment	Enthusiasm	Enthusiasm
Relation to teamwork	Unequal contribution	Division of work	Sense of being a team	Leading the team
Experienced outcomes	Relating entrepreneurial and engineering issues	Understanding entrepreneurial issues in a new way	Self-confidence and future orientation	Self-realising and social responsibility

5.1. Category 1: Applying entrepreneurial ideas to engineering

In the first category, the *nature of learning* was reproductive: accomplishing the course and applying entrepreneurial ideas to engineering were considered to be the essential goals of the entrepreneurial learning course. The acquisition and application of knowledge were seen as a united process. Nevertheless, accomplishing the compulsory course was the dominating goal.

We certainly acquired such general factual knowledge and we had to apply it, accomplishing all kinds of tasks and calculations. (Male, individual interview—simply referred to as 'interview' from here on)

[...] I had to strain myself, as I needed to finish the course! (Female, interview)

Since the students were familiar with traditional teacher-centred learning, the *response to pedagogy*, i.e. new way of doing things that was not teacher-led, was experienced as confusing and challenging, especially at the beginning of the course:

Experiencing this new kind of team learning during your last year of studies makes it difficult for many people to adjust to this new situation. (Male, interview)

We are used to being told what to do and for information to be handed out by the teacher, but not to have to figure it out by ourselves. (Male, interview)

This course was very different from the course that we had experienced before [...] in terms of teaching methods and how I had to learn (Female, interview)

As described earlier, collaborative teamwork played a crucial role in the entrepreneurship course. Therefore, it was not a surprise that students' *relation to teamwork* appeared as one dimension of variation. In this category, it was recognised that the students themselves and/or their classmates contributed less to the teamwork than was expected by the teammates. Thus, unequal contribution to teamwork was expressed:

We had people who made an effort and those who didn't, so the team efforts were rather unequal; I think this could be seen in the results. (Male, interview)

Teamwork [...], it's impossible to do this amount of work together with just 1 or 2 other people [...]. Everybody had to do something [...]; if someone did not want to, they were pushed until they did. (Male, interview)

Experienced learning outcomes in the first category were described in terms of relating entrepreneurial and engineering issues to each other.

This course helped me to connect it [entrepreneurship] to the knowledge that I had gained in other subjects concerning logistics, material technology, and other areas [...]; this course helped to tie it all together somehow. (Female, interview)

5.2. Category 2: Understanding entrepreneurial issues in a new way

The main feature that separated this category from the previous one was that the *nature of learning* rose from the reproductive level of accomplishing the course and applying knowledge to the transformative level. Thus, it involved gaining new meaning and a new kind of personal understanding of entrepreneurial issues.

It changed the way I think. (Male, interview)

All issues related to entrepreneurship are more complex than one would think at first [...]; it's not only about the knowledge, it's about the people as well. (Female, interview)

In this category *the response to new pedagogy* shifted from the confusion about not getting right answers from teacher and new ways of doing things to adjustment of new pedagogy. Here the main concern was to adopt a new a learning rhythm (i.e. to do weekly tasks instead of a test at the end of the course) and accomplishing challenging tasks in time. Tight time frames helped to overcome these challenges.

Weekly tasks kept us going, since we had to present results on weekly basis [...] and when missed something or someone was missing from the teamwork then workload accumulated promptly. (Male, group interview)

In this category, the students' *relation to teamwork* was characterised by an emphasis on the division of work:

We spent quite a great amount of time on this project, all of us. We divided the tasks, and everyone had to do their part; so, everybody gave input and we spent a lot of time working on it.
(Female, interview)

Compared to the previous category, here the *experienced learning outcomes* extended from relating entrepreneurial and engineering knowledge to overcoming challenges and changes in thinking.

When you are able to do it, it changes your thinking; it makes it more fascinating and motivates you to learn more about these issues. (Female, interview)

5.3. Category 3: Action oriented personal development

In this category, the *nature of learning* was seen to be developmental. The willingness to develop as an individual as a result of acquired knowledge, skills, self-confidence, and conscious reflection was dominant. The desire to take actions and change as a person was in focus of learning in this category. All challenges were considered to be an opportunity to learn, or as a rehearsal for one's future work life or becoming an entrepreneur, and this was a significant difference compared to the previous category.

I always had ideas [about entrepreneurship], but never thought that I had it in me—now I know I can do it [...]. I am more confident and braver [...], and I want to continue learning so that I am ready to really go for it! (Female, interview)

In this category *relation to pedagogy* changed from the adjustment (cat.2) to enthusiasm. Even though weekly tasks were considered challenging, learning by doing was understood as interesting and motivating way to learn.

Pedagogically extremely correct, meaning that once a person has done something with her own hands, experienced the process, it helps to arrive to different level of understanding [...] (Female, interview)

[...] This course was more challenging but also more interesting—once you got on top of things—it was really motivating [...]. (Male, interview)

I think that I am a studious learner and I liked it in here. (Female, interview)

Strong commitment within the group also distinguished this category from the previous ones. Students' *relation to teamwork* was characterised by active participation, personal

contribution, and the sense of being part of a team. Learning was collaborative—through discussions, cooperation, good atmosphere, compromises, mutually agreed role divisions, and efficient time management.

It was very beneficial to work as a group with different people, to find mutual time to meet and to divide tasks. Eventually, everyone had to sacrifice something to achieve good results. Doing it all alone [...], I think I would have missed something in terms of human relations. Definitely, it would not have been the same. (Female, interview)

The most important things were our team meetings, communication and ideas [...], to be able to make the right rules and other stuff, to be able to actually implement our ideas and do it together as a team! (Female, interview)

As for the experienced *learning outcomes*, new knowledge, skills and changes in thinking were recognised, as in the previous categories. In addition, in this category, strengthened self-confidence and future orientation were emphasised. Personal strengths were discovered, new personal development goals were set, and self-employment grew to be seen as an alternative worth considering and bringing along new perspectives for the future:

The idea of establishing my own company some day seemed so frightening before, but through this experience I gained the confidence and conviction that I will learn more and can establish my own company one day. (Female, interview)

It became much clearer—how to start up a business—and now starting my own one seems so reachable. (Female, interview)

I actually got more interested in entrepreneurship and still am [...] and I want to continue discovering about this topic after the course [...] and one day, to start-up my own company. (Female, interview)

5.4. Category 4: Self-realising through collective effort

The *nature of learning* in this category can be described as socio-visionary. In other words, mutual, collective effort and having a shared goal were considered to be a prerequisite for successful course achievement.

This was the one and only type of teamwork that developed mutual thinking; thinking about the team—to consider the others. (Male, interview)

We had to make a lot of compromises and needed to cooperate in order to achieve a mutual understanding and goals within the group [...], and somebody had to make sure that we share the same vision. (Male, interview)

As a leader you have to be able to commit yourself even if it is challenging and for me all these themes we went through during the course were important. (Male, interview)

There were no differences in the dimension of *response to pedagogy* between the categories 3 and 4. In both categories pedagogy was considered as motivating as enriching and was welcomed with enthusiasm.

We had lots of tasks that challenged us to do things and think differently; solve problems more creatively and this was really good [...] If I contrast this course for example to the economics course where we were presented only very specific certain types examples based on some type of legal entities then here it was more like – ok you have a great idea, go for it, try it out, learn while you are doing it, and so on [...] so we really ~~experienced~~ the whole process and learned throughout this project [...] This was enriching experience. (Male, interview)

In this category, the aim of personal development and experiencing the sense of being a team (cat. 3) was transformed onto developing personal leadership skills. Consequently, personal performance was perceived as if through the lens of a team leader who is a spokesperson for a group and an intermediary between the teacher and the group when needed. Thus, the *relation to teamwork* was that of leading it.

It was really labour-intense and mostly, I think, focused on teamwork [...] meaning how to deal with people efficiently to get things done, and on cooperation of different people, and on management and leadership issues of the team. (Male, group interview)

Acquiring a deeper understanding of teamwork and entrepreneurial issues, as well as gaining social responsibility through team leadership, self-realising and developing one's leadership skills and seeing future alternatives were considered to be the most important learning *outcomes* of the course:

[...] the most I learned from being a group leader, being an engine for the group. I learned to delegate and to keep the 'finger on the pulse' so that everything would be finalised in time [...]. And the results had to be good, not just 'mission accomplished'. (Male, interview)

I learned how to manage the team, to be a leader. I had to find different methods and use techniques to motivate the team members to work for our vision. (Male, interview)

We acquired many skills, relating to start-up processes and investments and so on [...]. But what was most important for me, personally, was that these were about structural and leadership issues inside a company [...]: how to lead and divide tasks and delegate, and so on. I learned a lot from that [...]; and how to control and meet deadlines and ensure good performances by the team. I learned a lot about teamwork and leadership. (Male, interview)

6. Discussion and conclusions

In the present study, we examined engineering students' conceptions of entrepreneurial learning as part of their study programme. The findings of this study were derived from the group and individual interviews that were analysed using a phenomenographic approach. The students' conceptions of entrepreneurial learning were summarised into four qualitatively distinct categories involving: (1) applying entrepreneurial ideas to engineering, (2) understanding entrepreneurial issues in a new way, (3) action oriented personal development, and (4) self-realising through collective effort. These qualitatively distinct categories differed from each other in four dimensions of variation: nature of learning, response to pedagogy, relation to teamwork, and experienced outcomes. In the following we first discuss pedagogical implications of these results and then examine broader significance of the findings from the perspective of research on conceptions of learning.

6.1. Pedagogical implications

Two of the identified dimensions of variation, namely *response to pedagogy* and *relation to teamwork* can be seen as critical from a pedagogical point of view. In other words, these dimensions reveal what has to be taken into account when aiming to promote students' proceeding from conception representing lower level of understanding to the one of deeper level of understanding (higher hierarchically).

Response to pedagogy. The findings illustrate significant differences in students' response to socio-constructivist activating pedagogy, varying from confusion (cat. 1) to adjustment (cat. 2) and further to enthusiasm (cat. 3 and 4). In order to avoid confusion at the beginning of the course, it is important to take time to raise students' awareness about the processes that will be tackled during the course (e.g. introduce learning methods). One way to approach this situation is to explain the new learning context in the light of the opportunities for personal development, preparation for work life and other advantages. Since activated learning may lead to emotional overload, main sources of emotions should also be discussed (see Arpiainen et al. 2013). Other aspects that need to be discussed and that contribute to the understanding of the pedagogy applied are the assessment criteria and its sequence. For example why feedback, peer-review and reflection are needed, or how individual grades are constructed in team-based learning projects, etc.

Moving from mere adjustment to a new pedagogy toward being enthusiastic about it may involve personal and motivational factors that may be challenging. Nevertheless, we believe that creating links between theory and practice, something that is emphasised in the

integrative pedagogy model (Tynjälä 2008; Tynjälä and Gijbels 2012; Author et al. 2014), usually motivates students.

Relation to teamwork. The findings also show variation in how the students understood working in teams. Teamwork can be improved by introducing and reflecting on principles of group dynamics, applying these principles into action and relating all this to real-life issues. This could be achieved by using learning diaries and allowing self-developed team rules and roles, and other ways. Michaelson et al. (2004) suggest that the majority of class time during team-based learning should be spent on such teamwork that supports immediate feedback for the team achievement. For less experienced students more structured approach of team based learning could be applied (see e.g. Michaelson et al. 2004). However, it should be remembered that entrepreneurial learning is also about unplanned events, freedom and creativity; so, a structured approach should be applied, keeping this notion in mind. Pittaway and Cope (2007) argue that through generative learning and reflection, individuals will not only be able to learn from experiences as team members but they will also be able to bring this learning to new situations.

Applying socio-constructivist pedagogy and team learning principles that support entrepreneurial learning also has an effect on teachers' practices. Teachers have to shift from the role of being a transmitter of knowledge to being a facilitator of learning, and this transition can be as confusing for the teacher as for students. However, this approach provides great opportunities for having fun with students' while learning together (Michaelson et al. 2004). As mentioned before, the facilitator of entrepreneurial learning has to provide freedom and create opportunities to enhance students' creativity, leaving them space to decide how to learn or act (Kyrö 2005). Teachers also have to provide time for reflection and evaluation, which are an essential part of the learning process (Kolb 1984; Kyrö 2005; Pittaway and Cope 2007; Tynjälä 2008).

In sum, in order to help students gain as much as possible from entrepreneurial learning it is important to make more explicit the reasons for pedagogical practices and to support teamwork. Thus, a well-planned instructional strategy, applying appropriate pedagogical tools, introducing team theories, and regularly engaging in challenges and reflection are all important to increase students' awareness and support their deep level of learning.

6.2. Expansion of conceptions of learning

The findings of our study indicate that entrepreneurial learning in engineering studies can be understood in a variety of ways. While for some it means applying entrepreneurial ideas to engineering or a source for new perspectives, others see it as an opportunity for personal development or as a way toward self-realisation through collective effort. These different conceptions of entrepreneurial learning are similar to the differences in conceptions of learning identified in many other, earlier studies (e.g., Säljö 1979a, 1979b, 1981; Marshall et al. 1999; Marton and Säljö 1979; van Rossum and Schenk 1984; van Rossum, Deijkers, and Hamer 1985; Marton, Dall’Alba, and Beaty 1993; Marton and Booth 1997; Tynjälä 1997; Boulton-Lewis et al. 2001, 2004, 2008; Thuné and Eckerdal 2009; Virtanen and Lindblom-Ylänne 2009; Otting et al. 2010; Yang and Tsai 2010; Paakkari et al. 2011, etc.). It is important to keep in mind that most of previous studies have investigated students’ conceptions of learning *per se*, whereas the present study focused on conceptions of *entrepreneurial learning* in the context of engineering education in particular. Of course, all learning takes place in a certain context, and therefore all conceptions of learning can be seen as context-bound, but this contextual nature of learning conceptions is seldom discussed. In our study, the contextual features become clearer when we compare the results of the present study to those of some of the previous studies. Accordingly, Table 4 shows the comparison of three phenomenographic studies on conceptions of learning over the past 20 years.

As Table 4 shows, *Increasing one’s knowledge*, the first conception in the study by Marton and colleagues (1993), is no longer indicated as such in the study by Paakkari et al. (2011) or in the present study. In our study, the first conception coincides with Marton et al.’s (1993) third conception and Paakkari et al.’s (2011) second conception. At the same time, Marton et al.’s (1993) sixth conception, *Changing as a person*, coincides with Paakkari et al.’s (2011) fifth conception and the present study’s third conception. Both Paakkari et al. (2011) and the present study highlight a shift toward the collective aspect of learning in their last conception, which is an aspect that was not mentioned at all in Marton et al.’s (1993) study.

Table 4. Comparison of the Conceptions of Learning Presented in Three Studies

Present study AUTHOR et al. (201..)						
Applying entre- preneurial ideas to engineering		Understanding entrepreneurial issues in a new way		Action oriented personal development	Self-realising through collective effort	
Paakkari et al. (2011)						
Reproduction of acquired health knowledge	Application of health knowledge	Developing personal meanings on health matters	Transformation of individual thinking	Personal growth	Collective meaning making	
Marton et al. (1993)						
Increasing one's knowledge	Memorizing and reproducing	Applying	Understanding	Seeing something in a different way	Changing as a person	-

It should be noted that the content and discussed contexts of the three studies differ from each other. Marton et al.'s (1993) study identified the Open University social sciences students' conceptions of learning; Paakkari et al. (2011) explored health education student teachers' conceptions of learning in health education; and the present study identifies engineering students' conceptions of entrepreneurial learning. However, in all contexts, the students were university students, who therefore all had some years of experience in higher education learning environments. What has happened during the 20 years between the studies can be seen to represent a paradigm shift, with transition from behaviouristic toward socio-constructivist and socio-cultural approaches in learning research. This shift in teaching practices is also reflected in the transitioning from the traditional practice of mere teacher-directed knowledge transmission toward student-centred, activated and collaborative pedagogy (this, at least, was the case regarding the courses that were under investigation by Paakkari et al. (2011) and the present study). The comparison of the three studies suggests that this shift may also be reflected in the students' conceptions of learning. A significant shift in conceptions of learning was the discernment of the collective aspect of learning that can be seen both in Paakkari's et al.'s study (2011) and in the present study. Thus, the sophisticated ideas of learning involving not only individual but also collective aspects seemed to follow experiences gained in new kinds of collaborative pedagogy. Learning as a collective effort rather than merely an individual activity also seems to be a motivating concept among university students. However, we need to keep in mind that many contextual factors may explain the differences in the findings between our study and the previous studies.

For example, in our study all of the participants were fourth-year students and thus maybe more mature in how they related to studying.

In conclusion, our findings suggest three implications: (1) considerable variation in students' conceptions of learning can be expected between the students when a new kind of learning environment is introduced; (2) pedagogically critical aspects in the transition from a traditional to a socio-constructivist learning environment include dealing with the challenges of new type of pedagogy and supporting functioning teamwork practices; (3) students' conceptions of learning may change over the course of time when learning environments and pedagogical approaches change. We hope that the results of this study contribute to further discussions about the possible shifts in learning conceptions and invite further research on students' conceptions of learning across different settings of higher education. In particular, studies focusing on possible differences in students' learning conceptions in different learning environments (such as traditional versus problem-based versus work-based) would be welcome.

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References

- Åkerlind, G. S. (2005). Variation and commonality in phenomenographic research methods, *Higher Education Research and Development*, 24 (4): 321–334.
doi:10.1080/07294360.2011.642845
- Åkerlind, G. 2012. "Variation and commonality in phenomenographic research methods." *Higher Education Research & Development* 31 (1): 115-127.
doi:10.1080/07294360.2011.642845
- Antonic, B., and Hisrich, R. D. 2003. "Clarifying the intrapreneurship concept." *Journal of Small Business and Enterprise Development* 10 (1): 7–24. doi: 10.1108/14626000310461187
- Arpiainen, R.-L., Lackéus, M., Täks, M., & Tynjälä, P. 2013. "The Sources and dynamics of emotions in entrepreneurship education." *Trames: Journal of the Humanities and Social Sciences* 17 (4): 383–399. doi: 10.3176/tr.2013.4.02

- Biggs, John. 1999. "What the Student Does: Teaching for Enhanced Learning." *Higher Education Research and Development* 18 (1): 57–75. doi:10.1080/0729436990180105
- Biggs, J., and Tang, C. 2008. *Teaching for Quality Learning at University*, University of Tartu Press, Estonia
- Boulton-Lewis, G.M., Brownlee, J., Berthelsen, D., and Dunbar, S. 2008. "Child care students' practical conceptions of learning." *Studies in Continuing Education* 30 (2): 119-128. doi:10.1080/01580370802097710
- Boulton-Lewis, G. M., Marton, F., Lewis, D. C., and Wilss, L. A. 2004. "A Longitudinal study of learning for a group of indigenous Australian university students: Dissonant conceptions and strategies." *Higher Education* 47 (1): 91-112. Stable URL: <http://www.jstor.org/stable/4151558>
- Boulton-Lewis, G. M., Wilss, L., and Lewis, D. C. 2001. "Changes in conceptions of learning for Indigenous Australian university students." *British Journal of Educational Psychology* 71 (2): 327-341. doi: 10.1348/000709901158550
- Bowden, J. 2000. "Phenomenography." In Bowden, John and Walsh, Eleanor Eds. Qualitative research series. *The nature of phenomenographic research* pp.1-19. RMIT University Press, Melbourne.
- Braun, V., and Clarke, V. (2013). *Successful qualitative research: A practical guide for beginners*. Sage Publication Ltd., London.
- Byers, T. H., Dorf, R. C., and Nelson, A. J. 2011. *Technology ventures: From Idea to Enterprise*, 3rd Edition: McRaw-Hill Companies, Inc.
- Collier-Reed, B., and Ingreman, Å. (2013). Phenomenography: from critical aspects to knowledge claim, in *Theory and method in Higher Education Research Vol.9*, Jeroen Huisman and Malcolm Tight Eds. Emerald Group Publishing Limited, UK, 243–260.
- The Commission, 2008. "The Best Procedure Project: Entrepreneurship in Higher Education, Especially in Non-Business Studies." Final Report of the Expert Group http://ec.europa.eu/enterprise/policies/sme/promoting-entrepreneurship/education-training-entrepreneurship/higher-education/index_en.htm, accessed 24.04.2013
- Cope, J. 2003. "Entrepreneurial Learning and Critical Reflection." *Management Learning* 34 (4): 429-450. doi:10.1177/1350507603039067

- Cope, J. 2005. "Toward a dynamic learning perspective of entrepreneurship." *Entrepreneurship Theory and Practice* 29(4): 373-397. doi: 10.1111/j.1540-6520.2005.00090.x
- Devlin, M. 2002. "An improved questionnaire for gathering student perceptions of teaching and learning." *Higher Education Research and Development* 21 (3): 289-304. DOI:10.1080/0729436022000020788
- Entrepreneurship studies in Estonian higher education. (2009). Report and action plan 2010-2013 is compiled by entrepreneurial experts, and ordered by Estonian Ministry of Communication and Economic Affairs.
- European Society for Engineering Education (SEFI) (2011). SEFI and the engineering Education in 2011. Published by SEFI, Brussels, Spring 2012. URL: <http://www.sefi.be/wp-content/uploads/SEFI%20Annual%20Report%202012%202013%20Copy.pdf>
- Fayolle, A. and Gailly, B. 2008. "From craft to science: Teaching models and learning processes in entrepreneurship education." *Journal of European Industry Training* 32 (7): 569-593. doi: 10.1108/03090590810899838
- Ferla, J., Valcke, M., and Schuyten, G. 2009. "Student model of learning and their impact on study strategies." *Studies in Higher Education* 34 (2): 185-202. doi:10.1080/03075070802528288
- Gibb, A. 2008. "Entrepreneurship and enterprise education in schools and colleges: Insights from UK practice." *International Journal of Entrepreneurship Education* 6: 101-144.
- Gibb, A. 2005. The future of entrepreneurship education – Determining the basis for coherent policy and practice? *The Dynamics of Learning Entrepreneurship in a Cross-Cultural University Context*. Kyrö Paula and Carrier, Camille Eds. pp. 44-68.
- Isomöttönen, V. (2014). Making group processes explicit to student: A case of justice. *ITiCSE '14 Proceedings of the 2014 conference on Innovation & technology in computer science education*. 195-200. doi:10.1145/2591708.2591717
- Jamieson, L. H., and Lohmann, J. R. 2009. *Creating a culture for scholarly and systematic innovation in engineering education*. Washington, DC: American Society for Engineering Education. Retrieved from <http://www.asee.org/about-us/the-organization/advisory-committees/CCSSIE> accessed 13.11.2012

- Jones, C. 2011. *Teaching Entrepreneurship to Undergraduates*. Edward Elgar Publishing Limited: Cheltenham, UK: Northampton, MA, USA
- King, C. J. 2012. "Restructuring Engineering Education: Why? How And When?" *Journal of Engineering Education* 101 (1): 1-5. DOI: 10.1002/j.2168-9830.2012.tb00038.x
- Kolb, David, A. 1984. *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs: NJ, Prentice Hall
- Kvale, S. 1989. To validate is to question. In S. Kvale (Ed.), *Issues of validity in qualitative research* (pp. 73–92). Lund: Studentlitteratur.
- Kyrö, P. 2005. Entrepreneurial learning in a Cross-Cultural Context Challenges Previous Learning Paradigms? *The Dynamics of Learning Entrepreneurship in a Cross-Cultural University Context*, Kyrö, Paula and Carrier, Camille Eds. University of Tampere Research Centre for Vocational and Professional Education, 68-102.
- Lans, T., Oganisjana, K., Täks, M., and Popov, V. 2013. "Learning for entrepreneurship in heterogeneous groups: experiences from an international, interdisciplinary higher education student program." *Trames: Journal of the Humanities and Social Sciences* 17 (4): 331-346. doi: 10.3176/tr.2013.4.05
- Litzinger, T. A., Lattuca, L. R., Hadgraft, R. G., and Newstetter, W. C. 2011. "Engineering Education and the Development of Expertise." *Journal of Engineering Education* 100 (1): 123-150. doi: 10.1002/j.2168-9830.2011.tb00006.x
- Marshall, D., Summers, M., and Woolnough, B. (1999). Students' conceptions of learning in an engineering context. *Higher Education*, 38 (3): 291-309.
- Marton, F. 1981. "Phenomenography: Describing conceptions of the world around us." *Instructional Science* 10: 177–200. ISSN: 1573-1952 (Online)
- Marton, F. 1986. "Phenomenography: A research approach to investigating different Understandings of reality." *Journal of Thought* 21: 28–49.
- Marton, F. 1995. "Cognosco ergo sum: Reflections on reflections." *Nordisk Pedagogik* 15 (3): 165-180.
- Marton, F., and Booth, S. 1997. *Learning and Awareness*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

- Marton, F., Dall’Alba, G., and Beaty, E. (1993). “Conceptions in learning.” *International Journal of Educational Research* 19: 277-300.
- Marton, F., and Pong, Y. W. 2005. “On the unit of description in phenomenography.” *Higher Education Research and Development* 24 (4): 335-348.
doi:10.1080/07294360500284706
- Marton, F. and Säljö, R. 1979. *Learning in the Learner’s perspective. III. Level of Difficulty Seen as a Relationship Between the Reader and the Text*. Reports from the Institute of Education, University of Göteborg, No. 78.
- Michaelson, L. K., Knight, A. B., and Dee Fink, L. 2004. *Team-Based Learning: A Transformative Use of Small Groups in College Training*. Stylus Publishing, LLC, USA.
- Obama, B. 2009. ‘*Educate to Innovate*’ Campaign for Excellence in Science, Technology, Engineering & Math (Stem) Education. The White House Office of the Press Secretary.
- Otting, H., Zwaal, W., Tempelaar, D. and Gijsselaers, W. 2010. “The structural relationship between students’ epistemological beliefs and conceptions of teaching and learning.” *Studies in Higher Education* 35 (7): 741-760. doi:10.1080/03075070903383203
- Paakkari, L., Tynjälä, P., and Kannas, L. 2011. “Critical aspects of student teachers’ conceptions of learning.” *Learning and Instruction* 21 (6): 705-714.
<http://dx.doi.org/10.1016/j.learninstruc.2011.03.003>
- Paakkari, L., Tynjälä, P., & Kannas, L. 2010. Student teachers’ ways of experiencing the objective of health education as a school subject: A phenomenographic study. *Teaching and Teacher Education* 26: 941–948.
<http://dx.doi.org/10.1016/j.tate.2009.10.035>
- Palincsar, S. A. (1998). “Social Constructivist Perspectives on Teaching and Learning.” *Annual Review of Psychology* 49:345-75. URL:
<http://search.proquest.com/docview/205845573?accountid=11774>
- Pittaway, L. and Cope, J. 2007. “Simulating entrepreneurial learning: integrating experiential and collaborative approaches to learning.” *Management Learning* 38 (2): 211-233. doi: 10.1177/0266242607080656

- Rae, D. 2011. Entrepreneurial Learning. By Zone Glyndwr University on Jun 02, 2011. David Rae's Presentation from Inspiring Enterprise 2011.
- Rae, D. (2003). "Opportunity centred learning: an innovation in enterprise education?" *Education + Training* 45(8): 542–549. doi: 10.1108/00400910310508928
- Rugarcia, R., Felder, R., Woods, D., Stice, J. 2000. "The future of engineering education I.A vision for a new century." *Chemistry Engineering Education* 34 (1): 16-25.
- Runesson, U. 2006. "What is possible to Learn? On Variation as a Necessary Condition for Learning." *Scandinavian Journal of Educational Research* 50 (4): 397-410. doi:10.1080/00313830600823753
- Sarasvathy, S. D. 2001. "Causation and Effectuation: toward a theoretical shift from economic inevitability to entrepreneurial contingency." *Academy of Management Review* 26 (2): 243-263. doi: 10.1111/j.1540-6520.2010.00425.x
- Säljö, R. 1979a. "Learning to learn." *Higher Education*, 8, 4, Student Learning (Jul., 1979): 443-451.
- Säljö, R. 1979b. "Learning in the learner's perspective. Some common-sense conceptions." *Reports from the Department of Education*, University of Göteborg, No. 76.
- Säljö, R. 1981. "Learning approach and Outcome: Some Empirical Observations." *Instructional Science* 10: 47-65.
- Sin, S. 2010. Considerations of quality in phenomenographic research. *International Journal of Qualitative Methods* 9 (4): 305-319.
- The Quality Assurance Agency for Higher Education (QAA) (2012). Enterprise and entrepreneurship education (EEE): Guidance for UK higher education providers September 2012, retrieved from <http://www.qaa.ac.uk/Publications/InformationAndGuidance/Documents/enterprise-guidance.pdf> , 24.04.2013
- The Oslo Agenda for Entrepreneurship Education in Europe 2006 available at: http://ec.europa.eu/enterprise/policies/sme/files/support_measures/training_education/doc/oslo_agenda_final_en.pdf, accessed 12 December 2012.
- Thuné, M. and Eckerdal, A. (2005). "Novice Java programmers conceptions of 'object' and 'class' and variation theory." *ITiCSE '05 Proceedings of the 10th annual SIGCSE*

- conference on Innovation and technology in computer science education*. 89-93.
doi:10.1145/1067445.1067473
- Thuné, M., and Eckerdal, A. (2009). Variation theory applied to students' conceptions of computer programming. *European Journal of Engineering Education* 24 (4): 339-347.
doi:10.1080/03043790902989374
- AUTHOR et al. (2014). "Engineering students' experiences of studying entrepreneurship." *Journal of Engineering Education*, 0 (0): 00-00. (In Press. Estimated publication time: October 2014). doi: 10.1002/jee.20056
- Tomayko, J.E. 1998. Forging a discipline: an outline history of software engineering education. *Annals of Software Engineering* 6: 3-18.
- Tynjälä, P. 1997. "Developing education students' conceptions of learning process in different learning environments." *Learning and Instruction* 7 (3): 277-292.
[http://dx.doi.org/10.1016/S0959-4752\(96\)00029-1](http://dx.doi.org/10.1016/S0959-4752(96)00029-1)
- Tynjälä, P. 1999. "Towards Expert Knowledge? A Comparison between a Constructivist and a Traditional Learning Environment in the University," *International Journal of Educational Research*, 31, 5: 355-442. doi: [http://dx.doi.org/10.1016/S0883-0355\(99\)00012-9](http://dx.doi.org/10.1016/S0883-0355(99)00012-9)
- Tynjälä, P. 2008. "Perspectives into learning at the workplace." *Educational Research Review* 3: 130-154. <http://dx.doi.org/10.1016/j.edurev.2007.12.001>
- Tynjälä, P. and Gijbels, D. 2012. Changing world – changing pedagogy. In Tynjälä, P. Stenström, M-L. and Saarnivaara, M. Eds. *Transitions and transformations in learning and education*, 205-222. Dordrecht: Springer.
- van Rossum E.J., and Schenk, S. M. 1984. „The relationship between learning conceptions: Study strategy and learning outcome." *British Journal of Educational Psychology* 54: 73-83.
- van Rossum, E.J., Deijkers, R., and Hamer, R. 1985. "Students' learning conceptions and their interpretation of significant educational concepts." *Higher Education* 14 (6): 617–641. URL: <http://www.jstor.org/stable/3446792>.

- van Rossum, E.J., and Hamer , R. 2006. *Learning and teaching: A model of linked continua of conceptions*. Paper presented at the 24th Conference of the European Council Hotel, Restaurant and Institutional Education, October 25.-28, in Thessaloniki, Greece.
- Virtanen, V., and Lindblom-Ylänne, S. 2009. "University students' and teachers' conceptions of teaching and learning in the biosciences." *Instructional Science* 38 (4): 355-370.
doi:<http://dx.doi.org/10.1007/s11251-008-9088-z>
- Yang, Y-F., and Tsai, C-C. 2010. "Conceptions of and approaches to learning through online peer assessment." *Learning and Instruction* 20: 72-83.
<http://dx.doi.org/10.1016/j.learninstruc.2009.01.003>