Curious minds in the classroom

Wetzels, Anna

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Chapter 1
Introduction

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1.1 Background

Teacher professional development is essential for increasing and maintaining both the quality of teaching and children's level of learning, and thus, essential for improving the overall quality of schooling (Day, 1999; Imperley, Wilson, Barrar, & Fung, 2007). The general aim of this dissertation is to describe the design of a professional development program for teaching science and technology in the earliest school years from a complexity viewpoint and to report the results of the related effect study.

Why is teaching science and technology in preschool and grades 1 and 2 so important? Young children are already little researchers, developing intuitive theories of their environment, based on their daily experiences and on innate core knowledge (Carey & Spelke, 1996; Van Geert, 2011). However, these intuitive theories are not always in line with scientific reality. Teachers can help children to gain an accurate understanding of fundamental theories, but this does not happen by simply replacing the intuitive knowledge with the right conceptions by means of direct transmission. Mere transmission of knowledge does not establish real change in the minds of children. How then can teachers help children to change their misconceptions over time with correct scientific reality?

Children ask questions such as: What are stars? Why does an apple fall down? Why does the sun stay high in the sky? Why do leaves turn brown in autumn? Where does the snow come from? Children show a lot of curiosity for everything that happens in their environment (Loewenstein, 1994). Children love to observe, touch, taste and further examine everything they encounter, as most parents with young children will confirm. What is striking is that once these children go to school, this curiosity seems to slowly vanish (Engel & Randall, 2008; Engel, 2009; Engelhard & Monsaas, 1988; Osborne, Simon, & Collins, 2003), and when children reach grades 7 and 8, many children hardly show any curiosity for this kind of natural phenomena at all.

In order to gain more insight into the process of vanishing curiosity, which eventually might be a natural and inevitable phenomenon, Engel (2006) observed the way teachers encourage curiosity in classrooms and made an overview of teachers' utterances during various activities and classes. She discovered that no matter what activity or class, teachers generally just check knowledge or remind children to stay on task and thus hardly stimulate curiosity at all.
A good example of this behavior during science class is the following:

For instance, in one fifth-grade classroom, the teacher had set out an activity

> meant to show the children something about how Egyptians first invented wheels. She gave small groups of children a long slab of wood, some small wooden wheels, some blocks to transport on the slab of wood, and a string with a small measurement tool that, when attached to the slab, could measure the distance and time the slab was traveling when pulled. The children were also given a worksheet on which they were to report how easy it was to pull the slab when the number of wheels were added and subtracted. Children were eager to work with the materials, and the room seemed lively with activity. The teacher moved about the room, offering hints and suggestions about how to pull the slab, so that the children could fill out the worksheets. She made frequent comments commending the kids on achieving the goal of filling out their worksheets. At one point a child started to fiddle around with the materials, pulling the string in unexpected ways, moving the wheels, and adding other small objects to the slab. The teacher replied, "Kids, I'll give you time to experiment at recess. Now it's time for science." (Engel, 2006, p. 7).

Thus, it seems that teachers hardly ask questions in the classroom and hardly encourage inquiry and curiosity in the classroom. Since inquiry and curiosity serve as the basis of science and technology learning, children's diminishing interest in science and technology during their primary school careers (Osborne et al., 2003) could be associated with their experiences in the earliest school years. This suggests that in addition to leading to diminishing interest, these early negative experiences could also result in negative attitudes towards science and technology in young children.

Young children's diminished interest in science and technology is likely to increase the probability of negative experiences with this science and technology. Since negative experiences with science and technology in school are correlated with less self-efficacy in science later in life (Bleicher, 2004), it is to be expected that children who have had such negative experiences will very likely not choose for a career in science and technology related topics later in life. This is extremely problematic in an age that depends on science and technology more than ever before. Scientific literacy is necessary for everyone, not only for those who pursue science and technology careers because everybody needs the ability to engage with science and technology and to use scientifically informed ideas to reflect on socio-scientific issues (Guerin, 2015). One merely needs to consider the myriad of problems society is dealing with at the moment, such as energy and water supply, waste disposal, global warming, problems of developing countries with regard to their economies, poverty and the labor market. All these problems need science and scientists to help our earth and its inhabitants move smoothly into the 22th century.

This leads to the conclusion that it is important for children to acquire early positive science and technology experiences, and to have their natural curiosity and interest in inquiry be stimulated from the early school years on (i.e., in preschool and grades 1 and 2 (group 1-4 in the Dutch school system). Various countries have already started nationwide programs to stimulate science and technology education for young children (e.g. in Germany, Haus der Kleinen Forscher ("http://www.haus-der-kleinen-forscher.de/en/," n.d.), in the Netherlands, the Dutch Institute for Educational Policy in Science and Technology (PBT), and the Curious Minds project, which will be described in more detail in the section 2.1).

An important starting point in this discussion is that the people who should provide these early positive experiences are the teachers. Their quality of teaching is crucial for pupils to keep a positive attitude towards science (Osborne et al., 2003). In other words, teacher and student co-construct knowledge in a socially situated learning perspective (Granott & Parziale, 2002; Sorsana, 2008). Science learning and teaching are created in the interaction dynamics between a child, an adult (in this study the teacher), and the materials as used in the transactions (Steenbeek & Uittenbogaard, 2009). If the interaction is positive, teacher and child can lead each other into a self-sustaining positive talent spiral, (Van Dijk, Van Geert, & Steenbeek, 2010) in which teacher and child stimulate each other to show higher levels of science reasoning and of teaching behavior that elicits scientific reasoning. The teacher plays a very important role in instigating this positive spiral. In other words, science and technology talent in children, which is extensively described in the Curious Minds project (Post, 2009; Van Benthem, Dijkgraaf, & De Lange, 2005) and which involves interest, curiosity, inquiry, diverse forms of reasoning, logical thinking and problem solving develops in this interaction. For this reason, we hypothesize that it is possible to stimulate the science and technology talents of young children by improving the skills of their teachers ("Start Science Sooner," 2010).

Nonetheless, improving skills of teachers in a professional development trajectory cannot be seen as a simple cause-and-effect process. Teachers work in a complex world and a complex school environment with several context variables that all have an influence on their behavior. A complexity viewpoint or ecological viewpoint (Dishion & Stormshak, 2007) is needed when taking all these factors into account, namely all the factors within a person and within society that act simultaneously and mutually interact to contribute to behavioral change to a greater or lesser extent. This complexity viewpoint is addressed in this dissertation by means of focusing on three intrinsic properties of complex dynamic systems, namely the iterative (or recursive) character of a process, the inter- and intra-individual variability of teachers' behavior, and the occurrence of patterns and mechanisms of change on various interdependent time scales (Steenbeek & Van Geert, 2013).

1.2 Research questions

The first aim of this dissertation is to develop and describe a coaching program for teachers (Video Feedback Coaching for Teachers, in short VFC-T) that influences teachers' behavior in order to stimulate pupils' scientific reasoning. The focus of the intervention is to develop a coaching trajectory that can be implemented in classrooms without costly investments in material and training hours. An important question is what such an intervention for teachers in lower grades for teaching science and technology should look like. In particular, what intervention characteristics are necessary when developing a coaching program aimed at changing teachers' behavior so they can teach science to young children? We realize that any such an intervention implies intervening in a complex and dynamic system, namely a concrete teacher in a concrete school context. This implies that a multitude of intertwining factors influence a teacher's professional development trajectory that must all be taken into account.

A second aim of this dissertation is to examine what the effect of the intervention is on a teacher's professional well-being. For instance, does the intervention enable teachers to feel comfortable to use the learned content regarding teaching science and technology in the classroom? Addressing teachers' well-being when designing the intervention is important because this will enhance their motivation for using the learned content in the classroom.

The third aim of the dissertation is to examine the results of the intervention: did it change the behavior of the teachers in the classroom, and did the teachers' behavioral change also change the behavior of their pupils?

1.3 Overview of the Chapters

The coaching program is described in chapter 2. The program is based on various general principles in the fields of talent and talent development, learning and teaching and behavioral change. This chapter is dedicated to the first aim of this dissertation, namely the development of a coaching program that influences teacher's behavior in order to stimulate pupils' scientific reasoning. The chapter starts with a description of the background of the program and continues with the way this coaching program is embedded in a nationwide program to stimulate science and technology in children, the Curious Minds project. Next, it proceeds with describing how the general principles of the Curious Minds project and general principles of behavioral change have been implemented in the coaching program. Additionally, the coaching program itself is described, as well as the training program for coaches.

Chapter 3 gives a theoretical overview of aspects that contribute to the effectiveness of interventions regarding teachers' professionalization. Subsequently, effectiveness and effectiveness studies are re-interpreted by using a complexity approach. Finally, a multiple case study empirically illustrates the complexity approach to the effectiveness of interventions. The chapter provides an additional answer to the first research question. The influence of the environment and various aspects of an intervention are described from a complexity view point as well as from a more 'standard' viewpoint.

Chapter 4 gives an answer to the second research question, namely, to what degree the VFC-T and the subsequent science and technology teaching in the classroom have a positive effect on teachers' well-being and motivation. For this effect study, a mixed method design is used, with qualitative and quantitative methods, to address both results in the classroom and the way teachers react to the program.

The effect study in chapter 5 gives an answer to the third research question: what are the results of the intervention in terms of teachers' and pupils' changed behavior in the classroom. Instead of just looking at the results that can be observed after the intervention, the study also focuses on changes during the intervention in the teachers as well as in the pupils. Behavioral change in this chapter is studied by observing to what degree teachers show changed behavior in their actual teaching with respect to stimulating pupils' scientific reasoning skills, and subsequently, to what degree their pupils show changed behavior with respect to their level of scientific reasoning skills during the science and technology lessons. This study uses micro genetic measures and focuses not only on changes in teachers' and pupils' behavior, but also on their interaction patterns in the classroom during science and technology lessons. In line with our complexity and dynamic approach, the results are given both on a group and an individual level.

Finally, chapter 6 provides a summary of the dissertation and a general discussion of the previous chapters. Possible consequences of the results of this dissertation for educational practice in the classroom are discussed, as well as the implication for teacher education regarding science and technology in the earliest school years. Furthermore, some implications for future educational research are discussed.