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# Students´ Different Strategies in their Development of Knowledge, Understanding, and Skills in Science Education

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## *Abstract*

*Students differ in their ways of accomplishing varied forms of knowledge, develop personal understanding and improve their skills. Likewise, teachers differ in their way of teaching depending on earlier experiences and training, thus, for teachers it is important understand the different strategies of the students and their own pedagogic profile in order to design learning situations advantageous for all students.*

*In this study we try to describe the development and the persistence of the learning outcome of five pre-service primary school teacher students and their teachers during one semester of science and technology teaching. The assessment of the students' fulfilment of the knowledge requirements was made during and shortly after the course, all of them passed. The focus here is to analyse the students and teachers different routes to achieve professional skills and was made eight months after the finished course. The students and the teachers met and discussed their experiences of their development during the course. The discussions in the whole group and in smaller subgroups were recorded and analysed. One area of interest was to describe the personal and professional development during that semester and how this was regarded retrospectively. This may be regarded as an assessment of the pedagogic activities and their relevance for the different students.*

*Another important objective was to describe the conceptual development of both the students and their teachers and to investigate if there were differences in their development. The development of the conceptual profiles of each person was constructed out of the discussions analysed to reveal developmental changes. The conceptual profiles were regarded to contain three basic zones, externalism, internalism and relational.*

*A third objective was to investigate the quality of the development out of the criteria of Doll, the four R's richness, recursion, relations, and rigor and to what extent these criteria were visible in the conceptual development?*

*On the professional and personal level all participants recognized a development, for the students supported by experiences during practical training at schools. The result also show that type of conceptual development varied between participants but large similarities in the degree of conceptual development of different concepts in one person. Finally, many of the generative phases of conceptual development were correlated to Doll's criteria of quality in teaching and learning.*

## 1. Introduction

Assessments of students' performances at examinations may be used to evaluate the learning outcome in relation to the design of different learning situations during a course [1]. This type of assessments, both of the learning outcome and of the pedagogy, is related to the students' performance at the end of the course. But, what is the outcome in a longer perspective? Once, in the assessment of the outcome of a four years teacher training program one of the students declared: "It's strange, I only remember the last course of each semester, the others are forgotten!" Of course the student had reached the goals of each course and passed all examinations but some of the learning outcome was lost.

Students also give different responses on pedagogic situations, learn different things, or may prefer to present different forms of learning outcomes. This may be become more prominent months or years after they participated in a specific didactic activity [2]. One reason for this is, of course, the students' use of new experiences, new relations, new theoretical frameworks, etc. to reiterate the original thoughts into new contexts and out of new perspectives [3]. From the perspective of the teacher it is not only important to know the sustainability of the results of a learning situation but also to know how this is appreciated by student. Not only students differ in their ways of accomplishing varied forms of knowledge, developing personal understanding and make improvements of their skills. Likewise, teachers do not only differ in their way of teaching depending on earlier experiences and training, they also are influenced by their participation in the learning processes of the students'. Thus, for teachers

it is important to understand the different strategies of the students and their learning contexts in relation their own pedagogic profile and development during a course in order to design learning situations advantageous for all students and for themselves.
As one of the objectives in an earlier study, Mutvei & Mattsson [4], aimed to identify the differences in the process of the achievement of new knowledge among six students (age 22–37) during an integrated course in biology, chemistry, physics, and technology within a pre-service teacher training program during 20 weeks. The results of that study did not give a clear picture on the personal level although a more general description of the personal and professional development of the students and the learning outcome development was presented. This was partly possible due to an included special, shorter study [5]. Retrospectively, we think it was premature to try to describe the development of the students during or immediately after the course, our tools for the assessment were to blunt, and in order to get a full picture also the teachers' development during the course should have been included in the study. In order to get a clearer view of the individual and collective processes we designed an assessment tool founded on conceptual profiles [6].

## 2. Objectives

The primary objective of this study was to describe the persistent personal and professional development, during one specific course, of both the participating students and their teachers. This may be regarded as an assessment of the pedagogic activities during the course and their relevance for the different students.
Another important objective was to describe the conceptual development of the students and the teachers and to investigate if there were differences between the individuals in this development and in that case also describe these differences.
A third objective was to investigate the quality of the development out of the criteria of Doll, the four R's *richness*, *recursion*, *relations*, and *rigor* [7] and to what extent these criteria made the development more visible?
Finally, do students and teachers have different routes to achieve professional skills and are their different degrees of persistence in the learning outcome of five pre-service primary school teacher students and their teachers during one semester of science and technology teaching.

## 3. Material and methods

The science course is a held during the fifth semester of a four-year primary school (year 4–6) teacher training program, and is optional. Five out of the six participating students that completed the course were included in this study and all of them reached the knowledge requirements of the course and passed their examinations of different parts during or shortly after the course. Two teachers responsible for teaching biology, physics, and the major part of chemistry was also included. Information from the other chemistry teacher and the teacher in technology was used but the development of these were not evaluated.
The students and the teachers met and discussed their experiences of their development during the course eight months after the finished course. The discussions in the whole group, five students and two teachers and one external moderator, an ecology teacher from the same department, and in smaller subgroups were recorded as audio files. During the discussions everybody tried to describe their experiences and development during and after the course. The discussions had an open structure but were supported by material from the course like schedules, manuals, and other texts used during the course.
The audio files were analysed using Doll's four R's [7]. The main scientific concepts of the course as, e.g., *force*, *gravity*, *molecule*, *digestion*, and *natural selection* were primarily analysed, but also other concepts outside the strict scientific framework used in the discussions and supporting the descriptions of conceptual development were included. In this concepts important in education as, e.g., knowledge content, understanding, learning, and learning design were analysed. Primarily the conceptual profiles were regarded to contain three basic zones, externalism, internalism and relational.

## 4. Results

Although the course was designed as a part of a teacher training program, it became clear, already in the beginning of the discussions, that neither the teachers nor the students consequently regarded it as a course aiming at deeper subject knowledge, science didactics, or professional development. As a consequence the experienced context varied among the students and teachers and influenced their use of the different science concepts. These differences could also be traced in memories of the

expectations of the students but also in the expected learning outcome. Based on these expectations the experienced context varied, not only between participants but also within them depending on the subject discussed.

Thus, we soon found *learning* to be an important concept to analyse as seemed to be central to all participants but with different denotations in different situations leading to different expectations. Learning more about a subject leads to another kind of knowledge compared to learn how to use didactic tools which also differs from developing the professional skills of a teacher. Subject learning was here mainly regarded as internalism, as it for most persons it is related to the remembrance of text book contents. On the other hand, learning science didactics was an example of externalism as didactic tools are at hand for the teacher. Learning professional skills is relational as almost all professional contexts includes relations to others also if they includes content knowledge and the use of didactic tools. Although the group were small it is not possible to present individual profiles here we will give some examples of what we found.

The teachers had not been taking into account the problems of the different contexts appearing within the same course and the time that was needed for the different projects. The plan was to work with the concept *force* during one week. "*After three weeks we still hadn't seen any conceptual change*". "*We thought we could teach you the meaning of force."* The teachers were not aware of the context dependence: "*We thought the concepts were independent of context".*

If we look at the students, the different expectations could be found in the same person at different occasions. "*I think the most important result for me had no relevance for the subjects, it was more personal, and it was more about group dynamics than science".* This may be understood as an acknowledgement of the group processes and their influence on learning and is relational. The same student also claimed at one occasion: "*I don't think I learned so much*" referring to subject content. The expectations on didactics were clearly pronounced and not satisfied: "*I thought I wanted to know more about how to teach science in alternative way. We discussed this much and we disagreed to some extent about the denotation of different concepts and about how to teach the concepts.* On the other hand, another student said: "*I really got tools or it widened my views in a different way and I lost some of worries*". This student also clearly stated what had been important for the development: "*But I think I learned much just because of you, we were reflecting but you were thinking, because you had achieved something or learnt something and gave ideas how we could transform specific areas within biology* ".

One of the most appreciated parts of the course was. "....when we were dancing, when we had that class about how to learn with the dance teacher, Paul, which was the most valuable part of the course." This is an example of aesthetic learning processes used for chemistry teaching regarded as more beneficial than practical work.

## 5. Discussion

The general opinions about the course were clearly positive when declared retrospectively. Although the relational and personal development were greatly acknowledged these were anyhow not directly regarded as important learning outcomes. They seem to be a natural result of the design of the course. They are regarded as positive outcomes but, maybe, as they are absent in the knowledge requirements of the course they are not as important as the achievement of other skills. In general discussions it also was easier to identify subject contents and didactic methods that ought to have been included in the course than spontaneously identify the actual learning outcomes. If we look at the planning of the course there were some main obstacles.

The teachers aim to focus on concept understanding when designing the course was based on earlier ideas of conceptual change [8] and big ideas in science education [4, 9]. These ideas may be useful if scientific theories are the main content of a course but within teacher training aiming at developing professional skills and ability to communicate it is probably better to focus on the understanding of concepts in different contexts. Further, the content of the course was also adapted to the Swedish curriculum for primary school [10] to prepare the students for their coming profession.

One problem connected to this view may be the lack of other contexts were the concept is used in another meaning. Several what we regarded as common words in Swedish were unknown to the students. This was especially significant in technology when the students describing or making different constructions. The technical development leads to products with invisible insides in closed capsules or mechanical objects replaced by digital ones. This also reduces the opportunities for hearing words for functional things like *lever*, *hinge* or *pendulum* as well as word for tools like *spanner*, *screwdriver, jack,* or *jigsaw*. This makes it harder to use analogies in the teaching and this reduces the possibility for the teacher to vary the language.

We also noted students primarily aiming at developing their professional skills rarely used the scientific concepts when describing their progress during the course. We thought the discussions should include more use of the science concepts but the students focused on rather talked about structure and didactic tools than theories and how they should be taught. The general opinion of the course was very positive but this was not directly in references to learning outcomes. All participants had developed closer relations to each other and this was regarded as important for their professional development. For the students this was supported by their experiences and the teachers' observations during practical training at schools.

Finally we made a similar observation as earlier reported [11]. Students with a non-scientific background seemed to be very content with the course as it gave them, as they regarded it, an overview and tools to teach without deep knowledge about the subject.

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