Professional development for inquiry-based science education in a low stake high support environment: The French ASTEP-program

Johanna Lundström
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Abstract

This work examines the learning outcomes of a French professional development program for science education in primary school, ASTEP. The program is based on a partnership between a primary school teacher on one hand and a subject expert on the other. Its uniqueness lies in the fact that the subject expert is a young university student who is challenged to be assessed on his/her learning for academic credits. Compared to most other professional development programs, ASTEP displays an alternative knowledge hierarchy, it is neither top down nor bottom up, but rather a form of knowledge exchange. Data on students’ and teachers’ reflections on the collaboration were analyzed through a grounded theory approach and subsequently organized within the interconnected model of teacher professional growth (IMTPG). Although the analyses indicated significant changes in the practice of the teachers, the learners who individually seem to benefit the most were the university students. The ASTEP program appears to provide a low stake high support scaffold for the students to refine their values and beliefs about a professional life and develop a professional identity.

Nyckelord/Keywords
Inquiry based science education, primary school, professional development, teacher education, integrated model of teacher professional growth, undergraduate science education, identity development.
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Introduction

There is general concern that students all over the world display little interest in the science taught in school and do not choose a science career (Anderhag, 2014; Anderhag, Emanuelsson, Wickman & Hamza, 2013; Tytler, Osborne, Williams, Tytler, & Cripps Clark, 2008; Tytler, 2009). Organizational and socio-economic structures, teaching traditions and curricula have been invoked to account for this failure to engage young people in science and opt for an academic career in science and technology. This has caused worries from takers of the education system such as industry and government (cf. Anderhag, Emanuelsson, Wickman & Hamza, 2013). As a result, there have been a number of initiatives from industry and academies to work outside their focus area to help in the development of science education. In this study I investigate the outcomes of one such initiative, the ASTEP program in France, whose design is a result of input from research in education and professional scientists’ beliefs about what counts in science education (Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003).

The reasons thought to be critical for the failure to raise students’ engagement in science are somewhat different in primary and in secondary school. In secondary school, students probably lose interest because school science is too abstract, too focused on traditional content, and devoid of personal and aesthetic experiences (Lindahl, 2007; Tytler, 2009, 2014; Anderhag et al., In press). In primary school the problem is rather that children are taught too little science and that, when science is taught, everyday rather than scientific objects become the focus of classroom activities (Anderhag et al, In Press). Moreover, the little science that is taught is often done by teachers who have very little or no science-education background. Longitudinal studies on career choice emphasize the importance of good and appetizing science education before the age of 14 (Ormerod & Duckworth, 1975; Tai, Liu, Maltese & Fan, 2006). In primary school, everyday explanations are often enough to catch childrens’ interest in science. But if no connections are made between everyday experiences and scientific objects, students will not have the opportunity to even begin to develop a taste for science (Anderhag et al, In press). In short, it seems as if much of the failure of school systems to catch students’ interest in science lies with teaching materials and methods in primary school that focus too much on everyday objects with no connections to scientific objects, and teaching materials and methods in secondary school that focus too much on scientific objects while neglecting how these connect to students’ lives.
The general consensus of scholars of science education in the 1990s was that teachers especially in secondary school tended to put undesirable emphasis on factual knowledge and leave out problem solving. Students’ loss of interest could be found in the traditional direct or deductive method of teaching. According to this view, instead of first introducing a concept and then providing arguments and explanations, teachers must change their practice into student lead inquiry-based approaches. In the EU Rocard report of 2007 (Rocard, 2007) recommendations were given for the implementation of Inquiry Based Science Education, IBSE at all levels of the education system. Advocates of IBSE claim that this approach is necessary for the following reasons (Harlen & Allende, 2009).

a) There is no way that students can learn everything they will need in science for a future adult life. The deductive method therefore becomes both insufficient and inefficient. Focus of core content must be on a few big ideas. Indeed, in 2010, ten experts suggested 14 big ideas of science education for a world that is constantly changing (Harlen, 2010).

b) Since the teaching approach itself is inductive rather than deductive, learners will understand what science is and how it works. When teachers change course from the traditional direct/deductive method to IBSE, the change means that they no longer teach about science, they actually teach science! In this process students must collect evidence to learn for themselves.

c) In the process of collecting and evaluating evidence, the learner must also develop communication skills. They need to develop an appropriate vocabulary, conventions of expression as well as representational skills. This means that when the young students grow up they will feel more at ease when talking about and expressing scientific thoughts and arguments.

d) Learning through inquiry means to develop skills to learn. This is a much more useful competence than the accumulation of large amounts of factual knowledge.

Inquiry based science education, IBSE, positions learning as an activity that the student does to improve his or her knowledge. Thus, any activity where the student collects, organizes, investigates and debates is IBSE, but mere transfer of factual knowledge is not. The key concept, inquiry, also establishes the role of questions and investigations in the collection and organization of new knowledge. Within the IBSE-framework, it is the collection and evaluation of evidence as argument that is the key to genuine knowledge.
In this needy soil of deficient science education in the 1990’s, initiatives to restore and redirect science education towards a more vivid state were taken mainly from academies. A first explicit initiative towards hands on science for younger pupils, was “Science and Technology for Children” in the US. The program has been developed and reorganized at the National Science Resource Center, NSRC, (since 2013 SSEC), for almost three centuries. Two leading institutions in Science: the Smithsonian Institution in Washington and the US National Academy of Sciences are main partners. The aim is to develop science education leadership and provide exemplary science education materials. Similar initiatives were subsequently taken in the UK, France (LAMAP), Sweden (NTA), Germany, Brazil and China.

In 2006 and onwards, the Interacademy Panel of International Issues (IAP), a network of academies of science around the world, published a report based on many workshops aimed at implementing IBSE in schools (Harlen & Allende, 2006). Among other aspects, the report called for better understanding of professional development (PD) of in service teachers and it was therefore suggested that the participating countries continue to share experiences on how to

- develop hands on materials and guidebooks for practical exercises in the classrooms,
- organize interactive meetings like seminars and workshops where teachers can share and develop their experiences,
- instruct teachers in the subject matter through lectures or written materials.

Science connect, Fibonacci and Pollen are three recent IBSE-focused projects in line with the suggestions of the IAP report and financed by the European Union. When the last of the three, Fibonacci, closed in 2013, more than 300 000 students in primary and up to secondary school, had been affected by the project. Teachers reported that they felt more confident in working through inquiry (Charpak, 1998).

In France, the organization La Main à la pâte (French for “hands on”), LAMAP, is the leading initiative concerning IBSE since 1996 and was also an influential partner in the Fibonacci and Pollen networks. LAMAP today has about 20 pilot centers around France. Various different partners like the town, the “département”, local groups and universities form zones for dispersion of an inquiry based approach to science. An estimate is that La main à la pâte reached 3000 classes in 2012. The organization mainly works with pre- and primary school, and is probably the main reason why science education in French primary schools now
reaches about 35 % of the classes compared to 3 % in 1996 (Ministère de l´éducation nationale, l´enseignement supérieure et de la recherche., 2014).

One of the PD programs of LAMAP is the ASTEP program (l´Accompagnement en Science et Técnologie à l´École Primaire) which has been in function since 2004. ASTEP is designed as a joint project between primary school organizers and universities. This partnership allows realization of the central idea of the program which is to have a subject expert entering into a primary school classroom to assist the teacher in designing for inquiry and expressing core content science with an appropriate vocabulary.

The ASTEP-program differs from most similar PD programs with subject experts since it takes place in the classroom while working with the pupils and not in an offset environment. In addition, the program is atypical since the subject expert in most cases is a young university student who is just starting their professional life. We therefore have two professional learners: the teacher and the university student who are equipped with widely different experiences from their professional and personal lives.

The overall purpose of this study was to deepen the understanding of expert scientists’ contribution to school development and to teacher PD programs involving subject expertise. For discussion purposes, I draw a general picture in two dimensions represented in a four-field diagram, Fig 1. The horizontal dimension represents whose profession is in focus, the profession of the scientist or the profession of the teacher. The vertical dimension represents the degree of overlap of competence. For instance, when a teacher attends a lecture by a scientist to understand more about science research frontiers, the professional world of the scientist is in focus. There is no (or very little) overlap with the teachers’ profession although the teacher will be able to use some of the new discoveries in science in their teaching practice. This type of PD is represented by the upper left quadrant. Other variants are exemplified in the other three quadrants of Fig 1.

Teacher professional autonomy is critical to their professional identity and to their societal status (see for example Wermke & Höstfält, 2014). Accepting this, their professional identity will be affected by who initiates their professional development, perhaps even when the initiator is a representative of the subject that the teacher teaches. With this study I hope to contribute to further understanding of the interplay between school subject, classroom practice and university disciplines for the outcome of PD of teachers.
The research question of the present study is:
What learning do teachers and the university students choose to report about from their experience of the ASTEP professional development program?

Figure 1. Dimensions of professional development involving subject expertise and teachers.
Study setting - La Main à la pâte and ASTEP

La Main à la pâte in France was created in 1995 by three well reputable physicists and members of the French Academy of Sciences: Georges Charpak, Pierre Léna and Yves Quéré. The idea was inspired from the US initiative on hands-on science lead by Leon M. Lederman, a personal friend of Charpak and like him a Nobel Prize laureate. Thus the initiative to La Main à la pâte comes from professional scientists, from individuals who recognize the difficulties and joys in doing science.

In France the initiative immediately received support and recognition from politicians and local communities. Over the years, the LAMAP network has spread all over France. Its success may be explained in part by the uniformity of the French school system making it easy to implement. Another aspect is the official instructions to focus on the “basic competences” of reading, writing and counting that were issued around 1980. This focus diminished the focus on other subjects like those of science, history or geography and was not in line with the long French tradition of les didactiques. This loss of tradition caused a demand in schools to return to subject content to implement reading, writing and counting, and may be an additional explanation why the material of LAMAP was so well received (Charpak, 1998).

Today LAMAP distributes kits for investigations according to IBSE through its 20 centers around France. Each center also organizes training for teachers. The material provided is arranged around specific themes such as floating and sinking, force, from seed to plant etc. Hands on exercises with suggestions of experimental material or actual experimental material, are provided. Thus the philosophy relieves the teacher of the burden of developing suitable classroom activities from scratch, it provides aid in extracting what subject content is the most essential for the learners and finally offers PD to teachers in implementing IBSE.

Professional development for IBSE pedagogy within LAMAP

Professional development of in-service teachers may take different forms, for example lectures, classroom coaching, workshops with a leader and collegial development. LAMAP has developed a few lines of PD for teachers, many of which were referred to in the previously mentioned Interacademy panel report from 2006 on the implementation of IBSE programs. In 2009 a new report was published with recommendations for how and towards what aim PD should be routed (Harlen & Allende, 2009).
This time, particular emphasis was given to the fact that if a change in practice towards inquiry based learning is to take place, then it is critical that the teachers grasp the subject matter to be taught. But any PD must also reflect the desired pedagogy of the PD program itself: “If teachers only follow instructions in their training, it is not surprising if they then teach their students only to follow instructions, with the result of inhibiting real inquiry.” (Harlen & Allende, 2009, p. 22)

The report established that IBSE pedagogy requires that the teachers give the pupils hands on exercises. But without solid content knowledge teachers feel uneasy to do so. Professional development must develop the teachers own subject content knowledge by engaging the teachers in first-hand experience of inquiry at their own level and in relation to the content to be taught. This principle is outspoken in the background of PD programs of LAMAP, the major one of which is ASTEP.

**The ASTEP program**

In France, ASTEP is a growing program and involves 51 of France’s 95 departments. In the 2013-14 school year as many as 2619 classes were reached by the ASTEP program and 3000 by a LAMAP activity in one form or another. In ASTEP one assisting scientist, a so called accompagnateur, partners with one teacher on one theme to be taught with an IBSE pedagogy during 6-8 class sessions. This general organization remains firm as do the instructions to the assistant scientist on what role to adopt in the classroom. The idea is that the teacher thereby gets support in developing their scientific vocabulary and understanding of concepts. The assisting scientist is there to provide assistance in inquiry based science education, its concepts, arguments and processes as well as with logistics of equipment (Ministère de l’éducation nationale, l’enseignement supérieure et de la recherche, 2004).

ASTEP was initially developed as a program that would primarily improve the professional competence of primary school teachers. The contribution of the assistant scientist is thus in good match with what Harlen and Allende (2009) identified as that which primary school science teachers are in most desperate need do obtain for the improvement of teaching of science.

ASTEP takes somewhat different forms in different departments or even diverse forms within the same city. For instance in the Paris region, about 100 university students and 10 retired scientists adopt the role as the assistant scientist each year. In the school year 2013-2014,
1298 out of 1500 all ASTEP’s assisting scientists, were university students in their second or third year, 129 were master students, 55 graduate students and the remaining 44 were either professional scientists or engineers or retired from these professions. The subgroup of assisting scientist that increases the most both in absolute and in relative numbers is the year 2 university students (Ministère de l´éducation nationale, l´enseignement supérieure et de la recherche, 2004).

**ASTEP in Paris**

In Paris, ASTEP is organized through the local LAMAP pilot center. University students who opt to participate sign up for a course of 3 ECTS organized by the biology department at l’Université Marie et Pierre Curie 5. The course name is *UE SACS Stage d’Accompagnateur de Sciences* (approximately Open Course Internship as Assistant of Sciences), hereby called ASTEP course.

Primary school teachers in Paris are requested to fulfill 12 hours of PD each semester. They can choose to develop their skills in teaching sciences and can do so through the local LAMAP pilot center (La main à la pâte, 2016). Each year the LAMAP pilot center in Paris arranges training of roughly 50 teachers in workshops and 65 novel participants in the ASTEP program. The teachers involved in ASTEP choose this PD among other alternatives.

The pilot center serves as a resource facility for experimental equipment. The center is not big. One senior teacher is employed as coordinator. She is hired in part by LAMAP, by the Academy of Paris and by the local universities. Off and on she has temporal help by a student from the École Polytechnique who takes on a 6 month practice as part of his/her university training. It is this coordinator at the pilot center who together with one university professor designates one teacher to one university student. She also runs the training of primary school teachers. In addition she and the university professor together introduce the university students to the ASTEP course.

To gain 3 ECTS, the university student has to fulfill the following.

- A 3 hour introductory session where the framework of ASTEP is introduced. In addition the students watch films from classroom work of LAMAP sessions in primary school and one interview with a French didactician and university professor. The idea is to develop the student’s understanding of classroom work with young children.
• Plan 6-8 sessions of science teaching together with their designated primary school teacher. The teacher and student must decide on a theme and lesson content together but they are instructed to use materials from LAMAP.

• Participate in the 6-8 sessions together with the teacher.

• Evaluate the 6-8 sessions together with the teacher.

• Present the planning and summarize his/her experiences in a 15 pages paper and a 20 minutes oral presentation with digital presentation techniques.

The students are graded F-A on their work. On the introduction to the course they receive one template for lesson planning and one template for the writing of their report paper. In the report, the student is demanded to reflect both on his or her role as part of a science in society project, but also their personal development. The course thus becomes both an inward and outward learning adventure to the student and they will be examined on their reflections including the development of and effects on themselves. Evaluation and assessment of their subjective observations and feelings is probably a new and different experience to most university students in the STEM sector. In most other courses they meet thresholds for passing based on subject core content and problem solving.

**The present study**

This study was carried out within one cycle of the ASTEP UMP course of 3 ECTS during November-December 2014. The ASTEP course was offered, but not mandatory, to undergraduate students in their second year of the chemistry program at UMPC, the biology program at UMPC, the mathematicians at UMPC, and to students inscribed in the engineering program at Paris Diderot.

This set included 50 students and they were all in their second year of university studies of mechanics, mathematics, biology, or chemistry. All of them had chosen ASTEP as an optional course (UE ouverte). None of them were inscribed in a teacher program but a master program leading to a degree for teaching in secondary school, was one of several options for them.

The organizers within the LAMAP and UMPC organizations paired one student to one teacher. The university had to refuse some teacher applicants, but all students who applied were accepted for the course. Since the ASTEP course is growing in popularity among students, there were ongoing discussions on whether to refuse applicants or expand the program.
Data collection
The initial idea was to investigate all professional development of teachers arranged by LAMAP. Since the ASTEP program turned out to be the dominant one both in time and numbers of teachers involved I decided to focus on it. With time the university-student learning became more and more evident. The primary data collection in classrooms and of teacher interviews served as a background to a secondary data collection. The more thorough, secondary, data collection includes written material of student papers and teacher surveys.

Observations in classrooms, meetings and teacher training sessions.
Two separate sessions for teachers training were followed. These took place at one of LAMAP pilot centers in Paris. The sessions were divided in two parts: one part to introduce the ASTEP program to the teachers and one part to give factual knowledge on the theme of sea level rise and climate change. The second part was designed both to teach the teachers about the scientific context but also to suggest and discuss suitable classroom activities. I also followed two cycles of ASTEP in class sessions, 4 out of 7 sessions with one student-teacher pair and 4 out of 7 sessions with one pair of a teacher and one assisting scientist who was a retired engineer. I took the part of an observer but with limited interventions. Field notes were taken for all these sessions. The final session of each cycle was also captured in audio and accompanying digital field notes using Livescribe Echo smartpen and notebooks. One startup meeting with 6 retired assistant scientists was observed and field notes taken. Observations were also made during one meeting between the 6 retired assistant scientists.

Interview with Catherine Guettet
The director of the licenciate program of physiology at UMPC, Cathrine Guettet, was interviewed on December 12th 2014. The interview was recorded and field notes taken.

Written and oral reports of the students
All student papers of one ASTEP course at the UMPC during the autumn semester 2014 were collected from one cycle of ASTEP. These 50 papers constituted the entire written student material for examination of that particular ASTEP course. In addition three oral presentations of the same course were recorded and coded like the written reports
**Teacher material**

Two interviews with teachers and their assistant scientist after their involvement in one full ASTEP cycle were carried out using a set of open questions. The material was transcribed and analyzed with the same codes as the student material (see above).

The organizers of ASTEP in Paris give out an evaluation form to the participating teachers. Evaluation forms from the ASTEP round in spring 2014 and fall 2015 were collected and analyzed.
Analytical approach

Grounded theory
A grounded theory approach was used as research method to understand what learning takes place among the university students and their partner teacher. This allows for an open-eye structuring of complex information or “the generation of theory from data” while avoiding as much as possible of predefined perspectives (Glaser & Strauss, 1968). Grounded theory data analysis is carried out through several, usually three rounds, of coding of data. In the first round, the initial coding, codes should be organized but down to earth. At this stage codes are not to match abstract interpretations or theories. In a second round, focused coding, codes are reorganized to fit with a model for interpretation (Thornberg, 2012). Lastly, in a third round of coding, theoretical coding, codes are further reorganized to generate a theoretical understanding and interpretation of the data of the study.

The interconnected model of teacher professional growth
Clarke and Hollingsworth (Clarke & Hollingsworth, 2002) have developed a model based on empirical findings, to understand the mechanisms that take place in between design of PD programs and outcome, the so called integrated model of teacher professional growth, IMTPG. The model focuses on change within four different change domains, and how change in one domain mediates change in another. The four domains in the IMTPG-model are the external domain, the domain of practice, the domain of consequences and the personal domain. The three latter are part of the teacher’s professional world while the external domain constitutes any input from the outside world such as school reforms, new knowledge or influences from media. The key for how this process can be understood is that change in one domain depends on change in any of the other three domains. In other words, two teachers experiencing the same input in for example the external domain, may change in different ways depending on previous beliefs, knowledge, attitudes (personal domain), classroom practice (practice) or student knowledge and behavior (consequence). The process of professional growth is continuous and iterative over a teacher’s life. The model is non-linear for professional development and allows for understanding life-long learning in iterative cycles.
Data analysis

Pre study
The field notes of teacher seminars, classroom sessions and other meetings were used for two purposes. The first purpose was to frame what instructions the teachers and students were given from the LAMAP on what an IBSE approach means and how it can be carried out in a classroom and to provide material for the initial coding of the data material. The second purpose of the use of field notes from these occasions was to validate the results of the coding of written material. The results of the coding of the student papers and the interviews that were coded, were back checked with the field notes. I was particularly observant on taking notes of discussions between and questions from the participants.

Grounded theory analysis
The discussion part of all the student texts were read to give an overview and to set up codes for initial coding. Next, 10 randomly selected student papers were coded with focused codes referring to

- Statements about career choice and personal background
- Statements about various aspects of the IBSE pedagogy
- Statements about observations of children
- Statements about personal development
- Statements about the school system including observations of the classroom teacher

The focused codes were sorted into main and subcategories, and quantified. A last, theoretical coding, was carried out through two refining rounds. In the first, inclusive round, descriptive statements about what went on in the classroom, reflections about here and now, as well as statements with inference to the future the practice. In the second, selective round, statements indicating long term change were separated out for further analysis and categorized into the domains of the IMTPG model.

The procedure for coding of the student papers or audio records was as follows: the text of each paper or transcript was reformatted to fit into an Excel workbook. On a separate sheet, codes were organized in data cells in column headings. A text passage corresponding to a certain code was given a specific identity number which was typed into its corresponding
column and linked to the data cell of text passage generating the code. This allowed for
simple quantitative analysis of text passages, i.e. the frequency of a specific code type. It also
allowed for reorganization of codes as well as an easy way to return and validate the coding.
Statements in the teacher surveys were sorted, and those statements that indicate longterm
change were into the IMTPG mode along with the same principles as in the last round of
coding of student papers.
Ethical considerations

All audio files were recorded with the consent of the participating teachers or students. I informed all adults about the objective of my presence in classroom observations, interviews, evaluation meetings, student seminars and teacher training workshops. No parents were informed since no primary data were collected focusing on individual children. No photos of persons were taken, only of classrooms and of teaching materials. I received permission from the university to analyze the student papers. All student and pupil names have been removed in the text that follows, and care has been taken to exclude any excerpts that may disclose the identity of a particular student. It is very unlikely that my participation has caused harmful stress or injury to any of pupils, students, teachers, professors or pensioners.
Results

Part 1 Inclusive analysis

In an early phase of this work, I decided to focus attention on what catches the students’ minds as they leave the context of the university and enter into a professional environment in which they have to adopt a new role. The discussion parts of the whole set of 35 preframed student papers were scanned to identify tentative categories for organizing a collection of students’ observations. The immediate impression of this initial scan was that students report on great changes in their personal development.

To verify this, and to understand how such a tentative outcome might relate to other new impressions that the students report on in their learning, an inclusive framework for qualitative analysis was developed. Five main categories were developed to include what is physically and functionally present in the classroom of relevance to the ASTEP course and to the students’ thoughts about their career choice. These were

1. Motivations to career orientation (career category),
2. comments on the qualities of the IBSE approach (IBSE category),
3. understanding of children’s learning (children category),
4. insights about oneself as a person (self category),
5. insights or criticism about functions of the school system, including the professionalism of the teacher (school category).

The statements that students provide together represent what becomes salient in their ASTEP experience. In Table 1 the distribution of their 201 statements is shown. The data represent the number of uninterrupted statements in each category or subcategory. Subcategories evolved during the process of coding. These subcategories and their relative representation provide an account of what the students thought worth bringing into their final reflections of the project. Each subcategory is presented in more detail in the text that follows together with examples of student statements in my translation into English.
Table 1: Distribution of student statements as sorted by main categories and subcategories. Main category “school” lacks subcategories.

<table>
<thead>
<tr>
<th>Main category</th>
<th>career</th>
<th>IBSE</th>
<th>children</th>
<th>self</th>
<th>school</th>
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<tbody>
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<td>Subcat.</td>
<td>No</td>
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<td></td>
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<td>planning and implementation</td>
<td>21</td>
<td>dynamics</td>
</tr>
<tr>
<td>reasons for choosing the course</td>
<td></td>
<td>4</td>
<td>revisions of plan, difficulties</td>
<td>22</td>
<td>language</td>
</tr>
<tr>
<td>suggestions for improvement</td>
<td></td>
<td>9</td>
<td>initiatives</td>
<td>10</td>
<td>sense of making impression</td>
</tr>
<tr>
<td>previous experience of children</td>
<td></td>
<td>4</td>
<td>previous experience of children</td>
<td>9</td>
<td>professional competence</td>
</tr>
<tr>
<td>ASTEP influence on career choice</td>
<td></td>
<td>9</td>
<td>ASTEP influence on career choice</td>
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<td></td>
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<td>personal satisfaction</td>
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<td>5</td>
<td>leadership</td>
<td>23</td>
<td>professional competence</td>
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<tr>
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<td>29</td>
<td>total</td>
<td>52</td>
<td>total</td>
</tr>
</tbody>
</table>

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Representative statements and further elaboration of the each category are displayed below. Anonymized student identities and code numbers are shown below each quote in square brackets, [student X, codecategory X].

**Motivations to career orientation**
The career category includes student statements about their future career, or the planning of it through the choice of an education program (reasons for choosing the ASTEP course).

*When someone explained to me what the ASTEP is, I chose it because on the one hand I like children and I had never led a group and I was curious to try. On the other hand, the idea of finding myself next to a teacher intrigued me. I hoped to get an idea about what this job really is without really being judged as a teacher student.*

[Student 1, reason 2]

The students also mention how their personal background e.g. how personal school experiences matter (previous experience of children), or how the ASTEP course, when finished, has helped them on deciding about their future on career choice (ASTEP influence on career choice).

*However this course has made it even clearer to me what I knew before. I knew that I did not want to become a teacher but not exactly why. After doing the course, I realized that even though I really liked the contact with the pupils, teaching is not part of my expectations for a future career. In summary, even though the course was very rewarding, I do not hope to continue in teaching science or anything else, but I do absolutely not regret choosing the ASTEP course because I got to meet the class teacher and her class, spend a lot of time with them and hopefully I managed to give the pupils a taste for science.*

[Student 2, reason 5]
Twelve out of the twenty nine statements in this category were repetitions of the objective of the ASTEP course and more or less identical to the instructions in the course manual (view of objective).

**Comments on the qualities of the IBSE approach**

The category dominating in text length is the IBSE-category as it contains all mandatory statements of how lessons were planned and how they went (planning and implementation). Descriptions of how the students and the teacher plan lessons and how the planning worked out constitute long uninterrupted sections of about 25 % of the student papers. An empty table frame is provided in the template for writing that the student gets from the university as part of the course material. This sheet is similar to sheets for planning that are commonly used by teachers in Paris elementary schools. One example of a lesson plan is shown below:

**Session 3**

*Objective: to construct electric circuits with the material that I have brought to the class*

*Key terms: isolator, conductor, semi-conductor*

<table>
<thead>
<tr>
<th>Implementation</th>
<th>Organization</th>
<th>Time-span</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revision of the previous session</td>
<td>collective,</td>
<td>5 min</td>
<td>Aluminum, plastic bags, cupper, water, string, wood, cardboard, paper,</td>
</tr>
<tr>
<td></td>
<td>oral</td>
<td></td>
<td>tissues, salt, flat battery, socket, lamp, electric cords with crocodile</td>
</tr>
<tr>
<td>Fill in a table where the task is to choose whether</td>
<td>Individual</td>
<td>5 min</td>
<td>Aluminum, plastic bags, cupper, water, string, wood, cardboard, paper,</td>
</tr>
<tr>
<td>the material conducts electricity or not</td>
<td></td>
<td></td>
<td>tissues, salt, flat battery, socket, lamp, electric cords with crocodile</td>
</tr>
<tr>
<td>Verify the hypothesis by using the distributed</td>
<td>15 pairs</td>
<td>25 mins</td>
<td>Aluminum, plastic bags, cupper, water, string, wood, cardboard, paper,</td>
</tr>
<tr>
<td>material</td>
<td></td>
<td></td>
<td>tissues, salt, flat battery, socket, lamp, electric cords with crocodile</td>
</tr>
<tr>
<td>Joint summary of the results and explication of the</td>
<td>Collective</td>
<td>5 min</td>
<td>Aluminum, plastic bags, cupper, water, string, wood, cardboard, paper,</td>
</tr>
<tr>
<td>words isolator and conductor</td>
<td>and oral</td>
<td></td>
<td>tissues, salt, flat battery, socket, lamp, electric cords with crocodile</td>
</tr>
</tbody>
</table>
In addition to lesson plans like the one above, the student is instructed to discuss the outcome of one of the sessions in more depth and give general comments on the entire sequence of lessons.

Typical comments included descriptions of what happened or what the pupils, the teacher or the student said, such as:

*After each experiment we summarized everything on the board and then we asked the children to write down a summary of their experiment and to summarize why it had worked or not. And we also asked them to make a note about what had not worked.*

[Student 4, IBSE 11]

*And so we decided to make boats from aluminum foil, each child was to make their own. I let the children make their boats all by themselves. After doing the experiment, I explained to them why some things float and some sink. The teacher helped me very much because it is necessary to use appropriate words so that they can understand so that they can remember.*

[Student 5, IBSE 5]

Other statements specifically address difficulties that the student meet when they try to implement the IBSE method (revisions of plan, difficulties, or suggestions for improvement).

*I realized that they [the pupils] had great difficulties to write down a simple observation, but it got a little bit better with time.*

[Student 6, IBSE 8]
I then wanted to make a session were we could use the knowledge that the pupils had acquired in the first session to show that what they had learnt was something they could see in everyday life.

[Student 1, IBSE 5]

**Understanding of children’s learning**

The children category includes all statements that the students make about how the pupils comment, make inquiries, collaborate, disobey etc. Quantitatively, the students report mostly on how the work goes on (dynamics) and how they draw conclusions (conclusions) such as:

[the teacher writes “How can we light the bulb without letting it touch the battery” on a flipchart] The pupils immediately suggested to put a wire between the bulb and the battery. I then asked them what it is that the wire might do and thereby I had introduced the idea that certain materials can conduct electricity and some not. After a short while they all agreed that wood, cloth or plastics could not conduct electricity, and they then thought about metals. We made a list of metals that we could use and decided together to use cupper.

[Student 4, pupil 4]

Even before this session about rotation of the Earth had started several children had asked about the alternation of nights and days. One little girl, [name], whose grand parents live in Mexico, confirmed “when it is night in Paris, it is day at their place”. And so we discussed how this fact influences her.

[Student 6, pupil 1]

It was difficult to make the children focus throughout the session, after 25 minutes of work they often started to talk with each other and make noises, but thanks to the teacher the quietness returned.

[Student 5, pupil 1]

The subcategory, initiatives, is relatively abundant and includes statements that the students make on how pupils move on with an energy of their own, without being guided or pushed. In some cases the student also makes reflections on how this initiative comes to be, like in the one below where it is inferred that a certain amount of understanding is necessary for participation.
I noticed that some pupils didn’t participate with their groupmates to do the experiments but then when things started going according to their hypothesis and they got some confidence they shouted out their ideas in a loud voice and much more so at the end of the project than in the beginning.

[Student 7, pupil 3]

Although the students are very observant about their own use of an adapted scientific vocabulary (self category), they do not comment much about how the children call objects and scientific principles (language). This subcategory only included four independent statements. Perhaps the students think, or realize, that it is their job to provide a scientific vocabulary to the children. They do not seem to see that the children invent scientific expressions by themselves.

**Insights about oneself as a person**

Within the self category, all statements were organized that had anything to do with what happens inside the student as a person. This could be feelings, insights about how their actions are received or general insights about the world.

One new code that emanated was about learning to organize ones work, or simply to work (professional competence):

*The work with the teacher has taught me to work more efficiently in a group (or a very small group) with the goal to get things in order very quickly to be ready without forgetting important details.*

[Student 8, self 9]

Another aspect that was quantitatively significant was various comments on the need to make an effort in the use of language (communication):

*I forced myself to find an adapted technical vocabulary which we could use in the sessions and also to adapt the experiments.*

[Student 1, self 4]
Several lengthy statements illustrate how the ASTEP experience makes the student feel joy and personal satisfaction:

*On the whole, this experience was very good for my personal development. I was delighted to share my knowledge with the pupils in this class and to discover a small part of the world of teaching.*

[Student 1, self 14]

*Also, this course was very rewarding on a human level. In fact, I managed to make connections to some children who spoke to me and they were not bothered or shy. I also felt useful since we were in a quite difficult neighborhood and our mission was to let them discover a subject that we like but they normally do not have the means to study and this makes me very happy especially when one of them said “Later, I want to be like you, I want to be a scientist”. I then understood that we had not worked in vain and that we had managed to give a taste for science to some children.*

[Student 7, self 5]

Very few of the students feel all at ease in leading a classroom and comment on the development of leadership qualities.

*Finally, I am glad to have learned to manage having a lot of looks directed at myself and sometimes an avalanche of questions. I’m basically satisfied about this, because I think that I made progress about developing authority and also to manage to speak out, although sometimes I [still] am intimidated when I see 20 children fixing their eyes on me to learn new stuff.*

[Student 7b, self 4]

*To get through this course, in fact, you had to put aside your personal difficulties and intervene. It is not possible to back out from the children. This is how I managed to gain self-confidence and during the last sessions I managed to intervene and make interaction with the pupils and with the teacher.*

[Student 2, self 10]
One aspect that was surprisingly subordinate was how the students reflect on their own understanding of the subject, although there were a few statements like:

*Moreover, it is really satisfactory to be able to transfer your knowledge to children since they have a thirst for knowledge and they ask very good questions to understand. This course has really taught me that I have to continue to learn because in spite of their young age, the children sometimes asked complicated questions that I did not always have a good answer for, but I anyhow keep a very good memory of the course.*

[Student 9, self 8]

**Insights and criticism about functions of the school system, including the professionalism of the teacher**

Finally, the school category included any comment that the student might make on how the school organization enables or inhibits the work with children as well as observations about how the teacher deals with the classroom work.

Typical comments were

*And also, in this class there was a child with autism and there was an assistant with him but I had to speak really slowly when I talked to him.*

[Student 1, school 2]

*As a pupil you do not understand the full dimension of what the teacher does in the classroom, he has to overlook, keep everyone focused, keep his eyes on everyone, understand what we do, that everyone follows, that we do not go too fast or too slow etc. All these points, you do not understand until you see it from the outside, but they are very important and very hard to manage on an everyday basis. I have now changed my opinion about what this profession of a teacher is, it is a profession of passion and above all humane.*

[Student 7, school 1]

The idea with this round of coding was to cover all that the students might see during their internship in primary school and in their work with the teacher. It generated five main categories of student statements, the method (IBSE), the relevance for the student’s own career (the relevance and usefulness of the university course), the encounter with children, personal development, and comments on the school system and the teacher as a professional.
Perspectives like authority, power, gender, culture are therefore not observed by default. However, if the organizational framework meets the initial requirements to be inclusive enough, this should allow for such perspectives to emerge. In the following section the data are reorganized to fit into the IMTPG model for long term, recurring and improving change.

**Part 2 Sifting out real and long term change**

In real life there are many things we do and observe, but not all is relevant when we look back, and this is the case also in the process of learning. The students react on what happens in the classroom, on their own attitude, on the method etc. The objective of this work was to understand what professional learning takes place during the ASTEP course. In a second part of data analysis, statements indicative of change were identified. Ninety-seven statements were found to be about some kind of transformation. Typical statements of change were such as “until know, I was unaware of”, or “this aspect was much more complicated than I had thought”. 104 deselected statements were considered to be either descriptive or analytic but only about temporary changes.

The statements that expressed long term change were collected and organized within the domains defined by the IMTPG model Clarke & Hollingsworth (Clarke & Hollingsworth, 2002), but with some adaptions to fit students who do not really have an ongoing profession to develop. In this scheme statements were organized as follows:

**External domain** – student statements of suggestions for organization of either the ASTEP course or of the school system.

**Practice domain** – student statements where they describe how they change their practice about how to act in the classroom during the ASTEP course or explicit statements of how the ASTEP course has changed the way the student thinks they will act in any future professional situation (and not necessarily in a classroom).

**Consequence domain** – student statements about observations that they have made indicating that the pupils or the teacher has learnt better as a result of the ASTEP program.

**Personal domain** – all student statements about how they value themselves as well as reflections about their competences. New knowledge which was not directly connected with themselves as a person was also organized within this domain in line with the original IMTPG model.
A majority, 39 out of 97 of the sifted out statements, originated from the self-category of the original coding and almost all the other statements had originally been placed in the child category or in the career category (24 and 9 respectively). When reorganized into the IMTPG model one statement related to the external domain, 39 to the domain of practice, 15 to the domain of consequence and 43 to the personal domain. No statements about long term change related to the external domain.

Statements about the students’ practice are most often statements about what they changed in their actions during their time in the classroom within the timespan of the ASTEP course.

The most obvious problem was to find a language simple enough for the CP level [6 year olds] without losing important concepts. It is hard, but we had to find something to catch the children’s interest. This is why the use of lamps was so smart, because more than anything the children really wanted to make them light up.

[Student 4, self 3]

Among the statements that concern change of practice, only a few included anything about how the student thinks they might act in a future professional situation. They describe changes they have made from a null level of professional experience as a result of the ASTEP course and in interplay with the teacher.

The student also identify long term consequences of their practice or of the ASTEP course. One recurrent theme was statements about their own impact on what kind of person the children will think a scientist is. An additional theme of consequences was observations that the children expressed enthusiasm about sessions to come. For instance:

Moreover, I noticed a total investment from the children. They really were impatient to start the science investigation sessions. For example, once me and [the teacher name] were five minutes late, and we could see that the children were very happy when they finally saw us arrive and so they arranged with their stuff really quickly so that we could get started as fast as possible. Throughout the science classes, the pupils were attentive, and they participated a lot as soon as one asked them questions. Especially surprising was how some of them were able to grasp the principles of the experiments really quickly.

[Student 7, pupil 2]
In contrast, statements from students that were organized within the personal domain, contain many implications for changes that the student will bring with them into their future professional life. What emerges is a dominance of statements relating to who the student thinks they are and their reactions to their image of themselves in the encounter with the school setting.

*Being very young, I anyhow managed to make a very special connection to them while managing to keep a distance characterized by respect and admiration because after all, I was a scientist to them, more than anything else.*

[Student 6, self2]

*Another difficulty I had in the beginning was to take the role as a person with authority in front of the pupils (but not more important than the teacher). I am a youth leader [animateur] during the holidays, but the way to relate to children in leisure settings is not the same as in a school situation.*

[Student 8, self3]

This type of statements constitute the majority of what was sifted as long term changes, and this finding is the most important in this analysis. The students are about to start a professional life within a few years, and the ASTEP course means for them to enter into a professional environment. These reflective statements must be considered as very important steps into a professional identity. To summarize, the students express how they see themselves, what in their view of themselves has changed and what they realize about how others see them.

Below follows synthesis of what the 32 statements in the personal domain that relate to self indicate.

1. “How I see myself and how I think others see me”.
   - overcoming shyness,
   - adopting the role as a professional,
   - take the role as an expert scientist,
- learning to adopt a role with authority,
- understanding how important motivation is for learning in general,
- better at taking “the stage”,
- getting used to the idea of being addressed with a title.

Also belonging to the personal domain of the IMTPG model were eleven statements about knowledge which I treat separately to simplify a discussion about identity. In these statements, the students express that they have realized that something is important to know, for instance the adaption of vocabulary, but they do not explicitly say that they will use this knowledge in practice. In summary:

II. “What I understand is important to do or know”.
- that it is necessary to develop content knowledge even for teaching in primary school,
- that it is essential to use an appropriate vocabulary,
- the importance of demanding children to trust observations [and not just memorize answers],
- the importance to give step by step appropriate explanations,
- to develop leadership competence,
- interact with children and demonstrate experiments in front of them,
- that the concept of scientific investigation is general and applicable at the university as well as in primary school,
- the importance of argument.

The teachers learning
Teacher responses in 35 surveys were analyzed with the same focus as in the analysis of the student papers, i.e. for testimonials of long term change. A sum of 26 such statement were identified and these were organized within the IMTPG model as described for the student materials and distributed as follows: external, 7; practice, 5; consequence, 4 and personal domain, 10.
Although these data represent only a narrow selection representing spontaneous statements they still indicate that the teachers develop different competencies and in different domains than the students during their ASTEP experience.

For example when the teachers comment on how the ASTEP program develops school organization, external domain, they say that they have realized science classes require two people and many sessions to work out well.

Their comments on change of practice are generally very explicit and genuine about how they will, from now on, be able to carry out science classes alone:

- “I feel absolutely at ease in holding science classes alone now”
- “I now feel fine about carrying out the classes but it is impossible to organize all the materials.”
- “I can now transfer the IBSE method to new areas.”

Although the survey is not demanding comments on what differences teachers see in pupils’ learning, there are still many spontaneous comments about this (consequence).

- “I have seen new sides of the children.”
- “The scientific investigations teach children to reflect.”
- “The scientific investigations make the children more dynamic and more engaged.”

Finally, like the students, teachers develop knowledge, attitude and beliefs (personal), for example self confidence in doing science:

- “The ASTEP improves my confidence in doing science.”

They feel more inspired:

- “I feel renewed by the encounter with the student.”
- “It gives inspiration to be 2.”

They understand about IBSE:

“I have learnt that it is a method that allows for making mistakes.”

As well as about subject content:

- “I have heard better explanations of science than I can produce myself.”
In spite of the limitations in the data collection of the teacher testimonies, they indicate that the teachers report a positive impact of ASTEP on their own learning as well as of their young children. This is in line with the overall intention of the ASTEP program which is to implement IBSE in classrooms through the young university student who is there to mediate a scientific approach. The teacher statements support that this happens.
Discussion
The results from this study indicate that the ASTEP program is successful in developing teacher competence to teach science with an IBSE pedagogy. The partnership with university student seems to work as intended, as a link which bridges the gap to science. However, it differs from most other PD programs where teachers connect to either an expert or other colleagues to transfer or exchange knowledge. During the IBSE experience teachers develop competence through change in several of the domains of the IMTPG model. The student provides valuable content knowledge to the teacher and as a result the teacher improves their skills in IBSE pedagogy.

The results indicate that the students as well learn new competences but as a bonus, also about their identity. Their learning develops through change in the personal and to some extent the practice domain of the IMTPG model. The identity learning is nothing that the teacher is expected to help the student with but happens because the student enters a new context. Several students express that the ASTEP experience has “warmed their hearts” and that the “children were wonderful” or general statements like “it was enriching”. The students’ own learning has limited effect on the improvement of science teaching in schools (simply because the students will not remain there), but the participation of the students has significant effects on science teaching in the classrooms during the duration of the project.

Design of the ASTEP program - apprenticeship PD for the implementation of IBSE
The ASTEP program is a far-reaching and recurring project. Research on the efficacy of PD programs in science education has grown in recent years. For example, Van Driel, Meirink, Van Veen, and Zwart (2012) based a global analysis of PD programs in science education on the IMTPG model. Their idea was to understand whether PD programs in science education were designed to meet six core features that have been identified in the literature to be critical for a program to be successful and they developed a framework to understand this. Their general conclusion was that in contrast to 2007, PD programs in 2012 really are designed to apply these success features and that the programs also showed good coherence and had a long enough duration. Out of the 44 PD programs that were studied more closely, they found that twenty-two (50%) were aimed at fostering teacher learning in the personal domain and the domain of practice, fifteen out of 44 (34%) additionally aimed at improvement of pupil learning outcomes. However, among these, only one (Heller, Daehler, Wong, Shinohara, &
Miratrix, 2012) qualified for what van Driel et al termed as a “type 3 study”, which means that one PD program is followed in several settings and with several coaches.

The six core features that are necessary for success in the design of a PD program are the following (van Driel et al., 2012) and based on Borko, Jacobs & Koellner (2010):

- that the PD program has a focus on classroom practice, on the teaching and learning of a particular subject matter,
- that the teacher is active and learns through inquiry,
- that the teacher learning is collaborative,
- that the intended learning of the PD of the program is considered coherent with the intentions of the school, district and colleagues,
- that the teachers get enough time and resources for the PD program.

If we apply the framework of van Driel et al to the ASTEP program, it seems to qualify as a type-3 study. Moreover it is designed to foster teacher learning within the personal domain and in the domain of practice and in addition it is aimed at direct improvement of pupil learning outcome. In summary, the ASTEP program is rigged for success according to principles found by expertise.

One aspect which differentiates ASTEP from most PD programs and also from those in van Driel et al’s analysis, is the hierarchy of the partners. The relation between the teacher and the assistant scientist is not a collegial relationship since this requires that the two partners share similar experiences. Another way to develop professional knowledge is to learn from an experienced professional, as an apprentice. Apprentice learning is the learning of skills in action where the learner learns from someone who is not necessarily very pronounced in his or her knowledge. For instance, in science, teachers have learnt to understand science through practice with scientists. Teacher students learn from observing experienced teachers in the classroom. Apprenticeship learning involves learning by imitation and differs from learning that takes place in an off set environment, for instance in a lecture or workshop where the learner adopts structured knowledge (Sadler, Burgin, McKinney, & Ponjuan, 2010).

In the ASTEP case, we have two professional learners, the teacher and the university student, who are equipped with widely different experiences from their professional and personal lives. In a way, both the primary school teacher and the university student, meet as
apprentices. None of them are real experts at IBSE but they learn in action in a common classroom.

As in many other countries, French primary school teachers often lack background training in science. Very few have any additional training in science after upper secondary school (college and lycée), and most have entered their teacher training programs from programs in the lycée other than science or technology. When the architecture of ASTEP and LAMAP was first designed, around 1998, Charpak and colleagues suggested a couple of organizational measures to improve the ability of primary school teachers to teach science with an IBSE approach. These measures included the creation of 16 centers, the in-house training of teachers and the accompanying of the teachers in the classrooms of scientists and the development of ASTEP as a program for professional development (Charpak, 1998).

An IBSE approach, as in the LAMAP material, does not automatically lead to improvement of subject content, for this the inquiry must address an aspect of science that is new to the learner. In a report to the Swedish National Agency of Education, Tytler (2010) summarized what misses out if a teacher lacks the necessary science content. The support that the teachers in the ASTEP program get from LAMAP the material and the student together, helps to avoid most, if not all of these fall-outs. I have summarized how I have found that this works in the table 2:

Table 2. Qualities missing out when teachers lack science content knowledge (Tytler 2010), and how these fallouts are intercepted by qualities of the ASTEP program.

<table>
<thead>
<tr>
<th>Difficulties when teachers lack science content knowledge.</th>
<th>ASTEP design</th>
</tr>
</thead>
<tbody>
<tr>
<td>design lessons for underlying science concepts and processes;</td>
<td>help from LAMAP material</td>
</tr>
<tr>
<td>engage students in exploration of scientific ideas, beyond focusing on investigation processes;</td>
<td>help from LAMAP classroom kit and discussion with student</td>
</tr>
<tr>
<td>recognize students’ conceptual difficulties with particular scientific ideas</td>
<td>Help from student</td>
</tr>
</tbody>
</table>
(distinguishing between valid and invalid reasoning);
ask questions that lead children to reveal and reflect on their ideas; help from student
avoid ‘blind alleys’; help from student
provide relevant sources of information and other resources; help from student
respond spontaneously and productively to students’ ideas; help from student
monitor progress in understanding, and taking advantage of teachable moments dialogue and help from student

**Teacher learning in ASTEP – redirecting instructional practice**

The clear intention of ASTEP PD program is to teach the teachers a “new” pedagogy of having the children lead the theme that they choose for their class. This is often a change of teacher attitude and of their practice. The intention is that the teachers within a near future will feel more at ease to teach science. The responses from the teacher surveys seem to confirm that this actually happened. Further support is in the national evaluation of the ASTEP program, covering about 2600 teachers in partnerships with students or retired professionals (Ministère de l’éducation nationale, l’enseignement supérieure et de la recherche., 2014).

Teachers in this study report that one major advantage with the project is that there is an additional adult in the classroom. They appreciate the help with the logistics and they appreciate the co-planning. There are no comments that the student is difficult or demanding. The teachers in ASTEP in this study seem to orient themselves into the scaffold of the LAMAP pedagogy, i.e. they change their attitude and belief about the IBSE pedagogy. They do this rerouting of praxis in their own classroom with children they already know and with a (low budget) assistant at their side. And, the teacher is the partner in the pair who runs the show as their professional practice is in focus and in command as in the top right quadrant of Fig 1.
In order to understand the efficacy of professional development programs, it is necessary to understand what the teachers learn and change. In this study, I have used the IMTPG model to catch the interaction between what the teacher sees happening to the pupils, ideas from the LAMAP material and discussions with the student, all interplay to change teachers’ practice as well as attitudes and beliefs. Attitudes and beliefs do not have to change first, teachers’ learning can take many different ways. The IMTPG model provides a different explanation to the causality of teacher change than for instance Russel and Martin (2013) or Apostolou and Koudaitis (2010) who put emphasis on teacher beliefs.

**Student learning in ASTEP – identity work at a low stake high support arena**

The ASTEP program was originally designed to improve science teaching in primary schools and the students help to do so. In contrast to the teachers, students in this study report significant uncertainty about how to act, what to say and when. They are not in command, but somehow they manage to help the teacher to understand the two areas of focus: IBSE and core content. The students also learn a bit of subject content. They most probably learn and reflect about the relevance of arguing and about how to understand causality. Yet, the most important learning goes on in the identity work that they do during the ASTEP program.

One acknowledged problem in developing university students to become efficient teachers of science, is that it is hard to redirect their practice from their own school experience. Jones an Luzon (2007) suggest 7 criteria to teacher educators, to stimulate new perspectives in teacher education and to bridge the gap between values and what teacher students learn. Their emphasis is in practice and on the importance of conceptual revolutions for rethinking of how teacher practice can be. The ASTEP students are not all on track to become teachers but they may play an important role in developing school practice.

The IMTPG- model describes how professional growth initiates and takes place in different domains. One domain, the personal, is characterized by the person’s perception of who he/she is. This is intimately linked to the concept if identity. Since an important part of the results concern the development of a professional identity among university students as well as a changed perception of identity among teachers, I chose to deepen the discussion about identity further.

The identity of a person can be described as what it is that constitutes why someone is “a certain kind of person” and how a person through new experiences may change to be a
slightly different kind of person than before the experience (Gee, 2000). Gee suggests four perspectives to view identity, and suggests that these four perspectives can be used as an interpretive tool to understand classroom practice as well as PD. The four perspectives are:

- The Nature-identity which is our inherent identity given to us by nature,
- the Institutional-identity which is our formal position in society,
- the Discourse- identity which is the identity given to us through dialogue and interaction with outsiders and,
- the Affinity-identity, which is the identity we seek and develop through membership in various “affinity groups”.

Identity according to Gee’s criteria has been used as an analytical lens to understand how this professional identity is developed (see for instance Luehmann, 2007; Saka, Southerland, Kittleson, & Hutner, 2013). In the postmodern world, identity formation is hard and necessary work for young people and of greater magnitude compared to what it has been historically (Gee, 2000). Luehman (2007) builds on Gees criteria to argue for how we need to understand the development of identity of novice teachers if we want to reform science teaching in schools. There are many challenges for novice teachers to meet for a successful professional life. Cognitive knowledge of competences are not enough, also affective qualities need to be managed (Geijsel & Meijers, 2005; Luehmann, 2007). Again, borrowing from Gee, Luehman defines “teacher professional identity” as being recognized by oneself and others as a certain kind of teacher. According to Luehman, beginning teachers need to experience out-of school teaching situations and safe places for the development of inquiry skills. But experiencing alternative ways and settings is essential but not enough. The teacher students also need to interpret and recognize their own participation together with others. A narrative of their own experience is a powerful tool for the development of identity and a toolbox for future actions.

“In sum, professional identity development as a reform-minded science teacher not only requires opportunities to participate in relevant experiences and the discourse, but to have one’s participation interpreted and recognized, as well as valued and accepted, by self and others. Teacher preparation programs need to provide support and opportunities for this ongoing recognition work. ...and thus, contribute to the development of
Young people of today are exposed to an abundance of choices in their lives. Gee describes how the modern and postmodern person has to use power from other sources than people in the premodern world, to develop their D-identity (modern) and A-identity (postmodern). Much of this modern identity work is about “finding oneself”. However, it often has a backside of emptiness and stress (Brinkmann, 2014). Luehman says that for development of professional identity of teachers, they need a safe scaffold and several different sites of different character for numerous assignments. The assignments should be of “low accountability and high in support” and include significant “recognition work”.

According to data presented in this work, ASTEP students make conscientious reports on what they did and how in the classroom and in the planning with the teacher. These reports are written within the safe scaffold of an organized course and on a predefined document template. There is little room for fall-out when it comes to mediating a picture of what went on in the classroom both over time and in content. In this analysis I have used grounded theory to find out what the students describe within this framework. One aspect is of course, that what they describe is in line with an IBSE pedagogy. But in their analysis, they spontaneously reflect on the development of their own competencies and on their identity development. This reflection becomes a story which is part of how the students invent themselves.

The ASTEP students may or may not become teachers depending on their future choice at the master level. Very few will become teachers in primary school. Still, the ASTEP experience contains many components that may facilitate their development of a professional identity. One is the confrontation with the new context of science in primary school. In this new discourse, the student has to abandon habitual expectations to be recognized mainly for their own understanding of complicated facts and instead relate to children’s understanding of science. But the reflection about this, which the student manifests in the papers and in their oral presentations, is probably weightier for their development of professional identity. The ASTEP course framework provides a low stake high support arena for this development.
Critical aspects of data treatment

Teachers and students report to the ASTEP organizers and to their university professors. Their reporting is influenced by the questions asked and also, for the students, their wish to pass their course. This may influence the validity of the data. In the case of the students, some aspects of what they write in their reports are requested, e.g. a short description of the purpose of the ASTEP program and descriptions of how the lessons were planned and how they went and so statements about this may be overrepresented and not a true measure of what the student actually learnt. The students have to say something about difficulties and satisfactions but not what. Similarly, the teachers are not demanded free comments, but they still give them. The degree of freedom of the latter two aspects, increases the validity of the data. To estimate the reliability of the grounded theory analysis, a few student papers that were not included in the random selection of 10 papers, were read through and they did not strike as being significantly different from those that were analyzed in depth.

Concluding remarks

In this work I show that the structure of ASTEP provides such possibilities for the students. I suggest that the identity work that the students do is of relevance to most future careers that they choose. Many countries like Sweden and France, see a drain of students from science teacher programs and from several other science programs. For a new generation to accept and supply roles in professional life they need both to accept and change how their predecessors have defined their role. I suggest that similar inclusion of work on identity that has here been demonstrated for the ASTEP course may reduce the drain of students from these programs.
References


