Helena Sagar is a part-time PhD student at CUL research school, University of Gothenburg. Studies financed by Kungsbacka county for 8 years; 3 years in partnership with Region of Halland. She teaches science and technology in Kungsbacka kommun, at Kullaviksskolan, ages 13-16 years. After dissertation she will be a lecturer (lektor) at compulsory school in Kungsbacka county and will continue to teach science and technology part-time. She has a background as research associate in genetic engineering at Genencor International Inc in California, USA; experience as "real-life scientist" has influenced her view of knowledge and her efforts to create entrepreneurial and authentic learning environments for her own students.

Hanne Mehli has a master in engineering within biophysics and medical technology, followed by practical-pedagogical education in 2003. She has been a PhD-student at the PhD-programme in Science Education at NTNU, Norway and taught subjects within basic physics and physics education. She is now working as a teacher at the upper secondary school of Orkdal, Norway. Her teaching subjects are mathematics, physics, general science and technology.

HELENA SAGAR

Department of Physics, University of Gothenburg and Kullaviksskolan, Sweden
helena.sagar@kungsbacka.se

HANNE MEHLI

Orkdal videregående skole, Sør-Trøndelag, Norway
hanne.mehli@gmail.com

Expanding teachers' competences in authentic and entrepreneurial teaching issues in science and technology

- an investigation of two approaches

Abstract

This qualitative study describes the variation and diversity in science and technology teachers' self-expressed outcomes from two CPD courses with different design and foci, however with the same major aim, to increase teachers' knowledge of authentic and entrepreneurial learning environments in school science and technology. Based on the same analysis tool both courses indicate impact on practice, however the complexity involved in CPD evaluations is illustrated. The different CPD approaches result in different outcome-types reflecting the respective foci of the two CPD approaches; the outcomes range from general changes in teaching strategies for more authentic and entrepreneurial learning environments to concrete examples of activities specific to the content knowledge. Thus, the question of what the CPD has been effective at needs to be addressed in evaluations. Additionally, we suggest further research to investigate whether CPD initiating reflection on teaching strategies together with specific content knowledge may provide more effective CPD.

INTRODUCTION

Students' declining interest in school science causes concerns, not only from a perspective of democratic participation in society (e.g. Gilbert, 2006) but also from the perspective of recruitment (e.g. Sgard, 2005). School science is accused of relating poorly with students' interests within these fields (Gilbert, 2006; Ryder, 2001), and with contemporary issues in society (Schreiner, 2006). Students do not get introduced to science as it is shaped in its authentic context (e.g. Gilbert, 2006). These cha-

racteristics, additionally relevant for school technology (Jidesjö, 2012; Sjöberg & Schreiner, 2005), are seen as contrary to desires of making school science and technology meaningful and engaging for young people, and to make it work as a means to democratic participation as well as a motivation for further education and work within the fields of science and technology. One response to this situation is the evolvment of authentic and entrepreneurial learning. Studies show that students are more interested and motivated to learn when offered opportunities to work with more authentic issues of science (e.g. Krogh & Thomsen, 2005; Osborne & Collins, 2001) and technology (Sjöberg & Schreiner, 2005).

Among all actors in education, the teacher has been shown to be the single most influential in manifesting the actual teaching practice and thereby influencing the student learning (e.g. Hattie, 2009; Totterdell, Hathaway & la Velle, 2011). Hence, teachers' experiences and competences must match the increasing demand for authentic issues and entrepreneurial skills in the classrooms. Too many science and technology teachers lack knowledge about the authentic professional culture within science and technology and hold on to the science and technology education which they are familiar with themselves (Crawford, 2007). Consecutively, it is a concern that teacher students get little experience with authentic and entrepreneurial learning environments during their education. Focus on authentic science and technology as well as scientific methods through continuing professional development, CPD, may therefore be needed for in-service teachers to better be able to meet their students' needs.

This study deals with two approaches to this challenge as it investigates teachers' outcomes from two different CPD courses; one focusing on entrepreneurial learning environments and the other on authentic professional science and technology.

THEORETICAL BACKGROUND

Authentic and entrepreneurial learning environments

The concepts of authentic learning (e.g. Lombardi, 2007; Rule, 2006) and entrepreneurial learning are described in a variety of ways in research reports (e.g. Leffler, 2009; Leffler & Svedberg, 2005; Mbebeb, 2009) as well as political documents (e.g. EU, 2006). The essence of these closely related learning concepts does not address the student learning per se but rather the environment in which the students get the opportunity to learn new concepts and skills (Lombardi, 2007; Rule, 2004). They have evolved as responses to the lack of overall authenticity in traditional teaching practices in which assignments often are presented without a societal and real-life context. This makes it hard for the students to relate to the issues and to find the learning meaningful. Additionally, school science and technology differs to a large extent from authentic science and technology, hence from the '*ordinary practices of the culture*' (Brown, Collins & Duguid, 1989). In addition to the concern of lack of authenticity in education, entrepreneurial learning has been introduced as a response to our rapidly changing society, which puts new demands on our young people (e.g. Lombardi, 2007).

More detailed overviews of the concepts authentic and entrepreneurial learning in the context of general education (e.g. Leffler, 2009; Lombardi, 2007) reveal that the concepts include the same components, however have different points of departures. The common components can be grouped into three dimensions:

1. *The authentic context*: The subject matter and skills, relating to the students, are framed in an authentic context resembling real-life situations, which may emerge from Collaborations between the School and the Surrounding world, CSS, (Sagar, Pendrill & Wallin, 2012).
2. *The authentic activities and assignments*: The learning activities and the assessment assignments resemble real-life tasks and situations; hence they are open-ended, complex and interdisciplinary in nature, ill-defined, and require analysis and reflection.

3. *The students' process of learning*: The students are empowered and encouraged to take responsibility for their school work and learning process, decision making and collaborative learning, focusing on student initiatives and creativity. This changes the teacher's role away from direct and teacher-led instruction towards a more scaffolding and coaching approach.

In the present study authentic and entrepreneurial learning refers to a learning environment which includes the above components. The learning environment is provided by the teacher's practice.

Teachers' knowledge and professional development

For teachers to provide a more authentic and entrepreneurial science and technology teaching they must get insight into 'real-life' applications related to science and technology education. This can be provided through continuing professional development, CPD, which here refers to planned and organized interventions with specific aims for the changes in teaching practice.

CPD may have impact on teachers' practice through different aspects of the teachers' required professional knowledge. In 1987, Shulman introduced a *professional knowledge base for teaching*, which includes 7 different aspects of knowledge that the individual teacher needs to possess to teach a specific content; content knowledge, pedagogical content knowledge, curriculum knowledge, general pedagogical knowledge, knowledge of learners, of educational contexts as well as of educational purposes and values. In contrast to general pedagogical knowledge, pedagogical content knowledge, PCK, includes knowledge about methods and strategies for an improved student learning as well as students' alternative conceptions in and around certain content. Since then, PCK has been discussed and redefined in relation to an all-encompassing professional knowledge base for teaching. From an investigation of teacher learning, Shulman and Shulman (2004) suggested a refinement of teachers' professional knowledge to additionally take social and collaborative factors into account. Adding the influence of individual and collective reflection on the teachers' transformation of individual experiences into more generalizable conceptions as well as personal dimensions, they state that:

An accomplished teacher is a member of a professional community who is ready, willing, and able to teach and to learn from his or her teaching experiences. Thus, the elements of the theory are: Ready (possessing vision), Willing (having motivation), Able (both knowing and being able 'to do'), Reflective (learning from experience), and Communal (acting as a member of a professional community). (p. 259)

They describe an able teacher as understanding what must be taught and how to teach it, which is what has been most extensively studied over the past 20 years in examinations of teacher knowledge and understanding; '*understanding the subject matter of the curriculum*' and '*comprehending the pedagogical principles and being capable of designing and implementing instruction consistent with them*' (p. 262). In this study we are mainly concerned with the subject matter and the pedagogical principles, in relation to the different foci of the two courses. We will refer to *content knowledge* as the subject matter and skills required learning in science and technology; that is '*what must be taught*' (Shulman & Shulman, 2004). *Teaching strategies* represent general as well as subject specific approaches to and methods for teaching; that is '*how to teach it*' (Shulman & Shulman, 2004).

The purpose of CPD is to support and inspire teachers to changes that lead to professional growth as well as change in teaching practice. Clarke and Hollingsworth (2002) presented The Interconnected Model to describe the complexity of effective CPD. It regards professional development as *change*, which may occur in four different domains; the personal domain, the external domain, the domain of practice and the domain of consequence. The model values changes in *all* domains of change and not only in the domain of consequence, which is student learning. All domains interact in a non-linear and non-structured manner; hence teacher changes which prevail are regarded as teacher's professional

growth rather than development. Other writings discuss teacher transformation as the process that turns changes into growth (e.g. Kennedy, 2005; Shulman & Shulman, 2004; Totterdell et al., 2011).

Reviews of what is considered to be effective CPD for teachers call for evaluations based on student achievement on different levels (e.g. Day & Sachs, 2004). There are, however, strong arguments for evaluating the impact on the teacher, an impact which does not necessarily have an immediate student impact, either due to the student group or to the fact that the teacher needs time to adjust to a new way of thinking around his/her teaching practice (van Driel, 2011; Sagar, Pendrill & Wallin, 2012).

How can the effectiveness of CPD be measured?

For many CPD interventions, evaluation and indications of impact need to be based on self-reports from the participants as other forms of data gathering may not be feasible. Also, self-reported estimates of learning are generally gathered in preference to direct measurement, since direct assessment may be perceived as intimidating by participants (Guskey, 2000).

Harland and Kinder (1997) developed a model of nine outcome typologies from CPD for teachers, entirely based on data consisting of the participants' own statements. The ultimate outcome, impact on practice, may occur directly or indirectly by impact from the other eight outcome typologies, which are ranked according to observed, relative impact on practice. Third-order outcomes have the lowest degree of influence on *impact on practice* and comprise *material and provisional* outcomes, *informational* outcomes as well as *new awareness* outcomes. Second-order outcomes comprise *motivational*, *affective* as well as *institutional* outcomes. First-order outcomes, which influence *impact on practice* the most, comprise *value congruence* as well as *knowledge and skills* outcomes. According to Harland and Kinder (1997) all ranked outcomes are valuable and needed to maximize the chances of professional growth leading to impact on practice. They also argued that some degree of *impact on practice* can occur even if not all outcome typologies are represented. However, the more outcomes and the higher the order of outcome, the higher is the probability for *impact on practice*.

Vos, Taconis, Jochems and Pilot (2011) provide a concrete example of how a third order outcome - a material for presenting chemistry in a real-life context as well as letting the students' curiosity guide the teaching practice - may not be enough for achieving impact on practice. It was concluded that there had to be value congruence between the material providers and the teachers for a true impact on practice, especially as the teaching practice aimed for by the material providers puts high demands on the teacher's flexibility and spontaneity.

Harland and Kinder's typologies *knowledge and skills* as well as *value congruence* are reflected in Shulman's early writings on a teacher's professional knowledge (1987) as well as in ability and understanding in the later writings (Shulman & Shulman, 2004). Additionally, the typologies point to the importance of the added dimensions required for a teacher to grow into an accomplished teacher; readiness, willingness and reflection - individually as well as in the community of teachers. Furthermore, Harland and Kinder's typologies give examples of what may be included in the different change domains in Clarke and Hollingsworth's Interconnected Model for effective CPD (2002), apart from the domain of student learning.

Harland and Kinder (1997) noted that reaction to a CPD event is highly individualized, with different outcomes for different participants, as additionally pointed to by, for example, Totterdell et al., (2011), Simon, Erduran and Osborne (2006) as well as Shulman and Shulman (2004). The teachers' knowledge, background and attitudes will affect how and what they gain from CPD efforts (e.g. Crawford, 2007). The individual outcome route (Harland & Kinder, 1997) is supported by Clarke and Hollingsworth's Interconnected Model for CPD in its recognition of the importance of the personal domain of teacher change as well as the complexity of CPD.

Lastly, Harland and Kinder (1997) address the question of being clear about *what* the CPD is effective at as well as the importance of investigating specific outcomes and different outcome-types within the typologies, before attempting to formulate general conclusions about the characteristics of effective CPD, if this should be done at all.

Aim of study

This paper explores the outcomes from two different efforts to increase teachers' competence in and about authentic science and technology. One focused on entrepreneurial learning approaches, the other on authentic professional science and technology. Both efforts had the same major purpose of generating a positive impact on students' interest in school science and technology. The aim of this study is to investigate the overall variation and diversity in the teachers' expressed outcomes. Additionally, the variation and diversity in outcomes will be explored in relation to the different foci of the actions.

The research questions are:

1. What outcomes, as expressed by the respondent teachers, can be identified from the two courses?
2. What is the contribution to the overall variation and diversity in outcome-types from exploring the different approaches?
3. How do the teachers' responses reflect the different approaches?

The courses

This study originates from two different CPD courses, strongly connected to authentic and entrepreneurial learning environments. The two courses had different foci in regards to teachers' required professional knowledge (Shulman, 1987), addressed as ability and understanding in later writings (Shulman & Shulman, 2004). Course A focused on *teaching strategies*; the teachers had an opportunity to learn knowledge and skills to assist in changing their teaching practice to provide more authentic and entrepreneurial learning environments for the students. Course B focused on *content knowledge*; the course allowed teachers to learn content knowledge and skills as well as processes (Mehli & Bungum, 2013) related to space science and technology through active participation in the authentic practice at the rocket range. Course A, titled Entrepreneurial Learning, was arranged in Sweden by the Region of Halland. Course B, The Nordic Teacher Space Camp (NTSC), was arranged by the Norwegian Centre for Space-related Education (NAROM), which is co-located with Andøya Rocket Range (ARR), an independent branch of the governmental Norwegian Space Centre on the island of Andøya in Northern Norway. The courses were planned, designed and executed independently of each other.

The aim of both courses was to support and inspire teachers to change their teaching practice to create an increased student interest in general and in science and technology in particular. Table 1 presents the most significant information about the two courses and the selected respondents.

METHOD

Selection of respondents

Since this study originates from empirical data, which initially were collected for separate studies, the selection of respondents varies between the two courses. However, with the purpose of identifying a general overall variation and diversity of outcomes as well as indications of outcome variations reflecting the different foci of the two courses, the different selection processes should not be crucial to the results.

From Course A, 7 respondents, three women and four men, were selected among participants during 2008 and 2009. Six of the seven respondents teach science and/or technology in secondary school,

Table 1. Presentation of design of the two different CPD courses which are explored.

	Course A	Course B
Country	Sweden	Norway
Focus	Teaching strategies and pedagogic methods for creating authentic and entrepreneurial learning environments for the students	Content knowledge and practical skills related to space science and technology
Target participants	All categories of teachers	Science and technology teachers for students aged 12-19 years
Content and activities	Lectures on/inspiration for entrepreneurial learning, EL. Concrete examples of EL and CSS (Sagar et al., 2012) Role play. Reflective group discussions	Lectures on space science and technology Practical work in groups preparing a research rocket launch
Course leaders and instructors	Teacher educators and researchers from Swedish universities Coaches in EL	Engineers, scientists and researchers from Andøya Rocket Range and Norwegian universities
Examination	Planning and teaching an entrepreneurial project including CSS (Sagar et al., 2012)	Completing the launch of a research rocket
Higher Education Units	7,5	None
Duration	Five separate days spread over 6 – 10 months	Five consecutive days
Category of time spent for course	Working hours during students' holidays	Free time during summer holidays
Responsible for initiative to take part in course	School management	Individual teacher

while one respondent teaches social sciences in close collaboration with the technology teacher, hence was well acquainted with the technology curriculum current in Sweden at the time of the intervention and the data collection (National Agency of Education, 2006). Five of the seven respondents were recommended by their respective school leader and then asked by the researcher to take part in the study, one volunteered for the study and one was asked by their school leader upon a request from the researcher. The respondents, who had 4-18 years of teaching experience, worked in two different schools with the same school leader at each respective school.

From course B, respondents were selected among those who participated in the NTSC in August 2009. All the 18 participating teachers answered an initial questionnaire, and were asked whether they accepted to be contacted for interviews. Of those who volunteered, four teachers from four different schools were selected for interviews. The respondents worked as science and/or technology teachers in upper secondary school and they represented a variation in background and geography as well as in teaching experience ranging from 2 to 30 years.

All respondents participated on a voluntary basis. The positive bias which this introduces to the study possibly adds value to the aim of identifying overall outcomes as well as variation and diversity in the outcomes from the two courses.

Collection of data

Interview data was gathered, in the teachers' native language, 3-6 months after the courses. The interviews were semi-structured, using open-ended questions, and addressed various elements of the course and how these influenced the respondents' experiences and perceived outcome. The teachers were also asked about what they saw as the most important gain from the course.

Analysis of data

As the aim of the study was to investigate the teachers' self-expressed outcomes, the CPD evaluation model presented by Harland and Kinder (1997) was chosen as a tool of analysis. This tool focuses on planned teacher change and applies to teachers of both young and older students. The interviews were transcribed and analysed using software programs; NVivo 9 for course A and Atlas for course B. All statements interpreted by the interviewer to express outcome from the course, were categorised according to the nine different typologies included in the CPD evaluation model. The material from the courses was analysed separately by the authors. The analysis was repeated by the same person at least six months after the first analysis, to increase the degree of reliability. The results from the two analyses were cross-checked and compared by both authors, for the purpose of aligning the interpretation of the outcome typologies. All respondents were given pseudonyms for the purpose of anonymity and the quotes presented were translated into the English by the authors.

RESULTS

Both courses resulted in outcomes within all three orders as well as impact on practice. The outcomes from both courses are presented together for each category and simultaneously illustrate and explain the different typologies in the CPD evaluation model (Harland & Kinder, 1997).

Third order outcomes

For course A, the *provisionary and material outcome* category is represented by components on a general level; concrete methods and assignments which can be used to allow the students to learn about the curricular goals and to self-evaluate as well as methods and strategies for providing more authentic and entrepreneurial student learning environments. The outcomes from course B are on a more subject specific level and include material outcomes like software, lectures and teaching resources.

Information outcomes from course A include statements revealing that the teachers have received information about entrepreneurial learning environments, while valuable information from course B relates to processes relevant to the work at the rocket range, the authentic practice of engineers, researchers and technicians, but also information about tools and methods.

The most frequently represented category *new awareness* includes statements which are often preceded by outcomes in the *information* category (Table 2), indicating that a certain reflection seems to have taken place around the information. For course A, the new awareness concerns assessment, interdisciplinary teaching, curriculum and goals, meaningfulness in assignments, question making to inspire reflection and analysis, authenticity, collaborations with the surrounding world as well as organisation and schedule. For course B, the new awareness relates to the practice and processes at the rocket range, as is the case for the information outcome category. These statements show realizations about the complex work, and that knowledge and cooperation is necessary on all levels to fulfil the tasks.

Table 2. Examples of statements indicating third order outcome.

	Course A	Course B
Provisionary and material outcome	– <i>It was a lot about making the students take part in the assessment, for example this about giving a written examination essay to a class-mate, who gives comments and then give it to somebody else and then you get it back. (Veronica)</i> – <i>/.../ to work in a more interdisciplinary manner. (Ulla).</i>	– <i>Well, we installed one of these trial licenses for 30 days, and now I have got a license here at school. (Lisa)</i> – <i>Their webpages with all the resources. (Albert)</i>
Information outcome	– <i>/.../got to know about eight key competences advocated for by EU, which I had never heard about. (Kaj)</i>	– <i>We got an introduction to software/.../ and we got information about the process at the telemetry unit during rocket launch. (Lisa)</i>
New awareness	– <i>We need to try to sit down, since a requirement for teaching more interdisciplinary is that I have clear goals formulated for science and that I, myself, first sit down and look at what areas that I can tie together, like sound and light and some things in technology. (Ulla)</i> – <i>The bigger number of teachers being involved during assessment, the more teachers and eyes are there to recognize different things...maybe a more fair assessment... that can become something very positive. (Ylva)</i>	– <i>We saw that even they [technicians and engineers], who had done this so many times, with all their knowledge and experience, when we were about to track the real rocket, there was hectic activity. To get the signal correct, connect cables and so on. So it shows that there is something to it to make it work. (Niels)</i>

Second order outcomes

Statements categorised as second order outcomes indicate a higher level of reflection among the teachers. These outcomes may be on a more personal level, or indicate that an individual or group process has taken place (Table 3). The *affective outcomes* expressed from course A teachers are related to the authentic and entrepreneurial teaching strategies presented and reflected on; they are closely linked to inspiration to change the teaching practice. This is different from the affective outcomes from course B as they relate to the individual teacher's personal experience emerging from their contribution to the actual practice at the rocket range as well as from the surroundings.

The category regarding *motivation and attitude* includes the second largest amount of statements. Statements reflecting increased self-efficacy and motivation, both in general and course-related are found here. *Institutional outcome* is the only category for which there is a marked difference in the degree of representation for the two courses. Course A is strongly represented by statements which reflect *institutional* changes inspired by the new awareness from the course, whereas statements from course B express frustration from lack of collective understanding.

Table 3. Examples of statements indicating second order outcome.

	Course A	Course B
Affective out-comes	<i>– I left from there [the course] full of energy and lots of ideas about what I was going to change. (Veronica)</i>	<i>– It's like, wow...All of a sudden it is no longer just a game. Not school science at all, this is where it happens. It is good, exciting. You occupy some space, it feels good. (Maria)</i>
Motivational and attitude out-comes	<i>– I got a little "kick in the butt"... We have talked for a long time about teaching in a more interdisciplinary manner, but we have never gotten to it, nothing has happened. But now I felt that we got a little... new inspiration. (Ulla)</i>	<i>– [I have] much better self-confidence, I think. By experiencing that I could do it. I could actually put together that printed circuit board. Such a small thing, but... 'Cause it's easy, when you're a teacher, to think that you are just a theoretician wandering around not knowing what the world really is like. But it was great to experience that you can do it, if you just get the opportunity. (Maria)</i>
Institutional out-comes	<i>– It was the first time we tested this. We anticipate that the ones [students] who are motivated have control over their study plan. On the last lesson on Thursdays, when this is, we check them on and off and ask them if they might be able to sit at home and study. They are very welcome to do so as long as we see results. It is the goals that count, WHEN they do it does not matter. That means that we are left with more resources, we are more teachers around them whom we definitely cannot let go home. (Veronica)</i>	<i>– We used it at the career fair. I guess that's when there was most talk about this. (Niels)</i>

First order outcomes

Generally, statements within the first order outcomes are more complex than outcomes of a lower order. Hence, with few exceptions, statements which reflect first order outcomes include expressions which have also been categorized in one or more lower order outcomes. Examples of first order outcomes are shown in Table 4.

Knowledge and skills outcomes from course A relate to knowledge about teaching strategies for a more entrepreneurial and authentic learning practice, hence not to a specific content knowledge. The new knowledge and skills acquired by the teachers in course B relate to the actual practice within the field of space science and technology. The teachers' indicate that they have gained practical skills and knowledge connected to the specific content of the course. They also express an increased understanding of what it is like to work in such a context and the processes behind a complex technological operation.

Table 4. Examples of statements indicating first order outcome.

	Course A	Course B
Knowledge and skills	– The meaning of entrepreneurial learning has been something else for me. I have now taken it to myself this thing about the meaningfulness, that it should be meaningful for the students to work with, the meaningful learning, that is how I want to work. That is what I bring with me from the course, and that it does not HAVE to be in collaboration with the surrounding world but it is about the sense of meaningfulness which can be done in different ways. (Kaj)	– I got a lot more insight into this field /.../. I knew what was going on from the outside, but had no idea of what was needed behind the curtains. That I know a lot more about now! (Lise) – I learnt practical skills like soldering. So I have had some ‘guest appearances’ in Technology because of that. (Maria)
Value congruence	– Now I have put on the students to make the contact [with a company]. /.../ It is the students who have to make this contact this time, not me as the teacher. If they do not manage to make contact, they can still learn from it. (Veronica) – But I HAVE changed the way I construct the questions and have started thinking about that the students should think that the assignments are meaningful, so that they [the questions] really reach out to them. (Allan)	– When you enter this area you discover all the problems there are to be addressed, problems you had no clue existed. And that gives you some knowledge. Even though you never make any practical out of this afterwards, you have the understanding of what it takes to launch a rocket. How many considerations, how much knowledge you need to be able to say that ok, we have to clear THIS part of the ocean. ‘Cause that’s where the rocket will fall down. (Niels) – All the groups were in it, right? And then you had to follow the progress, otherwise the whole process would be a waste of time. So you had to perform, for everything to work out alright. And I think everybody was on their toes, like... “now I must not do anything wrong’. You know, you were 110 or 150 % focused on your task. (Maria)

Value congruence is reflected in different dimensions in the outcomes from course A; they are either specifically oriented towards a concrete method, activity or item or oriented towards a more general and overarching idea, a general approach. The specifically oriented outcomes include value congruence in how to construct questions and assignments for the students such that they appear meaningful to the students, to let go of control such as letting the students make contact themselves with the surrounding world for the purpose of finishing a learning assignment as well as recognizing the stu-

dents' evaluation of their own and their class-mates' achievements and results as a valuable learning opportunity for the students.

For course B, this outcome is represented by statements reflecting teacher learning; the teachers have gained an understanding for the complex structures of practices and tools in modern science and technology as well as the processes behind one example of practical research. The respondents show a new understanding both of the importance of cooperation between groups and professions, and the importance of content knowledge and technological and practical skills.

Throughout this presentation of results the variation within the different outcome categories, which represent different outcome-types (Harland & Kinder, 1997), related to a teacher's required professional knowledge (e.g. Shulman, 1987); a teacher's ability (Shulman & Shulman, 2004) has been illustrated. *Value congruence*, however, is the only category for which the outcomes differ in the way that they relate to entirely different professional practices. Course A outcomes relate to the teaching practice, while course B outcomes relate to the authentic practice at a rocket range.

Impact on practice – ultimate outcome

Respondents from both courses express impact on practice. These statements further illustrate the differences, within the outcome categories, which emerge from the two courses. The quotes in table 5 make clear that the teachers' own perceptions of *impact on practice* are on a general level for course A. Teachers from course B express concrete assignments, software and data material as impact on practice. Most important for these teachers, however, is impact connected to better self-efficacy due to more practical as well as content knowledge, and more insight into the connections between school science technology and the authentic professional science and technology which they have experienced.

Table 5. Examples of statements indicating impact on practice.

Course A	Course B
– They [the two-hour-long lessons] were spread over the week but now they have been put together for seven-, eight- and nine graders on the same time. It is more flexible both for personnel and if you [the student] want to work with something entirely different, then all competences among the teachers are available for the students. (Veronica) – But I HAVE changed the way I construct the questions and have started thinking about that the students should think that the assignments are meaningful, so that they [the questions] really reach out to them. (Allan)	– Then he said: 'I draw these many times a day'. And I thought, I will cite him on that. 'Cause when my students are struggling with these free-body-diagrams, what forces that are active on an object that is some of the hardest stuff they do. And they can't see why they have to do it. /.../ But I have referred to him. If he, the rocket engineer does this...! Well, they [the students] accept that one. They thought it was a good explanation. Then it was not just me being a silly teacher, but they actually do use it in the real world. (Lisa) – I take it with me and use it. It is connected to what I knew from before. I have now concrete examples on how things work, right? (Niels) – I'm more trustworthy when I have done it myself, not just referring to others. (Lisa)

DISCUSSION AND IMPLICATIONS

Since both courses resulted in outcomes in all typologies, except *institutional outcomes*, this investigation indicates that both courses have a good potential for leading to impact on practice. This is strengthened by the fact that the outcome typologies of the evaluation model agree with the dimensions in which an accomplished teacher should grow for CPD to be effective, as stipulated by Shulman and Shulman (2004). Additionally, the typologies can be grouped into the three domains of teacher change which do not address student learning in Clarke and Hollingsworth's (2002) Interconnected Model for effective CPD; personal domain, external domain and domain of practice.

The different foci and methods in the two CPD approaches are clearly reflected in the teachers' responses and in the potential impact on practice. The different outcome-types reflect, to a large extent, the specific dimension of an accomplished teacher's ability (Shulman & Shulman, 2004), which was the focus of each respective course. Course A focused on general *teaching strategies*; '*how to teach*' as the participants were provided with tools and inspiration, in a reflexive environment, for changing the teaching practice to include more authentic and entrepreneurial components. In course B the focus was *content knowledge*, including *process knowledge* (Mehli & Bungum, 2013); '*what must be taught*'. The participants were given opportunities to learn subject matter as well as practical skills and to experience how science and technology may be applied in the authentic learning environment that a rocket range provides.

Harland and Kinder (1997) discuss different qualities of effective CPD in relation to *knowledge and skills*. They suggest a division of this typology into a subset of outcome-types to secure that an evaluation actually measures teacher changes which are aimed for by the CPD. This is clearly illustrated in the present study: Most *knowledge and skills* outcome statements from course A reflect the focus of the course as they address *teaching strategies*, while statements from course B focus on an increase in *content knowledge* related to space science and technology as well as an increased insight into a scientist's reality at work.

Additionally, this investigation illustrates the need for a clarification of outcome-types in other typologies than *knowledge and skills*, where *value congruence* represents the most important example. For course A respondents *value congruence* relates to the teaching practice whereas for course B it relates to the scientist and technologists' authentic practice. Course B's contribution to a more authentic and entrepreneurial teaching practice would be that the teachers themselves have learned knowledge and skills in an authentic context, as well as the self-experienced awareness about the real work and issues that scientist and technologists have to deal with on a rocket range. The *value congruence* outcome-type identified for course B respondents may assist the teachers in presenting and utilising the *provisionary and material outcomes* in an authentic context and manner. Vos et al. (2011) identified a need for teachers' *value congruence* in relation to the school material providers for a more contextualized and student driven chemistry education. It seems feasible to suggest that the more authentic and entrepreneurial teaching practice aimed for in their study object would further benefit from the *value congruence* outcome-type identified in the present study. Similarly, it seems feasible to suggest that the effectiveness of course B may have been broadened had the course included an additional aim for a similar *value congruence* outcome-type as in Vos et al.'s study and as in course A in the present study. The *knowledge and skills* outcomes from A are of an in-depth character requiring reflection and analysis in regards to *teaching strategies*, the focus of the course. Shulman and Shulman (2004) point to the importance of individual and collective reflection to enable the teachers to transform their individual experiences into more generalizable conceptions, which would correspond to *value congruence* in relation to a reformed teaching practice. The reflective aspect is indicated by the fact that these outcome statements mostly are expressed as changes; change in interpretation as well as usage of the curricular goals, change in methods of and approaches to assessment, changes in construction and focus of questions and assignments. The expression of changes

furthermore agrees with The Interconnected Model for effective CPD (Clarke & Hollingsworth, 2002) in which teacher 'development' in its initial phase is regarded as teacher changes, which may progress into teacher growth.

Other differences in outcome-type are related to an authentic and entrepreneurial teaching practice. Course A outcomes refer to all three dimensions as presented above in the theoretical background. The statements exemplify concrete changes; although changes expressed in general terms are dominant. The formulation of questions for the students to work with raised a lot of reflection and served as a source of inspiration for changes in teaching practice among several of the respondents (Table 5). However, the outcome statements do not present any concrete examples of how questions were actually changed accordingly.

Course B outcomes refer to the authentic context and authentic activities, in a concrete and specific manner, and include only few components regarding the process of learning for their students. These outcomes focus on how the teacher can provide the students with connections between school science and technology and the content knowledge which they have to learn. However, majority of the outcomes related to authentic and entrepreneurial learning reflect the teachers' own learning in the authentic context and authentic assignments which were provided at the rocket range.

Motivational and attitude outcomes also illustrate different outcome-types. Course A respondents refer to inspiration and motivation to try out the new ideas concerning *teaching strategies* in school. Course B respondents point to an increased motivation in relation to the learning process which they have themselves experienced. They express an improved self-efficacy due to their increased content knowledge as well as the 'real-life' experience as scientists and technicians at the rocket range. Hence, their increased motivation and self-efficacy emerges from their own authentic and entrepreneurial learning experience.

The content of course A included justifications and strategies for making organizational, that is *institutional* changes, such as providing teachers time to plan together for interdisciplinary teaching and include longer lessons to better allow for collaborative project work. This kind of reflexive pedagogic discussions were not part of course B, where institutional issues instead were related to the authentic practice at the rocket range. This may explain why institutional outcomes, from a school perspective, only occurred from course A. Additionally, all course A respondents attended the course together with one or more colleagues from the same school, unlike course B respondents. This rendered possible the collective reflection shown to be required for a transformation of individual experiences into more general approaches (Shulman & Shulman, 2004).

The importance of being aware, on several levels, of the different possible outcome-types is addressed by Harland and Kinder (1997):

Without investigations into specific outcomes and effects, research and theory-building around the effectiveness of teachers' CPD is in danger of accentuating a level of generality that is insufficiently defined and precise to be of much assistance to policy-makers, planners and practitioners. (p. 83)

In conclusion, on a general level, that CPD has been effective, one needs to address the question of what the CPD has been effective at (Harland & Kinder, 1997; Kennedy, 2005), a need which is illustrated and confirmed in the present study.

Another important issue to address in CPD evaluations is the evidenced argument that teachers illustrate individual outcome routes (Harland & Kinder, 1997), as further pointed to in additional research reports on CPD evaluation (e.g. Simon et al., 2006; Totterdell et al., 2011; Vos et al., 2011) as well as in models for effective CPD (Clarke & Hollingsworth, 2002). Although the background and knowledge of

the individual teacher has great impact on the outcome, individual concerns have not been addressed here. The purpose of the present study was to investigate the contribution to the overall variation and diversity in outcome-types from exploring two different CPD approaches on a general rather than on an individual level.

The empirical data illustrates a heavily intertwined character among the outcome categories. In the present study *information* outcomes appear to be a prerequisite to *new awareness*. Additionally, higher order outcomes are more complex than lower order outcomes and often include outcomes from lower orders in the statements. For example, in the course A statements, *impact on practice* has been preceded by the *institutional* outcome that the teachers' take time to sit and plan together. This results in an *impact on practice*, on an individual level, consisting of goal-oriented interdisciplinary school projects being provided for the students.

Authentic activities were described in the simplest way as '*ordinary practices of the culture*' (Brown et al., 1989). Authentic scientific practice is framed both through the methods and through its content and processes. The exploration of these two courses points at two different interpretations of a scientific culture. This study shows how teachers can gain insight into authentic and entrepreneurial learning both by learning *about*, and by learning *by experiencing*. The results further indicate differences in impact on teaching practice, as the participants in course A necessarily were more focused on their students and how to make changes in their own teaching. These teachers express knowledge about approaches to create entrepreneurial learning environments. They reflect and practice differently around assessments, make efforts to formulate more open-ended and ill-defined problems and questions for the students as well as encourage the students to make contacts with the surrounding world by themselves. The course B participants express impact on practice in ways more related to their personal experiences and learning, both of content matter and authentic scientific practice. By working in an authentic context, doing authentic activities and being responsible for their own learning and a common project, they also gained insight that may have impact on their own teaching. This impact can be indirect, like self-efficacy and direct, like content knowledge and increased awareness of the connections between school science and technology and authentic science and technology. The general character of the outcomes from course A indicate that changes in *teaching strategies* need to be reflected upon in more subject specific terms for more concrete changes to occur. The outcomes from course B indicate that the transfer of teaching strategies, from a self-experienced learning in an authentic setting, to the teacher's own practice does not automatically occur, even though the experience result in strong *affective* as well as *motivational and attitude* outcomes.

This illustrates the challenges in transferring authentic experiences to the situated school practice, as well as connecting more general teaching strategies to the science curriculum or concrete activities within technology. Further studies would be needed to verify whether a CPD course focusing on authentic and entrepreneurial science and technology, including *content knowledge* as well as *teaching strategies* would result in a larger variation and diversity of outcome-types from one and the same course.

REFERENCES

- Brown, J. S., Collins, A. & Duguid, P. (1989). Situated Cognition and the Culture of Learning. *Educational Researcher*, 18, 32-42. DOI: 10.3102/0013189X018001032
- Clarke, D. & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education*, 18, 947-967.
- Crawford, B. (2007). Learning to Teach Science as Inquiry in the Rough and Tumble of Practice. *Journal of Research in Science Teaching*, 44(4), 613-642.
- Day, C. & Sachs, J. (2010). *International Handbook on the Continuing Professional Development of Teachers*. Glasgow: Bell & Bain Ltd. Original work published in 2004.

- van Driel, J. (2011). *Teacher development*. Key note at 9th European Science Education Research Association (ESERA) Conference, 5th – 9th September, Lyon, France.
- European Commission (2006). Key Competences for Lifelong Learning – A European Framework. *Official Journal of the European Union*: http://ec.europa.eu/dgs/education_culture/publ/pdf/ll-learning/keycomp_en.pdf Derived on 2013-01-03.
- Gilbert, J. (2006). On the Nature of “Context” in Chemical Education. *International Journal of Science Education*, 28(9), 957–976.
- Guskey, T.R. (2000). *Evaluating Professional Development*. Thousand Oaks, CA: Corwin Press).
- Harland, J. & Kinder, K. (1997). Teachers' Continuing Professional Development: framing a model of outcomes. *British Journal of In-service Education*, 23(1), 71-84.
- Hattie, J. (2009). *Visible Learning – a synthesis of over 800 meta-analyses relating to achievement*. Oxon: Routledge.
- Jidesjö, Anders (2012). *En problematisering av ungdomars intresse för naturvetenskap och teknik i skola och samhälle – Innehåll, medierna och utbildningens funktion*. Doctoral thesis, Studies in Science and Technology Education (FontD), Linköping: FontD.
- Kennedy, A. (2005). Models of continuing professional development: a framework for analysis. *Journal of In-Service Education*, 31(2), 235-250.
- Krogh, L.B. & Thomsen, P.V. (2005). Studying students' attitudes towards science from a cultural perspective but with a quantitative methodology: border crossing into the physics Classroom. *International Journal of Science Education*, 27(3), 281-302.
- Leffler, E. (2009). The many faces of entrepreneurship: a diverse battle for the school area. *European Educational Research Journal*, 8(1), 104-116.
- Leffler, E. & Svedberg, G. (2005). Enterprise Learning: a challenge to school education? *European Educational Research Journal*, 4(3), 219 – 227.
- Lombardi, M. M. (2007). Authentic Learning for the 21st Century: An Overview. *Educase Learning Initiative*. ELI Paper 1:2007.
- Mbebeb, F. (2009). Developing productive life skills in children: Priming entrepreneurial mindsets through socialisation in family occupations. *International Journal of Early Childhood*, 41(2), 23-34.
- Mehli, H. & Bungum, B. (2013). A space for learning: How teachers benefit from participating in a professional community of space technology, *Research in Science & Technological Education*, DOI:10.1080/02635143.2012.761604 <http://dx.doi.org/10.1080/02635143.2012.761604>
- National Agency for Education. (2006). *Curriculum for the compulsory school system, the preschool class and the leisure-time centre*, Lpo 94. Ödeshög: AB Danagårds Grafiska. (Original work published in 1994.)
- Osborne, J. & Collins, S. (2001). Pupils' views of the role and value of the science curriculum: a focus-group study. *International Journal of Science Education*, 23(5), 441–467.
- Rule, A.C. (2006). Editorial: The Components of Authentic Learning. *Journal of Authentic Learning*, 3(1), 1-10.
- Sagar, H., Pendrill, A-M. & Wallin, A. (2012). Teachers' Perceived Requirements for Collaborating with the Surrounding World. *NorDiNa*, 8(3), 227-243.
- Ryder, J. (2001). Identifying Science Understanding for Functional Scientific Literacy. *Studies in Science Education*, 36, 1-44.
- Schreiner, C. (2006). *Exploring a ROSE-garden: Norwegian youth's orientations towards science – seen as signs of late modern identities*. Doctoral Thesis, Faculty of Education, University of Oslo. Oslo: AiT e-dit AS.
- Schreiner, Camilla & Sjöberg, Svein. (2005). Et meningsfullt naturfag for dagens ungdom? [A meaningful school science for today's youth?]. *NorDiNa* 2, 18-35.
- Sgard, F. (2005). *Global Science Forum Activity on Declining Interest in Science Studies Among Young People. Objectives and Preliminary Report on the Qualitative Analysis*. Paper presented at the 10th OEC/Japan Seminar, Tokyo. Available from <http://www.oecd.org/dataoecd/0/40/35169401.ppt#1> (accessed 2012-12-28).

- Shulman, L.S. (1987). Knowledge and Teaching: Foundations of the New Reform. *Harvard Educational Review*, 57(1), 1-22.
- Shulman, L. S. & Shulman, J. H. (2004). How and what teachers learn: a shifting perspective. *Journal of Curriculum Studies*, 36(2), 257-271.
- Simon, S., Erduran, S. & Osborne, J. (2006). Learning to Teach Argumentation: Research and development in the science classroom. *International Journal of Science Education*, 28(2-3), 235-260.
- Totterdell, M., Hathaway, T & la Velle, L. (2011). Mastering teaching and learning through pedagogic partnership: a vision and framework for developing 'collaborative resonance' in England, *Professional Development in Education*, (37)3, 411-437 <http://dx.doi.org/10.1080/19415257.2010.510003>
- Vos, M.A.J., Taconis, R., Jochems, W.M.G. & Pilot, A. (2011). Classroom Implementation of Context-Based Chemistry Education by Teachers: The relation between experiences of teachers and the design of materials. *International Journal of Science Education*, 33(10), 1407-1432.