MAKING EDUCATIONAL REFORMS PRACTICAL FOR TEACHERS

USING A MODULAR, SUCCESS-ORIENTED APPROACH TO MAKE A CONTEXT-BASED EDUCATIONAL REFORM PRACTICAL FOR IMPLEMENTATION IN DUTCH BIOLOGY EDUCATION

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Chapter 1

GENERAL INTRODUCTION

1.1 Introduction

"Change in education is easy to propose, hard to implement, and extraordinary difficult to sustain" (Hargreaves & Fink, 2006, p.6)

A large number of educational reforms have been proposed in recent decades. However, the implementation of most of these proposals in teachers' classroom practices have been found to be problematic (Fullan, 2007). Many attempts failed or were not implemented according to the original design, with the risk of losing the essence of the reform proposal. How is it then, that most change proposals are poorly adopted by schools and teachers? To understand this, we need to focus on the teacher, the work of teaching and the challenges that this brings. In the process of implementing educational reforms, teachers are the "key agents" for achieving changed classroom practices (Borko, Elliott, & Uchiyama, 2002; Fullan, 2007; Spillane, 1999). To successfully implement a reform proposal, teachers need to enact the proposed reform in their daily teaching practices. A problem with this is that change proposals are mostly formulated as visions or ideals and seldom as programs for practice (Borko, 2004). Teachers have to translate such visions into practices, which they rarely do according to the original design of the reform (Remillard, 2005; Van den Akker, 2003). In the process of translating a vision or ideal into practice, teachers tend to domesticate the proposed reform into familiar practices (Doyle & Rosemartin, 2012). The reason for such failure to implement change can best be understood by examining the work of teaching and the challenges that it brings. A teacher has to teach relatively large groups of students with a variety of backgrounds, having limited time, space, and resources. In addition, a teacher has multiple goals that he/she wants to achieve that are always present to guide decisions such as promoting student willingness to participate, covering content or fostering learning (Kennedy, 2005). In short, teachers work in a complex and demanding classroom ecology (Doyle, 2006) that holds certain limitations and challenges. To cope with this, teachers have

developed routines over time that have become part of the fabric of everyday classroom life (Janssen, Westbroek, Doyle, & Van Driel, 2013). When teachers are confronted with a reform proposal, the language of the reform proposal simply seems to be incongruent with their everyday, routinized practices.

The question then becomes how to bridge the gap between the world of educational reforms and the practical demands of everyday classroom teaching. Already in 1977, Doyle and Ponder posed that teachers will only implement change in their classrooms if they consider it to be practical. His practicality theory prescribes that for successful implementation of change, the change proposal needs to contain instrumental content, be congruent with regular teaching practices and cost little time and effort. To date however, the majority of educational reforms seem to have overlooked these important criteria of practicality theory.

In settings where educational change is required, teachers are asked to (1) learn new knowledge or skills, (2) understand the meaning of the change proposal and (3) be willing to change (Fishbein & Ajzen, 2010; Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010). Such teacher learning is mostly facilitated by offering teachers professional development (PD) opportunities. Literature shows several features of high-quality PD such as situating teacher support in practice and addressing problems of practice, focusing on student learning, giving teachers opportunities to learn actively, taking teachers´ regular practices as starting point for change and making the support school-based (Borko, Jacobs, & Koellner, 2010; Garet, Porter, Desimone, Birman, & Yoon, 2001; Supovitz & Turner, 2001; Van Veen, Zwart, Meirink, & Verloop, 2010). Although such features of effective PD can be very helpful in designing a PD program that supports the implementation of an educational reform, we propose that a crucial element is missing: practicality.

This research project was aimed to make a context-based educational reform practical for implementation in Dutch biology education. The context-based reform proposal predominantly comprises the introduction of a context-based curriculum, where biological topics are organized and taught by using contexts that help learners to connect new knowledge to prior knowledge and come to see the important role of biology in society and professions (Boersma et al., 2007). The context-based reform proposal was implemented in September 2013.

In the present research, two approaches were used to make the reform proposal practical: a modular approach and a success-oriented approach; these are further elaborated in section 1.3.3. The focus of this research was to make a context-based reform practical and explore the resulting development of teachers' instructional approaches and their intentions to implement the reform.

1.2 Context of the study

This study was conducted in the setting of a national reform for biology education. In a joint report (KNAW, 2003), several stakeholders identified three problems in biology education: a lack of relevance, a lack of coherence (especially between biological concepts), and an overloaded curriculum. In response to this, the minister of education, culture, and science established a National Biology Education Innovation Committee (CVBO) which was charged with the task of working out a solution to the three identified problems. In 2007, the CVBO committee proposed a context-based curriculum for Dutch biology education (Boersma et al., 2007). This proposal predominantly comprised an update of the biological subject matter and a revision of the biological concepts and skills to be learned for the final examinations. However, the committee did acknowledge the inevitable effects on teaching practices and also formulated guidelines for designing context-based lessons. Our research was aimed at assisting teachers in bridging the gap between the proposed curriculum change and their regular, day-to-day practices by making the context-based change proposal practical.

This research was part of a broader research program in the Netherlands (DUDOC). In the DUDOC program (2007-2012), 20 science and mathematics teachers (pre-university education) were trained to become educational researchers while carrying out a PhD project for three days a week and meanwhile continuing to teach in secondary schools for approximately two days a week. The focus of the DUDOC research program was to support the implementation of the current reforms in science and maths and make the implementation more evidence-based.

1.3 Conceptual framework

In this section, we describe three important elements of our research: Context-based education (1.3.1), professional development programs in the context of educational reform (1.3.2), and the concept of practicality (1.3.3).

1.3.1 Context-based education

Context-based education is an approach to education in which subject matter is organized and taught by using contexts. It is not only advocated in the Netherlands, but has already been implemented in several other countries; for example, Salter's science in Great Britain (Bennett & Lubben, 2006) and "Chemie in kontext" in Germany (Parchmann, Gräsel, Baer, Nentwig, Demuth, & Ralle, 2006). The use of a context to teach subject matter is thought to bridge the gap between the often abstract and difficult scientific concepts and the world the students live in (Kortland, 2007). Students often see school science as disconnected from the real world, leaving them with little interest in science, little understanding of the role of science in society and little awareness of career possibilities in the field of science (Solomon, 1996; Boersma et al., 2007; Bennett, Lubben, & Hogarth, 2007). In more traditional approaches to school science, both in teaching approaches and textbooks, science was a mere accumulation of facts in which students had to memorize the main scientific ideas with little application of those ideas in real-world problems (Solomon, 1996; Bennett et al., 2007; Gage, 2009).

Reviews of the effects of context-based education show that it can: a. Make students feel more positive towards science and increase the perceived relevance of scientific topics (Bennett et al., 2007); b. Help students come to see the important role of science in society (Bulte, Westbroek, de Jong, & Pilot, 2006); c. Evoke students' misconceptions (Scott, Asoko, & Leach, 2007); d. Help students to learn how to self-regulate their learning processes (Bennett et al., 2007) and e. Help to move the emphasis away from learning scientific 'facts' to involving students in scientific activities for which they develop skills (Krajcik, McNeill, & Reiser, 2008).

At the classroom level, the teaching-learning process of context-based education typically focuses on a meaningful context that is presented at the start of a lesson (Bennett et al., 2007). From this context, a problem or question naturally

follows that develops a 'need-to-know' for scientific concepts (Bulte, Westbroek, de Jong, & Pilot, 2006; Wieringa, Janssen, & Van Driel, 2010). Following, students have to gain insight in the concepts that are needed to answer the question or solve the problem (Bennet et al., 2007; Glynn & Kobala, 2005). There can be two options for this: students' self-regulation or a teachers' regulation (Vermunt, 1998; Zimmerman, 2002). In the first option, students have to perform certain activities themselves to answer the question or solve the problem by, e.g., searching for necessary information or relating important concepts. This is followed by reflection on the content and process of learning. In the second option, the teacher regulates learning by, e.g., presenting the needed information. This is then followed by providing students with learning activities in which they have to answer the question or solve the problem.

In order to define the term 'context', authors have proposed many descriptions such as personal situations, cases, future professions, themes, or practices (Aikenhead, 2007; Goedhart, 2004; Pilot & Bulte, 2006). In the Dutch setting, the CVBO chose to base their definition of a context on Vygotsky's sociocultural perspective and the closely related activity theory (Boersma et al., 2007; Vygotsky, 1978). A context is hence seen as a *social practice* in which practitioners participate in a central, historical activity (Van Oers, 1998). What follows from this view is that learning activities at classroom level can only have meaning when they are situated in authentic, real-world, historical, social, and culturally defined practices (Boersma et al., 2007). Other authors argue that this is only one option for using contexts. Mapping the terrain, Gilbert (2006) proposed four much-used models of contexts: (1) a direct application of concepts, (2) a reciprocal relationship between concepts and applications, (3) a personal mental activity (e.g., a personal narrative of a major event that relates to the concept), (4) a context as a social practice where learners see themselves as participants in a historical community of practice.

In our research project, we offered the participating biology teachers a short overview of these four models of contexts. From this, they were able to choose the type of context they wanted to use; this could differ between participants and change over time. Contexts should, however, be relevant to students with diverse backgrounds (Glynn & Kobala, 2005). The main reason for not giving a narrow definition of a context is that the participants in our research were being supported in making stepwise changes in the

direction of context-based education, with their regular practices as the starting point for development. And as these regular practices could be rather traditional, offering a fixed definition, such as proposed by the Dutch reform committee (CVBO), could turn out problematical for starting teachers' development. Finally, as the participants in our research designed one lesson at the time, they could hardly design lessons in which the concepts learned in one context were used or applied in another context. The notion of recontextualization (Van Oers, 2001) was, therefore, not part of this research.

1.3.2 Professional development in the context of educational reform

The changes in classroom practices demanded by reform visions ultimately rely on teachers (Borko, 2004, p.3)

Changes to teachers' classroom practices are hard to make on the basis of the visions and rationales that are presented in reform proposals. If they were easy, more classrooms would look like the ones envisioned by reformers (Wilson, Peterson, Ball, & Cohen, 1996). Changes in classroom practices require a great deal of learning on the part of teachers, which is difficult without support and guidance in the form of professional development (PD) initiatives (Ball & Cohen, 1999; Borko & Putnam, 1996). As Borko et al. (2002) put it: without PD, educational reforms are doomed to fail. Many authors have presented lists and overviews of characteristics or features of designing effective PD opportunities (Desimone, 2009; Garet et al., 2001; Guskey, 2000; Loucks-Horsley et al., 2010; Supovitz & Turner, 2001; Van Veen, Zwart, Meirink, & Verloop, 2010). In this section, we will predominantly use the recent and extensive review by Borko et al. (2010) as a basis for discussing such principles. They present the following features for effective PD: (1) PD content is situated in practice and addresses problems of practice, which helps teachers to see the relevance of the PD. Concrete tasks such as designing, teaching and reflecting on concrete lessons and classes helps them to make connections between the new PD content and their existing classroom practice (Darling-Hammond & McLaughlin, 1995). PD programs presented in isolation from teachers' actual classroom practices are doomed to fail (Lieberman & Pointer Mace, 2008). (2) The content of PD is focused on students' learning, because that is considered to be the ultimate goal of education (Fishman, Marx, Best, & Tal, 2003). (3) The preferred

instructional practices are modelled in the PD. (4) Teachers learn actively, because acquired knowledge doesn't transfer immediately into more effective practice; teachers have to practice and experience the effects of changes themselves (Guskey, 2000). (5) Teachers preferably learn collaboratively and in professional learning communities. (6) The PD setting is school-based, and (7) PD opportunities or models are preferably ongoing and sustainable.

1.3.3 Practicality

Professional development (PD) initiatives are highly needed in the implementation of educational reforms because teachers are typically asked to teach in ways that are significantly different from their regular practices (Borko, Elliot & Uchiyama, 2002). The above-mentioned set of criteria for effective PD serves as a good, evidence-based set of guidelines for designing PD programs that are aimed at achieving changes in classroom practices. However, upon closer inspection there seem to be two problems with these features: they hardly seem to be useful in concrete settings for shaping PD, and the classroom settings seem to be neglected. The first problem appears when using the guidelines to design, e.g., a PD program. Borko et al. (2010) states that effective PD programs address problems of practice and include concrete tasks such as lesson design, actual enactment of such lessons and reflection. However, this does not specify in what way these problems should be addressed or how lesson design or reflection can lead to fundamental changes in teaching practices. Nor does it specify how teachers' existing practices are taken into account when designing lessons. Another feature of effective PD states that teachers should be focused on student learning. It does not specify, however, how teachers should come to know their students´ learning outcomes or how they can use such knowledge to make changes that positively affect those outcomes. The second problem with these principles is that they seem to overlook the settings in which teaching takes place. Doyle (2006) has argued that classroom life is a multifaceted setting where many things happen simultaneously and where many actors all have their goals and interests. In the midst of that, teachers must orchestrate and sustain a safe and challenging environment where they try to accomplish multiple goals such as keeping momentum, covering scheduled content, or attending to students' emotional needs (Kennedy, 2005). In such a demanding classroom ecology (Doyle,

2006), teachers are known to have formed routinized, functional approaches to teaching which help them to cope with not only their own demands, but also the demands of school management, national standards, and parents. In these challenging settings, teachers have little time and possibility to think about change, especially when they do not see the immediate benefits for their classrooms. Teachers will, therefore, only implement a change proposal when they consider it to be practical for their classrooms (Doyle & Ponder, 1977). Practicality is defined as "an expression of teacher perceptions of the potential consequences of attempting to implement a change proposal in the classroom." (Doyle & Ponder, 1977, p.6). A change proposal is considered to be practical when it meets the following three criteria: a. Teachers should be able to envision how that change proposal would work out in their classrooms (*instrumental*); b. The content of the proposal should be connected to how teachers regularly teach (*congruent*); and c. The proposal should have high benefits and low costs in terms of effort and time (*cost*). In this way, practicality theory seems to hold a solution to the two problems described earlier: It describes three criteria for making abstract change proposals more practical and it pays attention to the classroom ecology. However, these criteria are still rather descriptive; they need further elaboration and specification for concrete settings. In the present research, these criteria were further elaborated into two approaches.

First, a modular approach was proposed that is focused on the use of lesson segments that teachers already know and regularly use (e.g., *tell, apply, test*). This approach is primarily based on work by Holland (2000). He showed in his research that any innovation can best be seen as the rearrangement and adaptation of already existing segments. Janssen et al. (2013a) have translated this idea to the field of education and proposed the use of smaller segments to innovate. The modular approach used in this research uses lesson segments to design and redesign many forms of instructional strategies through the recombination and adaptation of already existing lesson segments. In this research, the lesson segments were used to (1) represent teachers' regular instructional approach (2) represent the instructional approach of the context-based reform proposal, and (3) assist teachers in making steps using their regular instructional approach as starting point. Because the lesson segments were formulated at classroom level and provided instrumental content for the reform proposal, the hypothesis was that this would specifically increase the instrumentality of context-based education.

Second, a success-oriented approach was proposed. This approach is briefly introduced in this section; for further elaboration, see Chapter 3. It is known that building on what teachers already do and relating proposed changes to regular teaching practices can be very effective in achieving change (Darling-Hammond & McLaughlin, 1995; Putnam & Borko, 1997). This can, however, be done in several ways. In this research, we pose that teachers should not so much build on what they already do by working on their deficiencies, but rather build on their earlier successful experiences. Building on successful experiences is predominantly based on elements of positive psychology (Seligman, 2002) and the solution-focused approach from the field of psychotherapy (De Shazer, 1985; Miller, Hubble, & Duncan, 1996). This latter approach is a widely used method to motivate people to make changes that are based on their personal strengths and earlier successful experiences. Solution-focused psychotherapy starts not by focusing on problems, but by exploring the target situation. It then proceeds to check if there has ever been a situation in which the problem was not present or (part of) a solution was already successfully present. Such earlier successful experiences are then further discussed in order to propose solutions for the current problem and directions for change. The assumption is that there have always been situations in which parts of the solution were already present. Translating this approach to the world of education, Janssen, De Hullu, & Tigelaar (2008) showed that pre-service teachers formulated stronger intentions to change when reflecting on successful experiences than on problematic ones. Specifically for educational reforms, this would mean that thinking back to earlier successful experiences could assist teachers in the formulation of strong intentions to change in the direction of the reform. In the present research, we proposed that there could be two sources for finding earlier successful experiences: the teachers' own experiences and external students' data such as students' learning outcomes. The hypothesis was that building upon earlier successful experiences could promote the congruency of the context-based reform.

Finally, the combination of the modular and the success-oriented approaches uses that which is already present and facilitates teachers in making stepwise changes to their practices, which is expected to have low costs and high benefits at the classroom level. And as this research was school-based and situated in teachers' actual classroom practices, the hypothesis was that such an approach would also reduce the amount of time and effort needed and, therefore, result in low costs.

1.4 Research goal

The research goal for this study was to make a context-based educational reform practical and explore the resulting development of teachers' instructional approaches and intentions to implement the reform. The context-based reform was made practical using two approaches: a modular and a success-oriented approach. The outcomes were used to determine implications for the implementation strategy of the context-based reform in Dutch biology education. The overarching research question was:

How can the context-based approach to biology education be made practical for teachers?

This overall research question was answered by conducting four studies; these are described in the next section. In Chapters 4 and 5, we describe how both the modular and success-oriented approach were used to design a PD program aimed at learning teachers how to design context-based education (Chapter 4) and how to use students' data to implement change (Chapter 5). In Chapter 3, the same two approaches were used as a basis for a motivational interview technique aimed at eliciting teachers' strong intentions to change in line with the reform. Prior to these studies, however, we conducted a study to construct and internally validate an ID model containing a set of lesson segments that could be used in the modular approach (Chapter 2).

1.5 Overview of the study

Chapter Two

Chapter two describes the model construction and validation study that formed the start of this research project. The requirements for this model were that it had to be both practical and usable, not only by biology teachers, but by teachers in all subjects and in many different settings. On the basis of literature on ID models (Merrill, 2001; Gustafson & Branch, 2002), we aimed to construct and internally validate an Instructional Design (ID) model consisting modular lesson segments. The main goal for this ID model was to assist teachers in the expansion of their existing teaching repertoire and to enable teachers to use the lesson segments to design a large variety of lessons.

Using the lesson segments, teachers should be able to increase their teaching repertoire, which would then help them to design an instructional approach for specific settings or learners. The lesson segments should also be usable in making stepwise changes from more traditional instruction towards the instructional approaches proposed in contemporary reform proposals. In a three-round Delphi study, 11 experts reviewed and internally validated an ID model that met the set requirements. The research question for this study was: What are the characteristics of an ID model that supports teachers in continually expanding their repertoire of instructional strategies and how can such a model be internally validated?

Chapter Three

This chapter describes a study that was focused on teachers' intentions to change. Existing approaches to PD mostly lack attention to teachers' willingness to change and are predominantly aimed at the development of knowledge and skills or at creating a positive learning environment (Ball & Forzani, 2009; Borko et al., 2010). In the current study, so-called 'motivating-for-educational-change' interviews (MECI) were performed, after which we studied the development of biology teachers' intentions to change towards the context-based reform proposal. The MECI technique was based on both the modular and the success-oriented approach (see section 1.3.3). The research question for this study was: What are the developments in the strength and specificity of biology teachers' intentions to implement a context-based educational reform after performing a 'motivating-for-educational-change interview' (MECI), and what are the underlying mechanisms?

Chapter Four

In the study described in the fourth chapter, a PD program for biology teachers was designed and performed. This PD program was based on three design principles: (1) allow teachers to build upon earlier successful experiences (success-oriented approach); (2) allow teachers to attain the goals of the reform proposal by recombining and adjusting their existing lesson segments (modular approach); (3) support teachers

from a distance and according to their individual needs. The study was focused on the development of teachers' (n=8) classroom practices and also explored the strength of their intentions for each step in their development during the PD program. The research question was: How do the strength of teachers' intentions and their teaching repertoire develop in the course of a professional development program focusing on practicality in designing and implementing context-based education?

Chapter Five

This chapter describes a PD program in which biology teachers (n=5) collected and used students' data to make changes to their instructional practices. By measuring data on learning outcomes and regulation of learning processes, the teachers were able to monitor the specific effects of their instructional approaches. Next, the teachers used the success-oriented approach while interpreting and using these data to make changes to their instructional practices. During this process, we supported the teachers using three practical frames (Klein, Moon, & Hofman, 2006), all of which were based on the modular approach: (1) every lesson consists of a series of lesson segments, (2) every lesson segment can be regulated by either the teacher, the student, or shared and (3) different types of contexts can have different functions. In this study, we examined to what extent and in what ways teachers used these practical frames, and we also explored how students' data influenced the teachers' development in terms of classroom practices. The research question for this study was: How do practical frames contribute to teachers' interpretation and productive use of students' data on learning outcomes and regulation of learning processes in the setting of a PD program, and what are the influences of using such students´ data on teachers´ professional development?

These four studies together were used to answer the following overarching research question of this research project:
How can the context-based approach to biology education be made practical for teachers?
In Chapters 3 and 4, we explicitly focused on the strength of teachers' intentions to make changes in line with the reform. In Chapter 3, we studied the strength and

specificity of teachers' intentions prior to any attempt at change. In chapter 4, we studied the strength of teachers' intentions during a PD program in which each teacher designed four lessons. In Chapters 4 and 5, we studied the specific developments in teachers' instructional approaches that resulted from using the modular and the success-oriented approach.

Chapter 2

THE CONSTRUCTION AND INTERNAL VALIDATION OF A MODULAR ID MODEL THAT SUPPORTS TEACHERS IN EXPANDING THEIR REPERTOIRE OF INSTRUCTIONAL APPROACHES

Abstract

This chapter reports on the construction and internal validation process of an ID model that can be used by teachers to expand their repertoire of instructional approaches. The underlying aim for this research was to obtain valid, instrumental support for teachers who intend to expand their teaching repertoire in response to, e.g., the implementation of an educational reform or a personal desire to optimize their instruction. We proposed that such support should be in the form of an ID model that is grounded in the criteria of practicality theory. The resulting ID model is based on the concept of modularity, which allows teachers to make stepwise changes to their instruction and take their pre-existing instructional approach as the starting point for change. The ID model predominantly contains a set of lesson segments that teachers can combine and recombine to propose many different approaches to instruction. This chapter reports on the initial ID model construction and the following three-round Delphi study in which eleven experts reviewed and internally validated the ID model. The experts reached consensus on an ID model that complies with the set demands of internal validation: comprehensiveness, expected practicality, and expected effectiveness in assisting teachers in expanding their repertoire of instructional approaches.

2.1 Introduction

All teachers have a certain repertoire of instructional approaches at their disposal. The term 'repertoire of instructional approaches' refers in this study to the variety of instructional techniques and skills that a teacher is familiar with and that he/she can use to teach subject matter. Some teachers have developed a broad repertoire, but most teachers remain limited in their repertoires. More experienced teachers might use their existing repertoire more effectively, but can still remain limited in their repertoire (Borko & Putnam, 1996; Hammerness, Darling-Hammond, & Bransford, 2005). One important reason why teachers generally do not develop broad repertoires of instructional approaches is that the complex setting of teaching with its many demands does not give many possibilities for the expansion of these repertoires (Ball & Forzani, 2009). To deal with the often complex teaching profession, teachers have developed certain routine approaches to instruction that free up time for other aspects of their work. In this way, routines help them cope with the many demands and tasks that accompany the teaching profession. Other possible benefits of a routinized approach to teaching are that it helps novice practitioners to increase their teaching skills and creates greater standardization across classrooms or schools (Hammerness et al., 2005).

There is a great deal of support in literature for the view that teachers should, however, not be limited to fixed approaches to instruction and can best be regarded as innovators who are sources and creators of the knowledge and skills needed for instruction (Ball & Cohen, 1999). In this perspective, teachers who want their students to learn successfully have to design instructional approaches that are not fixed or routinized, but tailored to their students' specific needs and capacities in a specific setting (Hammerness et al., 2005). As routinized or scripted approaches to instruction are not always adequate for these purposes, teachers have to develop ´adaptive expertise´ (Hatano & Inagaki, 1986). Adaptive experts can use their knowledge flexibly to find solutions to problems that arise in new settings. In fact, the development of such adaptive expertise has become the gold standard for becoming a professional (Bransford, Derry, Berliner, & Hammerness, 2005). Teachers who have become adaptive experts can continually adapt their instructional approaches to facilitate optimum learning for specific learners in specific settings.

If teachers are asked to innovate and design instruction that is tailored to specific needs, dilemmas, or questions, the presupposition is that they already have a broad repertoire of instructional approaches at their disposal. As mentioned above, teachers generally develop a limited repertoire of instructional approaches throughout their careers. They should, therefore, be supported in the process of expanding their repertoires. Such support is mostly given in the form of models or frameworks aimed at providing teachers with the knowledge or strategies that they lack. But such a deficiency approach to teacher learning seldom seems to be successful. Any teacher support will only be effective if teachers perceive it as being practical (Doyle & Ponder, 1977; Janssen, Westbroek, Doyle, & Van Driel, 2013b). The aim of this study, therefore, was to construct and validate an Instructional Design (ID) model based on this concept of practicality. With this model, teachers could be assisted in expanding their repertoire of instructional approaches.

Richey, Klein, & Nelson (2004) state that the construction and systematic validation of ID models typically involves three important steps: 1. Initial model construction; 2. Internal validation; and 3. External validation. This chapter focuses on the first two steps; it describes how the initial model was constructed and presents the research that was done on the internal validation of the ID model. We based the initial ID model on the criteria for practicality. This initial ID model was then submitted to a three-round Delphi study, in which eleven experts participated.

2.2 Theoretical framework

2.2.1 The expansion of teachers' repertoire of instructional approaches

Teachers are the key to student learning (Ball & Forzani, 2009; Fullan, 2007). Having a broad or limited repertoire of instructional approaches, therefore, can respectively help or hinder teachers in giving their students optimum learning conditions. The reason most teachers remain limited in their repertoires (Hammerness et al., 2005) is thought to be the context in which teachers work and the restrictive implications of this for change. Teaching mostly takes place in a complex situation where teachers have to address several different goals simultaneously, such as motivating learners,

covering content, and promoting classroom norms (Kennedy, 2005). The complexity of the setting in which teachers work is further illustrated by Doyle's (2006) notion of classroom ecology. He describes teachers' multiple agendas and shows that they have to take many factors into account, such as the need to assess learning outcomes, aspects of grouping, obvious and less obvious targets, and the classroom program that students are used to. This complex setting in which teachers work, largely determines how they perceive change proposals. It is known that teachers will only change if they perceive the change proposal as being 'practical' at classroom level (Doyle & Ponder, 1977; Janssen et al., 2013b). Practicality is then defined as "an expression of teacher perceptions of the potential consequences of attempting to implement a change proposal in the classroom." (Doyle & Ponder, 1977, p.6). Three criteria serve to determine the extent to which a change proposal is found to be practical: *Instrumentality*, which describes the extent to which teachers understand how a change proposal will work out at classroom level; *Congruency,* which describes the extent to which a proposed change is congruent with how teachers perceive their own situation; and *Cost,* which is described as the balance between investment in terms of time and effort and return in terms of benefits at classroom level. Most change proposals do not comply with these standards of practicality; as a result, teachers often seem to ignore change proposals or translate them into familiar patterns consistent with the grammar of classroom practices (Tyack & Cuban, 1995; Kennedy, 2005, Janssen et al., 2013b). This leads to a situation where teachers seem to prevent change from occurring in schools (Fullan, 2007). When this happens, teachers' repertoires of instructional approaches remain limited. This is illustrated by Gage (2009), who performed international classroom observations and found that teaching is still commonly viewed by teachers as the presentation of knowledge, and learning as the application of knowledge or skills.

A broad repertoire of instructional approaches implies that teachers can choose from a wide spectrum of instructional techniques and skills. Teachers who have a broad repertoire do not only know how to use the more routinized behaviouristic instructional methods such as presentation/explanation and drill/practice, but are also familiar with more constructivist approaches to teaching, where learners have more self-regulation, for instance, and lessons start with meaningful tasks in which learners work rather independently to solve problems or answer questions (Greeno,

Resnick, & Collins, 1996; Mayer, 2002; Merrill, Barclay, & van Schaak, 2008). As most teachers do not develop such broad repertoires automatically, they should be supported in the process of expanding their repertoire of instructional approaches. Such support is mostly given in the form of general instructional design models or frameworks that are aimed at supporting teachers in lesson design. In their overview of instructional design (ID) models, Gustafson and Branch (2002) classify those models that individuals can use to design single lessons as 'classroom-oriented models'. In their view, one of the most important representatives of this group is the Gerlach and Ely model (1980). In the Netherlands, a similar model is often used to show pre-service teachers how to design single lessons. In the model, designers take a linear approach and start their design by specifying content and objective. Designers then assess the entry behavior of learners, after which they perform the following five simultaneous and interacting activities: (1) Determination of strategy; (2) Organization of groups; (3) Allocation of time; (4) Allocation of space; (5) Specification of resources. Finally, designers evaluate their performance and give feedback on possible improvements. We assessed the expected practicality and expected effectiveness of the Gerlach and Ely model (1980) in assisting teachers in the expansion of their teaching repertoires. First, the instrumentality of the components seems to be relatively low. This is because the components of the model are not described at classroom level, but at a rather abstract level (e.g., organization of groups, allocation of resources). Even though the Gerlach and Ely model can be very helpful by specifying which choices teachers should make, it does not offer instrumental content for those choices. Second, the congruency of changes with existing classroom practices is not clear. By its adaptable nature, the Gerlach and Ely model seems to offer the possibility of being congruent. But because of its abstract components, the model does not help teachers to see how they can make changes to their teaching practice and thus expand their repertoire of instructional approaches. Finally, the model requires a large investment in terms of finding options to choose from, and its benefits at classroom level are mainly that it helps teachers to think about every aspect of classroom practice. It does not seem to provide much direction for lesson design. The findings of other, more descriptive studies confirm that that such models do not give much direction for change and are also not much used by more experienced teachers (Gustafson & Branch, 2002; Yinger & Hendricks-Lee,

1995). What seems to be needed is an approach to teacher support that assists teachers to expand their repertoire of instructional approaches in such a way that they perceive it as being 'practical'.

In the present study, therefore, we aimed to construct and validate an Instructional Design (ID) model that was expected both to be practical and to assist teachers in the expansion of their repertoire of instructional approaches. The construction of the initial model is described in section 2.2.3, followed by a description of the research on the internal validation of the model. Internal validation is defined in this study as "the confirmation that the components and procedures in a model make sense to its users and are authentic towards that for which they were designed" (Miles & Huberman, 1994; Richey, Klein, & Nelson, 2004). We based the criteria for determining the internal validity of an educational intervention on those proposed by Nieveen (2007):

1. *Comprehensiveness.* Are the components of the model clear and unambiguous?
2. *Expected practicality.* Is the model usable by its users in the setting for which it is designed?
3. *Expected effectiveness.* Does the use of the model result in what is aimed for? (In this study, assisting teachers in expanding their repertoire of instructional approaches).

Richey et al. (2004) proposed three methods for internal validation: expert review, usability documentation, and component investigation. In this study, we performed an expert review in the form of a Delphi method; this is described in section 2.3.1.

2.2.2 The construction of an initial ID model on the basis of modularity

The initial ID model is expected to be used in different settings, all of which require a practical approach to change (Doyle & Ponder, 1977). Examples of such a setting are when teachers wish to learn new instructional approaches in order to optimize their students' learning outcomes or when teachers are required to change their teaching practices in response to, e.g., the implementation of an educational reform. The common feature of such settings is that teachers are expected to learn, e.g., new instructional techniques or skills to expand their repertoire of instructional approaches. Literature on the principles of effective teacher change shows that we should consider two important

principles in this process: taking teachers' pre-existing teaching practice into account and supporting teachers in making step-by-step changes instead of confronting them with big change proposals (Borko, Jacobs, & Koellner, 2010; Hammerness et al., 2005).

On the basis of the criteria of practicality theory and these principles, we proposed that the ID model in this study should be based on the concept of modularity (Baldwin & Clark, 2000; Campagnolo & Camuffo, 2010; Holland, 2000), which is defined as 'the possibility to combine and recombine already existing modules'. Modularity is commonly applied in constructional settings, where modules are specific building components that can be combined in many ways to form different structures. Working with modules offers architects and other designers the opportunity to build upon already present constructions and, very importantly, the modules can be separated and recombined to form a different structure. Translated to educational settings, the concept of modularity offers teachers the possibility to design many types of instructional approaches using a limited number of modules (Janssen, De Boer, Dam, Westbroek, & Wieringa, 2013a). A modular approach implies that teachers´ pre-existing teaching practices can be divided into smaller segments and recombined to form other instructional approaches. As such, a modular approach to instruction is hypothesized to comply with the previously described principles for teacher change of taking pre-existing teaching practices into account and facilitating a step-by-step approach to change.

Reviewing educational literature, we searched for much-used models or frameworks structured around the use of modules or smaller components to design the instruction of single lessons. We identified several models or groups of models. As the aim of the model in this research was to assist teachers in their process of learning new approaches to instruction, we evaluated these models using the two criteria for effective teacher learning: the possibility of taking teachers' pre-existing teaching practices into account and making step-by-step changes. First, we found that some models in literature offer teachers an extensive list of scripted, linear instructional approaches (e.g., direct instruction, mastery learning) that they can use to design instructional approaches (Joyce & Weil, 2008). Such models might be helpful in enabling teachers to understand all possibilities for instructional design, but they hardly offer teachers the possibility of building upon what they already do, nor do such models enable a step-by-step approach to learning. Second, we found models such as the 'principles of effective

teaching' (Marzano, 2007) that describe the most important design principles that teachers should keep in mind while designing effective teaching strategies (e.g., the activation of prior knowledge, the importance of feedback). Although such principles can be very helpful in enabling teachers to understand the extent to which lessons are successful, they do not seem to give much direction for the design of instructional approaches, let alone meet the requirements of connecting to pre-existing teaching practices or having a step-by-step approach to change. Finally, we found a group of classroom-oriented ID models such as the above-mentioned Gerlach & Ely model (1980), which seem to give little direction for teacher learning due to their minimal content (see section 2.2.1).

In designing the initial modular ID model for our study, we proposed that it should first and foremost be focused on the most effective components of instruction. Merrill (2009) states that these are the parts of instruction that directly promote learning activities, such as presentation, practice, or demonstration. In our research, we named such components of lessons 'lesson segments'. Put in specific orders, these lesson segments can represent single lessons that teachers give on an everyday basis (Dam, Janssen, & Van Driel, 2010; Merrill, 2001). Using the lesson segments in specific orders, teachers should be able to design their regular approach to instruction, but also the instructional approaches of, e.g., more contemporary reform proposals and many steps in between.

Besides the order of lesson segments, however, there seems to be another important principle for designing instructional approaches: the regulation of the lesson segments (Vermunt, 1998). More traditional approaches to instruction mostly consider learning as the transfer of knowledge from teacher to student, who learns it through listening or memorization (Richardson, 1996). In this situation, teachers mostly regulate the components of learning and students are predominantly seen as a 'blank slate' (Cuban, 1990). More student-centred, contemporary instruction takes a different viewpoint on learning and states that students should ´discover´ information themselves. Underlying theories such as constructivism or situational learning emphasize the students' internal processes through which they process and understand new knowledge using their prior knowledge and experiences (Hammerness et al., 2005; Greeno, Resnick, & Collins, 1996). In lessons based on these latter theories, students

typically regulate more parts of the lessons or share the regulation with the teacher. Such lessons mostly start with meaningful tasks, followed by a phase in which students work rather independently to solve problems or answer questions (Greeno, Resnick, & Collins, 1996; Mayer, 2002; Merrill, Barclay, & van Schaak, 2008).

Next, we proposed that the initial design of the modular ID model in our research should contain a set of lesson segments and the possibility to vary the regulation of each lesson segment, allowing this to be done by either the teacher or the students, or shared. The next step in the initial model design was to draft the formulation and definitions of the lesson segments. We based the initial set of lesson segments on the work of Merrill (1983). His Component Display Theory includes four modules that, due to their focus on the primary teaching-learning process, we expected would serve as a good basis for our initial modular ID model: presentation of general content (*Tell*) or specific content (*Show*), and recall of general information (*Ask*) or use of general knowledge in a specific situation (*Do*). However, we had to add and rename several lesson segments. Merrill's work was focused on representing direct instruction, whereas our focus was on assisting teachers to design a large variety of instructional approaches and not only direct instruction. We first renamed the lesson segment *Do* as *Apply* and changed *Ask* to *Recall* to draw a clear distinction between tasks aimed at recalling and those aimed at application (Mayer, 2002). We then replaced *Show* with the lesson segments *Case* and *Discover,* because these are typically parts of more constructivist instructional approaches (e.g., case-based instruction, scientific inquiry). Finally, we added the lesson segments *Reflect* and *Evaluate* to give teachers an opportunity to design instructional approaches in which evaluation or reflection takes place on, e.g., the learning goals of their lessons. The complete set of lesson segments that was tested as part of the first modular ID model is represented in Table 2.2. This study was aimed at answering the following research question:

What are the characteristics of an ID model that supports teachers in continually expanding their repertoire of instructional strategies and how can such a model be internally validated?

2.3 Methods

2.3.1 Background of the Delphi method

The Delphi method used in this research was first proposed by Gordon (1964). In the early 60s, researchers of the RAND "think tank" in California developed the Delphi method to explore the use of expert panels to address forecasting issues. The Delphi method is a form of expert review and is based on the idea that the combined opinions of many experts have greater validity than the opinions of any single expert. It is a method that avoids face-to-face confrontations between experts and, as such, avoids the danger that the most dominant expert will determine the outcome of a discussion or that experts will be reluctant to change their opinions in front of their peers (Gordon, 2010). Instead, it is designed to encourage a true debate in which the reasons that experts give for extreme opinions are given an equal weight. Experts who hold such extreme opinions are asked to elaborate on their reasons and, together with a summary of all the responses, these opinions are given back to the complete group of experts for a following round of opinion-gathering; this continues until agreement is reached. As such, the Delphi method is a sort of controlled debate and is based on anonymity and feedback. It has been used thousands of times in areas such as the definition of back pain (Dionne et al., 2008) and dysfunctional tear syndrome (Behrens, Doyle, Stern, Chuck, & McDonnell, 2006).

A Delphi method typically consists of three or four phases with at least four experts in the subject under investigation (Gordon, 2010; Slocum, 2005). In the first phase, the problem is presented, the subject is explored, and the experts state their opinions or propose their solutions. In this phase it is important to use examples and ask clear, unambiguous questions. It is also recommended that answers on effectiveness or practicality be quantified using scales (Gordon, 2010; Slocum, 2005). In the second phase, experts with opinions towards the extremes can be asked to further underpin their opinions. Along with these explanations, the summarized input from the first round is given back to the experts in a third phase, followed by questions on the groups' solution or solutions. This same step can be repeated to reach consensus. The first phase typically includes exploratory questions; further phases include more closed questions on the group's proposed solution or solutions.

2.3.2 Selection of participants

At the time of the Delphi study, all experts (n=11) but one worked as teacher educators at university level, at the same institute as the researchers. They had an average of eight years of experience in educating teachers in various school subjects, and they had an average of 22 years of experience in teaching lessons at secondary level in their specific school subjects (varying from 6 to 28 years). They were selected to participate in this study because of their expertise in: a. teaching their own school subject; b. teachers' lesson design; and c. the use of models to design lessons. The ID model in this chapter was aimed at assisting teachers of all subjects in secondary education. Therefore, we selected experts from a variety of school disciplines. The experts originated from the following disciplines: history, social science, economics, philosophy, linguistics (*n*=2), physics, biology (*n*=2), mathematics, and chemistry. Eight of these eleven experts completed all of the Delphi questionnaires.

2.3.3 Procedure in the Delphi method

We performed a Delphi method in order to reach consensus about a modular ID model used to assist teachers in expanding their repertoire of instructional approaches. In the Delphi method, we asked questions that were aimed at determining the extent to which the modular ID model met three criteria for internal validity, based on work by Nieveen (2007): (1) Comprehensiveness; (2) Expected practicality; and (3) Expected effectiveness. As to the order of questioning, Nieveen (2007) states that the early stages of questioning need to be focused on comprehensiveness. As soon as a global design has been achieved, experts should also be asked to assess the expected practicality; this is followed by questions on the expected effectiveness in the final stages of development. For an overview of the number of assignments and questions about the above-mentioned criteria, see Table 2.1. For an overview of all the assignments, the kind of questions and their relation to internal validity criteria, see Appendix 2.1. We first constructed an initial modular ID model on a theoretical basis (see section 2.2.2) and performed a pilot which consisted of interviews with two experienced teachers; each lasted approximately two hours. In the pilot, we handed the participants the initial ID model, gave them an example for each of the lesson segments, and asked them what lesson segments and

form of regulation would fit for the example. Next, we asked them to use the modular ID model to represent their most common approach to instruction and their most desired instructional approach. Finally, we asked their opinions on the components of the model and their use in practice. Although both participants in the pilot were positive about the comprehensiveness, expected practicality, and expected effectiveness of the modular ID model, they also had some critical remarks (see results). Based on these, we adapted the ID model and presented the revised model to the experts in the first phase of the Delphi method.

Table 2.1

Number of questions for every criterion of internal validity

	Comprehensiveness	Expected practicality	Expected effectiveness
Pilot	2	1	1
Phase 1	4	2	1
Phase 2	3	-	2
Phase 3	-	1	1

In phase 1 of the Delphi method, we handed each participant an introductory letter containing background information on the Delphi method, an explanation of the purpose of the Delphi method in this research, a time schedule, and directions for answering. This was followed by an explanation of the process by which we constructed the modular ID model, the ID model itself, and a set of questions to be answered. We asked both open and closed questions with an emphasis on the comprehensiveness of the modular ID model (see Table 2.1). In the first question, we gave the experts four written descriptions of common lessons. Next, we asked them to look closely at the text and describe the same lessons with the aid of the modular ID model. One of the written descriptions of the lessons was as follows:

A teacher starts the lesson by explaining important facts. After he has mentioned all the important terms that are printed in italics in the textbook, the students have to answer four questions chosen by the teacher. In these questions, the students have to recall knowledge from the textbook. He then discusses the answers with the class. Next, he presents a newspaper article that is related to the topic. Three students ask short questions about the content of the article, which he briefly answers. Then he assigns six questions from the textbook as homework for the next lesson. Students work on these questions for the remaining ten minutes until the bell rings.

The answers to all the questions in the first phase of the Delphi method showed the strong and weak points of the proposed ID model (see section on data analysis). There was no need to ask the experts to give extra explanations. On the basis of this, we adapted the ID model in several ways (see results).

In the second phase of the Delphi study, we gave the experts an overview of all the answers given as well as an extensive summary of the strong and weak points that were evident from the answers. Next, we described how these comments helped us to make adaptations to the ID model, and presented the revised ID model. In this second phase, we again asked questions about its comprehensiveness, but also included questions about the expected practicality and expected effectiveness of this revised model (see Table 2.1). The answers given in this second phase enabled us to further improve the ID model.

In the third and final phase, we again gave the experts an overview of all the answers given in the second phase, explained how we revised the model, and presented the revised ID model itself. Next, we asked two questions which were focused on the expected practicality and expected effectiveness of the model (see Table 2.1). This was the final part of the Delphi study.

2.3.4 Data analysis

The data from the pilot consisted of the answers to four questions, spread over the three criteria for internal validity. The pilot interviews were recorded on a voice recorder and played back. The first and second author then examined in what way the two participants used the ID model to describe the various lessons that had been presented to them in writing. Components of the model that the participants used differently or asked questions about were marked as weaker points of the model. We compared these

weaker points with the opinions that were given in response to the other questions of the pilot to see if there was any overlap. This specific information about the strong and weak points of the model was used to change the aspects that were marked as weak.

The data from the first, second, and third phases of the Delphi were analysed as follows: The answers were first summarized according to the criteria of internal validity, i.e., comprehensiveness, expected practicality and expected effectiveness. After this, the outcomes were discussed by the first and second author and changes were proposed. With regard to comprehensiveness, we first asked questions requiring the experts to use the model to describe the lesson situations. This was followed by questions requiring the experts to quantify their opinions on the comprehensiveness of the model. In examining the answers to these questions, we focused on where the experts used the model differently in describing lesson situations (e.g., 40% used the lesson segment "recall" and 60% used the lesson segment "test"). We then compared this with the experts' opinions on the comprehensiveness to further underpin the areas for change. In other questions, we asked the experts to express their opinions about all criteria of internal validity on a 1-4 Likert scale (1=very low and 4=very high). Areas with an average score of 3.3 or lower were considered insufficient and were marked for improvement.

The answers to the open questions about the criteria were summarized per criterion of internal validity. Then, through discussion, the first and second author formulated concrete recommendations for the model, which sometimes were literal quotes of the experts. When there were no concrete recommendations in the answers, we discussed the options for change until agreement was reached. In summarizing the answers, we noticed that the experts sometimes offered opinions about issues that concerned multiple criteria. Therefore, new categories had to be devised. For the answers in the first phase, we added the categories 'metacognition' and 'suitability for all subjects'; in the second phase, we added the categories 'extent to which the model improved' and 'general recommendations for change'.

2.4 Results

2.4.1 Pilot

In the pilot phase, we asked two participants to give their opinions on the first modular ID model. Although they were both very positive about the practicality of the model for their teaching practice and its use as a "language" through which we were able to talk about instructional approaches and propose changes, they also had some trouble using the model. The exercises in which they had to use the modular ID model to describe lessons showed that they had problems in understanding the difference between "Evaluate" and "Reflect". They also asked some informative questions about the lesson segment "Discover". When asked about her opinion on the model, participant 1 stated that the definitions of the lesson segments made them hard to place in the required orders. She opted for clearer and more usable definitions. She also stated that she was able to use most of the lesson segments, but she found the "Discover" lesson segments especially hard to use. Participant 2 stated that he would have liked a lesson segment about the approach to answering a certain question or solving a problem. He also mentioned that he missed a lesson segment that offers the possibility of starting the lesson with a central question or emphasizing the importance of a central question. Finally, he found that the "Discover" element was too broadly described and not usable in his teaching context.

The outcomes of the pilot made clear that we needed to adapt some of the names and definitions of the models' components. We changed the "Discover" phase to "Central question" and "Answer". This gave teachers the possibility of starting the lesson using just a "Central question", but also gave them the possibility of including a phase in the lesson design where students could look up or discover information. We also included the lesson segment "Devise an approach". The development of the complete set of lesson segments and their definitions are represented in Table 2.2.

Table 2.2

Development of the lesson segments and their definitions throughout the Delphi research phases

Lesson segment	Definition
	Pilot
Tell	Presentation of general knowledge or skills
Recall	Recalling of knowledge, skills, or procedures
Case	A case description, a sketch, a motivating picture, an object, or a story that is aimed at focusing attention on the topic
Discover*	Discovery of information or a phase where students can find information
Apply	Application of general knowledge or skills in a specific situation or demonstration of general knowledge or skills in a specific situation
Evaluate*	Evaluation of acquired information. Is it correct and valid?
Reflect	Reflection on acquired information or the steps in a procedure
	Phase 1
Tell	Presentation of general knowledge or skills
Recall	Recalling knowledge, skills, or procedures
Case*	Extensive description of a specific situation
Central question*	Use of a central question to focus and guide the direction of all students' learning processes
Devise an approach*	Devising an approach for answering the central question
Answer*	A variety of ways to find an answer to the central question
Apply*	Application of general knowledge or skills in a specific situation or demonstration of general knowledge or skills in a specific situation. This is mostly a rather small assignment
Test	Testing students' knowledge and abilities, and comparing these with the set expectations
Reflect	Looking back on the learning process and/or content, which serves as a basis for concrete recommendations for the future

Phases 2 and 3

Orientation	Introduction of the topic, formulation of learning goals, activation of pre-existing knowledge and planning the time and activities
Tell	Presentation of general knowledge or skills
Prepare activating task	Introduction of the task, or specific goals. Presenting questions, activation of specific pre-exiting knowledge and planning of time and learning activities
Perform activating task	Performing a task in which students have to apply their general knowledge and/or skills in a specific situation or a task in which students have to discover or find information to perform the task
Prepare task to retrieve factual knowledge/skills	Introduction of the task, formulation of specific goals or questions and planning of time and learning activities
Perform task to retrieve factual knowledge/skills	Questions or assignment in which students have to recall previously acquired knowledge and/or skills
Test	Testing students' knowledge and abilities, and comparing these with the set expectations. This can be done for the entire lesson or for a certain part of the lesson (e.g., a task)
Reflect	Looking back on the learning process and/or content, which serves as a basis for concrete recommendations for the future

Note. Lesson segments marked with * were replaced or adapted in the subsequent research phase.

2.4.2 Phase 1

The written responses to the questionnaire in the first phase of the Delphi method were summarized using the following categories: (1) Comprehensiveness, (2) Expected practicality, (3) Expected effectiveness, (4) Representation, (5) Metacognition.

Comprehensiveness

In the first phase of the Delphi, we included a specific question aimed at investigating the experts' opinions on the comprehensiveness of the different lesson segments (see Table 2.1). It was clear from this that the experts found the descriptions of three lesson segments comprehensible (Tell, Recall, and Reflect); other lesson segments were scored as less comprehensible (see Table 2.3). This is further illustrated in the answers to the question in which the experts were asked to use the ID model to describe four written examples of lessons (Table 2.1, question 1, phase 1). By analysing the outcomes, we were able to determine to what extent the experts used the lesson segments and regulation in the same way and thus agreed on the content and use. The answers gave us four insights:

1. The experts were divided in their opinions on the regulation of the lesson segments. It was not clear to them if they needed to describe the regulation as the person who decides on the content of a particular lesson segment (e.g., the teacher chooses the application questions) or the person who performs a particular lesson segment (e.g., the students answer several application questions). Two experts recommended giving examples of each of the regulation possibilities for every lesson segment.
2. The experts found it difficult to use the model to determine the lesson segment for the activation of prior knowledge. Some used the lesson segment *Test*, whereas others used *Recall*. One expert recommended creating a new lesson segment for this function.
3. The experts were also divided in their opinions about the lesson segment *Devise an approach*. Could they use this lesson segment for an entire lesson, or only for the lesson segment *Answer*?
4. The experts disagreed on whether or not the lesson segments *Recall* and *Apply* could

be clearly distinguished. Especially when there are several assignments at once, it seemed hard to use. Several experts also noted that *Recall* and *Apply* are only two possible cognitive skills. They recommended composing a broader description to include other higher-order cognitive skills such as analyse or synthesize (Krathwohl, 2002).

Table 2.3

Overview of the comprehensiveness of each lesson segment in Delphi phase 1

Lesson segment	Average score	SD
Tell	3.6	0.66
Recall	3.6	0.50
Case	3.1	0.74
Central question	3.3	0.82
Devise an approach	2.8	0.74
Answer	3.1	0.79
Apply	3.4	0.74
Test	3.1	0.87
Reflect	3.1	0.68

Note. Participants scored their opinions on a 1-4 Likert scale.

Expected practicality

We included one question specifically aimed at exploring the extent to which the experts expected the ID model to be practical. We asked this both in an open-ended question and in a closed, quantitative question (using a 1-4 Likert scale). The average score for the expected practicality of the ID model was 3.4 (SD =0.46). This high level of practicality is further underpinned in the following answers from experts (quotes):

1. "The concept of lesson segments is strong. It can help teachers to gain insight into what they actually do in their classroom".
2. "It is a good model that can easily be understood by teachers to analyse and design lessons."

3. "The lesson segments and regulation make it possible to make small adaptations, for which teachers could be more easily motivated than big changes."
4. "I think that the ID model with lesson segments can indeed be easily used by teachers. It creates awareness about the possible variations in sequences, but also gives options for stimulating more student regulation and participation in lesson phases. It also presents a broad checklist and reminders for broader lesson designs."

Expected effectiveness: Level to which the ID model is expected to assist teachers in expanding their repertoire of instructional approaches

The experts were asked to score the expected effectiveness of the ID model on a 1-4 Likert scale. The average score was a 3.0 (SD = 0.96), indicating that these experts scored the expected effectiveness of the ID model relatively high; this is also illustrated in the following quotes:

1. "Especially the lesson segments help in analysing the existing approaches to instruction, which is a condition for starting a change process. The lesson segments can also give options for change."
2. "I think that we should avoid a situation where we prescribe a certain sequence to teachers. Therefore, it should be clearly stated that multiple sequences are possible and that there is no need to suddenly change the entire sequence."
3. "The lesson segments and regulation help to focus a lesson on a certain goal and give options for design."
4. "Far too often, teachers think that the standard *explain-apply* lesson is their sole option; this helps them to understand that there's more."

Suitability for all subjects

Experts in linguistics, social science, and history education found it difficult to recognize their desired and regular instructional approaches using the ID model. Especially the lesson segments *Case*, *Central question*, and *Answer* were hard to use for experts in these subjects. As one expert stated, "When describing my most desired lesson, I noticed that I used other elements than those provided in the ID model. For example, when I am presenting knowledge, can this be the same as the case-question-answer sequence,

all regulated by the teacher?" The other experts had no remarks about those three elements of the model.

Metacognition

A response from five experts was that they required more attention to the processes known as metacognitive design (Zimmerman, 2002). This would mean drawing a clear distinction between the three distinct steps in efficient learning processes: Orientation (planning), performance (monitoring), and reflection. As one expert stated, "I can use *Reflect* to activate prior knowledge, but the definition points towards the end of a lesson. How can I activate prior knowledge or clearly explain the learning goals at the start of the lesson?" Another expert stated, "If I use *Test* at the start of the lesson, it has a different meaning than it has when I use it at the end of the lesson."

Revisions to the model based on feedback from phase 1

Although the expected practicality and expected effectiveness were considered to be rather high, the experts did suggest revisions. We summarized these as follows:

a. Make the lesson segments more suitable for all subjects
b. Add metacognition. Especially add an introduction or orientation phase
c. Keep the following segments: *Tell, Recall,* and *Reflect*. Change the others.
d. Make a clearer distinction between lower-order cognitive skills (e.g., remember, understand) and higher-order skills (e.g., apply, evaluate, create).
e. Clarify the regulation of the lesson segments

In response, we changed the ID model to make it more suited to all subjects by removing the more science-related lesson segments *(Case, Central question, Devise an approach,* and *Answer)*. Instead, we added a clearer distinction between two major tasks, focused respectively focused on lower-order cognitive skills and higher-order cognitive skills: a task requiring students to recall knowledge or skills and a task requiring students to apply the knowledge in a new situation or find information to solve a problem or complete a task. Based on the specific recommendations concerning metacognition, we also included a new lesson segment named *Orientation,* which teachers can use to explicitly activate pre-existing knowledge and discuss the lesson's outline or learning

goals. Finally, we clarified the regulation aspect by explaining that the regulation can be determined by posing the question: Who executes the content of the lesson segments? For the revised model, see Table 2.2.

2.4.3 Phase 2

In the second phase of the Delphi method, we again sent the participants an electronic package, containing all the answers the experts had given in the first phase, a summary of the answers in the first phase, the revised modular ID model (see Table 2.2) and a questionnaire about the revised model (see Appendix 2.1). The answers to this questionnaire were summarized using the following categories: (1) The extent to which the revised model was improved, (2) Comprehensiveness, (3) Expected effectiveness.

The extent to which the revised model was improved

All experts agreed that the revisions to the model were indeed improvements and solved some of the problems that arose from the first model. In answering an open question on the level of improvement, some experts commented (quotes):

1. "This classification is clearer to me. It especially helps to make a good distinction between "remember" and "use" tasks."
2. "It is much more organized, shorter, and easier to use. But be careful not to make it too abstract."
3. "It is a clear improvement and easier to handle for making changes in lesson design."
4. "I think that the attention to orientation is a very important improvement."
5. "The image and content of every lesson segment is very clear to me."
6. "Getting rid of lesson segments such as *Case, Answer,* and *Apply* is a good thing. The revised model is easier to use and easier to understand."
7. "Adding orientation was very important. I also think that the explicit difference between the two tasks is relevant and useful for teachers."

Comprehensiveness

The experts used the revised modular ID model to describe three lesson situations that were given to them in writing. Through analysis, we noticed that there were only small differences in their use of the model to describe these examples. Using lesson segments to represent a teachers' desired instructional approach, the teacher and two researchers made few deviating choices. We gave possibility to make comments, but none were reported.

Expected effectiveness

Almost all the experts were positive about the use of this model to expand teachers' repertoire of instructional approaches. One expert, however, had doubts on the expected effectiveness. He mentioned (quote): "Does this revised model really help to generate new lessons? Teachers can still be primarily focused on tasks that focus on recalling knowledge. How can we ensure that teachers will design innovative lessons? Maybe this ID model should be incorporated in a professional development program to be effective."

Other experts identified the following areas to be reconsidered (quotes):

a. "It would be helpful to add examples of how different lesson segments and regulation work out in a classroom situation."

b. "I agree on this revised model. A final remark would be that this can only be used for single lessons. Concepts such as transfer are, therefore, not included."

c. "Maybe we should give some concrete examples of how a certain lesson segment and a chosen form of regulation would work out in the classroom."

Revisions to the model based on feedback from phase two

On the basis of the feedback from the second phase, we added to the model a list of examples for each form of regulation to make the concept of regulation clearer and show how the lesson segments can be used in different regulation settings (e.g., more independent approaches to instruction).

2.4.4 Phase 3

In the third phase, we emailed the experts all of the answers from the second phase, a summary of these answers as described in section 2.4.3, and an explanation of the revisions made to the prior model. The added list of examples for each form of regulation of lessons segments is represented in Appendix 2.2. In this third phase, we asked two questions pertaining to the set requirements of expected practicality and expected effectiveness (see Table 2.1). Having examined the list of examples and the summary of the second phase, the experts replied that they thought that the ID model could indeed be expected to be both practical and effective with regard to its aim. Because the experts had no further remarks, we concluded that consensus had been reached and the Delphi study was ended.

2.5 Conclusion and discussion

This research was focused on the construction and internal validation of an ID model aimed at assisting teachers in the expansion of their repertoire of instructional approaches. After initial model construction and a pilot, eleven experts gave their opinions on the strong and weak points of a modular ID model through a three-round Delphi study. All input from the experts was used to make revisions to the model until consensus was reached. The most distinctive adjustments were to the content and formulation of the lesson segments, to the way teachers can organize the regulation of each lesson segment, and the addition of metacognitive elements to the modular ID model (orientation-enactment-reflection). We conclude from the results that the experts who participated in the Delphi study reached consensus on a modular ID model that complies with the set requirements of comprehensiveness, expected practicality, and expected effectiveness. Together, these criteria determine the extent to which an educational intervention is internally valid (Nieveen, 2007). Although the modular ID model was found to be internally valid by the experts in this study, further research is needed to externally validate this model; for example, through field studies in a variety of settings to ensure generalizability.

Important requirements for the modular ID model were that it had to both assist teachers in expanding their repertoire of instructional approaches and be considered

to be practical in its use at classroom level. The modular ID model that resulted from this study is based on the concept of modularity. The 'modules' of the ID model are concrete lesson segments that focus on the most important feature of instruction: the design of the primary teaching-learning process (Merrill, 2001; 2009). By combining and recombining the different lesson segments in the model and designing the regulation for each of these lesson segments, teachers can design many approaches to instruction. The modular ID model can be considered to be practical because it meets the three criteria that have been set for practicality (Doyle & Ponder, 1977). First, it is instrumental in that the lesson segments (e.g., *Tell, Reflect)* and their regulation can easily be understood at classroom level. Second, the ID model is congruent with teachers' common approaches to instruction. The modular nature of the modular ID model gives teachers the possibility to use their most common instructional approach as the starting point for change and to introduce changes by recombining or adapting these lesson segments. Finally, the modular ID model can be used in teachers´ own setting and time (little cost); they do not have to attend faraway meetings or get much training to use this model. The resulting modular ID model also seems to comply with the earlier described principles for effective teacher change; using the modular ID model, teachers are expected to be effective in developing their instructional practices in a step-by-step manner, taking their regular instruction as a starting point.

The experts who participated in this study gave additional comments during the research phases which gave two insights into the implications of the modular ID model. First, it became clear that the modular ID model gives options for developing a broader repertoire of instructional approaches by creating awareness of the possible variations in sequences. Second, the modular ID model may be useful in facilitating the discussion between teachers on how to design good lessons. This relates to findings by Grossman and McDonald (2008), who state that teachers do not yet have a clear terminology which they can use to discuss and compare their instructional approaches. The lesson segments and their regulation that were internally validated in this research could well serve as such a 'common language' that facilitates discussion among teachers about their approaches to instruction and enables them to learn from each other. In showing an explicit example of the construction, refinement, and systematic validation of a modular ID model, our research contributes to the field of instructional model validation; however, further research on these issues is needed.

Appendix 2.1

Survey of all the questions asked in the subsequent phases of the Delphi study and their focus in terms of the specific criteria of internal validity

Order	Questions	Criterion of internal validity
	Pilot	
1	The participants were handed one example for each of the lesson segments and asked what lesson segments and what form of regulation would fit for that example	Comprehensiveness
2	The participants were asked to use the ID model to represent their most common instructional approach and their most desired instructional approach	Comprehensiveness
3	The participants were asked about their opinion on the practicality of the ID model	Expected practicality
4	The participants were asked about their opinions on the use of the model for expanding teachers' repertoires of instructional approaches	Expected effectiveness
	Round 1	
1	The experts were given four written descriptions of lessons and asked to describe the same lessons using the ID model	Comprehensiveness
2	The experts were asked to describe their most common instructional approach and their most desired instructional approach, both in writing and using the ID model	Comprehensiveness
3	The experts were asked about their opinions on missing or superfluous elements of the ID model	Comprehensiveness

4	The experts were asked to what extent they thought that the definition of each lesson segment was clearly described and logical for its users (on a 1-4 Likert scale)	Comprehensiveness
5	The experts were asked about their opinions on the expected practicality of the ID model (on a 1-4 Likert scale)	Expected practicality
6	The experts were asked about the level at which the ID model could be used by teachers to expand their teaching repertoire (on a 1-4 Likert scale)	Expected effectiveness
	Round 2	
1	The experts were given three written descriptions of lessons and asked to describe the same lessons using the ID model	Comprehensiveness
2	The experts were asked to use the ID model to describe their most desired instructional approach (which they also described in the first phase)	Comprehensiveness
3	The experts were asked to comment on the adjustments that were made to the model	Comprehensiveness
4	The experts were asked about their general opinion on the use of the ID model for the expansion of instructional approaches	Expected effectiveness
	Delphi phase 3	
1	The experts were asked about their opinion on the expected practicality of the ID model	Expected practicality
2	The participants were asked about their opinion on the use of the model for expanding teachers' repertoires of instructional approaches	Expected effectiveness

Appendix 2.2

Overview of concrete examples for the regulation of each lesson segment by either the teacher or student, or shared

Lesson segment	Regulation	Examples
Orientation	Teacher	The teacher presents the learning goals. The teacher asks what is known about a certain topic
	Shared	The teacher consults the students about the learning goals. The teacher and students construct the planning together
	Students	Students determine the learning goals. The students determine the planning
Tell	Teacher	The teacher presents the general knowledge or skills
	Shared	The teacher and students interactively present the general knowledge or skills
	Students	One or several students present the general knowledge or skills
Prepare activating task	Teacher	The teacher prepares the task
	Shared	Teacher and students jointly prepare the task
	Students	Students prepare the task
Perform activating task	Teacher	The teacher performs the task and demonstrates to the students how this can be done
	Shared	The teachers visibly assists students as they perform the task by helping with process and/or content
	Students	Students perform the task independently. The teacher only provides support on demand

Lesson segment	Regulation	Examples
Prepare task where students recall factual knowledge	Teacher	The teacher prepares the task
	Shared	Teacher and students jointly prepare the task
	Students	Students prepare the task
Perform task where students retrieve factual knowledge	Teacher	The teacher performs the task and demonstrates to the students how this can be done
	Shared	The teachers visibly assists students as they perform the task by helping with process and/or content
	Students	Students perform the task independently. The teacher only provides support on demand
Test	Teacher	The teacher tests to what extent the students have attained the learning goal, and compares this with a set expectation
	Shared	The teacher and students jointly test to what extent the students have attained the learning goal, and compare this with a set expectation
	Students	Students test to what extent they have attained the learning goal, and compare this with a set expectation
Reflect	Teacher	The teacher looks back on the learning process and/or content and gives recommendations for the future
	Shared	The teacher and students jointly look back on the learning process and/or content and decide on recommendations for the future
	Students	Students look back on the learning process and/or content and give recommendations for the future

Chapter 3

ATTENTION TO INTENTIONS - HOW TO STIMULATE STRONG INTENTIONS TO CHANGE

Abstract

The implementation of educational reforms requires behavioral changes from the teachers involved. According to theories on successful behavioral change, teachers need to possess the necessary knowledge and skills, form strong positive intentions to perform the new behavior and have a supporting environment for change. Existing approaches to teacher professional development in the context of educational reforms are predominantly aimed at the development of knowledge and skills and at creating a supporting environment, but lack attention for teachers' intentions to change. In the study described in this chapter, we performed so-called 'motivating-for-educational-change' interviews (MECI) and explored the developments in teachers' intentions to change in the direction of the proposed national biology education reform, that is, the introduction of a context-based curriculum. The MECI comprised two tools: building on earlier successful experiences and using lesson segments to rearrange instructional approaches. We explored the influence of the MECI technique on the strength and specificity of teachers' intentions. After conducting the MECI, participants (n=9) expressed that they were able to see in what way they had already implemented aspects of the reform in their regular instructional approaches. This served as a basis to formulate strong and specific intentions to change their regular instructional approach towards that of the proposed reform while taking their regular instructional approach as a starting point.

3.1 Introduction

In recent years there has been much debate on educational reforms and their implementation in secondary education. Many educational reforms have been found to cause implementation problems, and the teachers involved have questioned the value of the proposed reform for their daily practice (Fullan, 2007). Research about the implementation of educational reforms shows that teachers play a crucial role in achieving the goals of a reform (Fullan, 2007; Van Driel, Beijaard, & Verloop, 2001). A reform proposal can therefore only succeed if teachers expand and change their behavioral repertoire in line with the reform. However, changing teachers' regular practices and routines has proven to be very difficult. For a successful behavioral change it is not enough to simply offer teachers new knowledge and skills; they first have to be motivated to change. Literature on behavioral change shows that people need both the ability and the willingness to change their behavior successfully (Fishbein & Ajzen, 2010). However, in current approaches to teacher professional development there seems to be an emphasis on supporting teachers in their ability to change, whereas teachers' willingness to change receives too little attention (Borko, Jacobs, & Koellner, 2010).

In the study described in this chapter, we therefore explored teachers' intentions to change. We performed so-called 'motivating-for-educational-change' interviews (MECI) and explored the resulting developments in the strength and specificity of teachers' intentions to change in the direction of a context-based reform proposal. If successful in achieving strong intentions, the MECI could be a useful tool to administer at moments such as the start of a professional development program or when motivation to continue professionalization is lacking. The MECI technique was based on two approaches: using lesson segments to assist teachers in rethinking their practices and using earlier successful experiences with parts of the proposed reform to assist teachers in proposing strong intentions to change. We focused on the strength and specificity of intentions, as these are found to be the closest determinant for the occurrence of new behavior (Fishbein & Ajzen, 2010). The research took place in the Netherlands, where the National Reform Committee For Biology Education proposed a context-based reform program (Boersma et al., 2007) in secondary biology education. The research question was the following: What are the developments in the strength and

specificity of biology teachers' intentions to implement a context-based educational reform after performing a 'motivating-for-educational-change interview' (MECI), and what are the underlying mechanisms?

3.2 Theoretical framework

One of the most important factors in the success rate of any educational reform is the way in which it is implemented. When implemented, reform design aims such as increased student outcomes or higher student motivation are often not achieved as expected (Van den Akker, 2003). In the process of implementing a reform proposal, there are many actors. There is a vast amount of literature concerning the change of classroom practices that places teachers as "key agents" in attempts to change classroom practice (Borko et al., 2010). As Fullan (2007) stated: "Educational change depends on what teachers do and think – it's as simple and as complex as that" (p. 129).
In the implementation of any educational reform, it is therefore important that teachers expand their behavioral repertoire on the basis of the reform requirements. In the field of social psychology there is a wide consensus on the conditions for effective behavioral change. Three major conditions are considered to be necessary for any new behavior to occur (Fishbein & Ajzen, 2010):

1. An individual has the knowledge and skills necessary to perform the new behavior.
2. The environment must support the occurrence of the behavior.
3. An individual has formed a strong positive intention to perform the new behavior.

In many of the current approaches to teacher professional development in the context of implementing educational reform, there is a strong emphasis on the first condition. In such an approach, there is attention for the development of knowledge that teachers need to implement a reform (Borko et al., 2010). Also, in recent years, the notion has sprung up that teachers need to develop the necessary skills, so that they are also capable of implementing the change proposal (Ball & Forzani, 2009; Grossman et al., 2009). In regard to the second condition, some of the existing approaches also pay attention to the limited availability of time, possibilities and resources that teachers have for changing their behavior. However, the third condition, the formation of a

strong intention to change, is lacking in many attempts to implement a reform proposal. This formation of strong intentions to change behavior may however well be a crucial step in the process of implementing a reform proposal into classroom behavior.
In their influential work on understanding intentions, Fishbein and Ajzen (2010) state that intentions can be defined as "the readiness to perform a certain behavior" or "an indicator of how hard people are willing to try to perform the behavior". The stronger the intention, the more likely it is that the goal behavior will be carried out. In their theory of planned behavior, Fishbein and Ajzen (2010) state that three kinds of beliefs serve to determine the strength of an intention:

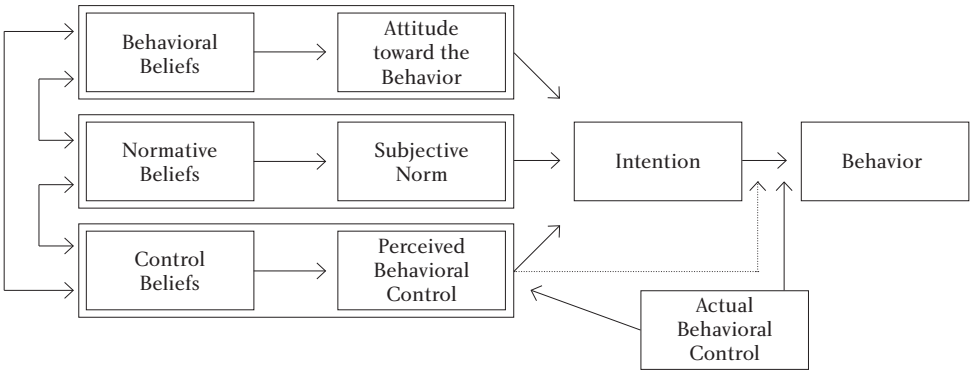
a. Behavioral beliefs: Positive or negative consequences people might experience if they performed the new behavior. Together these beliefs are responsible for a positive or negative attitude.
b. Normative beliefs: Beliefs about the approval or disapproval of important groups or persons on the execution of the new behavior. These beliefs are responsible for the perceived social pressure to engage or not to engage in the behavior.
c. Control beliefs: Factors that help or hinder the attempt to carry out the behavior. These beliefs constitute the perceived behavioral control, and are thought to be closely related to Bandura's well-known concept of self-efficacy (Bandura, 1977; 1997).

What follows is that many factors that hinder attempts to carry out the behavior (control beliefs), many expected disadvantages of the outcomes (behavioral beliefs), and low social support (normative beliefs) can lower the strength of an intention and vice versa. Beliefs about certain behavior have been studied extensively in educational research (Pajares, 1992). Such belief studies are however mainly focused on general educational beliefs about, e.g., teaching and learning, or teachers' epistemology (Boulton-Lewis, Smith, McCrindle, Burnett, & Campbell, 2001; Schommer, 1990). In recent years there has been a call for more domain-specific beliefs, such as teachers´ orientations towards specific topics (Van Driel, Bulte, & Verloop, 2007). But even in such more domain-specific belief studies, a straightforward relationship between the beliefs and the actual practice of teaching seems to be lacking (Ajzen & Fishbein, 2005; Richardson, 1996; Stipek, Givvin, Salmon, & MacGyvers, 2001). In the present research,

we propose that this gap between teachers´ beliefs and concrete teaching practices can be bridged by using intentions as proposed by Fishbein and Ajzen (2010). These intentions are underpinned by beliefs (see Figure 3.1), but are also closely related to the actual behavior. In fact, the strength of intentions is known for its' ability to predict the occurrence of specific behavior (Fishbein & Ajzen, 2010).

Figure 3.1

Graphical representation of the theory of planned behavior (Ajzen, 2006)



It is, however, not solely the strength of an intention that determines the chance for a new behavior to occur. People can have strong intentions but still have problems acting upon them (Orbell & Sheeran, 2000). In his work on analyzing this discrepancy between intentions and behavior, Gollwitzer (1999) tried to make intentions more effective. He found that the goals formulated in intentions are more easily attained when the intentions are more specific about the how, when and where. This measure of specificity could well be the complementing factor needed to fully understand how intentions influence behavior.

On the basis of this understanding of the nature and formation of intentions we developed an interview procedure to motivate teachers for educational change which is aimed at increasing both the strength and the specificity of intentions. Interviews in general mainly serve as a source of information and contain unbiased questions.

The 'motivating-for-educational-change' interview (MECI) in this study is, however, developed to affect teacher's thinking and in this way resembles the motivational interviewing technique as proposed by Miller and Rollnick (2002). The MECI comprises two tools: building on earlier successful experiences, and using lesson segments to rearrange lesson structures which are described in the following sections.

3.2.1 Building on earlier successful experiences

The first tool is structured around the use of teachers' earlier successful experiences. The idea of working with successful experiences is derived from the field of psychology, where Seligman (2002) and others emphasize that "treatment is not fixing what is broken; it is nurturing the best". Central to this positive approach is helping people to use their positive qualities and strengths of character for personal growth and change. On the basis of the same idea psychotherapists in the early 1980s worked on a new method for helping patients to tackle problems (De Shazer, 1985; Miller, Hubble, & Duncan, 1996). Their approach focused directly on patients' skills and goals instead of an in-depth analysis of patients' problems. Patients first stated what goals they wished to achieve, followed by a check whether they had ever actually realized these goals in previous settings (i.e., finding positive exceptions in the past in which the desired behavior was already present). These, sometimes small, positive exceptions were rephrased into solutions for the patients to solve their problems and achieve their goals. In short, this approach focuses on solutions instead of problems and aims to build on earlier successful experiences with, sometimes parts of, the goal behavior. Translating this approach to educational, Janssen, De Hullu, & Tigelaar (2008) found that pre-service teachers' reflection on successful experiences led to stronger intentions and more positive beliefs than when they reflected on problematic experiences. In the same way, Bandura (1977; 1997) found that earlier mastery experiences resulted in a strong sense of control over similar future behavior. During these mastery experiences teachers have, in some way, seen that they are able to execute the required behavior. This implies that the use of earlier successful experiences could also help teachers to think back to the benefits of their execution of that behavior in the past, which in turn could positively influence the strength of their intentions and their behavioral beliefs for future behavior.

3.2.2 Using lesson segments to rearrange instructional approaches

In his work on analyzing all sorts of innovations, Holland (2000) states that most innovations can be understood as the rearrangement of the smaller parts or building blocks that make up a certain structure. Holland (2000) describes that in order to propose an innovation, one first needs to find the essential building blocks within a certain environment and next, arrange them differently to propose innovation. Translated to education, this implies that educational innovation can be reached by rearranging the main building blocks of educational settings. These building blocks should then be focused on the most effective elements of education that directly influence student learning. Merrill (2009) showed that these most effective parts of education are the main teaching-learning activities such as presentation, practice or demonstration. In our research, we therefore determined such building blocks to be the segments of lessons as teachers give many every day. Put in specific orders, such lesson segments can then represent many forms of single lessons given by teachers on an everyday basis. In our research, we made use of such lesson segments in the setting where teachers have to learn to change their practices towards the reform requirements.

From literature it is known that the strength of an intention to perform certain new behavior depends for a large part on how much the individual in question values the goal situation as an improvement (Pollock, 2006). In order to judge whether something is an improvement one has to be able to compare the existing and goal situation (Simon, 1978). However, this is often not possible due to different terminology or levels of abstraction of the two situations. In educational settings the change proposal (goal behavior) is mostly formulated as a vision or rationale instead of a program for practice. Such visions conflict with the practices of many teachers, which are very specific and concrete about how to act. This situation asks for a tool in which the two situations can be represented at the same level of abstraction and in the same terminology. The lesson segments as proposed in this study could serve as such a tool to (1) represent teachers' regular practices; (2) represent the change proposal at classroom level; (3) make comparison possible and (4) facilitate teachers to recombine or adapt the lesson segments of their regular teaching practice to change in the direction of the change proposal. In previous research by the author (Dam, Janssen, & Van Driel, 2010), such a set of lesson segments was internally validated. The elaboration of the factual lessons segments for the present study is further described in section 3.4.2.

The MECI technique thus comprised two tools; i.e., building on successful experiences and using lesson segments to rearrange lesson structures. Combining these tools was hypothesized to positively influence both the strengths and specificity of biology teachers' intentions to make a change towards the proposed context-based reform (see also section 3.4.3.)

3.4 Method

3.4.1 Selection of participants

The context-based educational reform is meant for all biology teachers at secondary level in the Netherlands. Therefore, we selected participants varying on many different characteristics such as age, teaching experience, and experience with context-based education (see Table 3.1). When selecting the participants we used both purposive and snowball sampling. Nine biology teachers from six different secondary schools in the west of the Netherlands agreed to participate. Participating teachers taught upper and/or lower level classes in general secondary or pre-university education.

Table 3.1

Survey of participants

Participant	Age	Teaching experience (years)	Experience with context-based education	Grade Level [a]	Upper/Lower secondary level
Walter	40	10	0	PUE	Higher
Anne	52	4	0	GSE	Lower
Ryan	34	5	4	PUE	Higher
Kathryn	49	12	0	PUE	Higher
Howard	49	11	3	PUE	Higher
Becky	46	10	0	GSE	Lower
Mark	28	3	0	GSE	Higher
Julia	7	10	0	GSE	Higher
Ivy	42	10	0	PUE	Higher

Note. [a] PUE - Pre-university education, GSE - General secondary education

3.4.2 Lesson segments

The lesson segments in this study served as a tool to bridge the perceived gap between a teachers' regular practice and the change proposal for biology education, that is, the introduction of a context-based curriculum. By rearranging and/or adapting one or more lesson segments, teachers were given a tool to propose a change in the direction of the proposed reform. We chose to base the lesson segments on the work of Merrill (2001), who proposed four lesson segments to design different forms of direct instruction (tell, show, ask and do). However, we also needed to add lesson segments that enabled the design of teaching practices based on ideas from constructivism. For this, we looked into the characteristics of context-based education as described in section 3.4.3 (e.g., starting with a context with central question, reflection on concepts to be learned).

The teachers' regular practice, represented in lesson segments, served as a starting point for change (e.g., *explain* → *reproduction and/or application* → *answering questions*). Next, teachers could propose an intention to change this regular practice in the direction of the reform by adding, rearranging or adapting lessons segments. For the complete set of lesson segments as used in this research, see Table 3.2.

Table 3.2

The set of lesson segments as used in this research

Lesson segment	Definition
Orientation	Introducing the subject, formulating goals, activating prior knowledge and planning time and activities
Test	Assessing to what extent the learning outcomes and/or processes match the pre-set goals
Reflect	Looking back on results or processes, finding explanations for success or failure, finding improvements
Explain	Explaining or presenting the content
Context with central question	Introducing the context with an attendant central questions or problem

Reproduction and/or Application	Reproduction: assigning questions or tasks for which previously acquired knowledge or skills have to be literally repeated Application: assigning questions or tasks in which previously acquired knowledge or skills have to be applied in new settings
Answering questions	Answering the questions

3.4.3 Context-based biology education

In the Netherlands, a National Reform Committee For Biology Education (CVBO) proposed a context-based reform (Boersma et al., 2007) in secondary biology education. This context-based reform proposal was designed to increase the relevance and coherence of the curriculum, and reduce the curriculum overload. The aim is to achieve appealing curricula in which the subject matter is taught and organized through contexts. The underlying idea is that students will learn to direct their own learning and come to see the important role of biology in society and further education. The use of a context in education is thought to increase relevance, coherence, and meaning for students (Gilbert, 2006). As the aim for contexts in the proposed reform is to be culturally defined and realistic, the reform committee has proposed three categories for these contexts: professional, academic, and the public sphere (Boersma et al., 2007). In the Netherlands, government policy states that educational policy makers can prescribe certain content and final requirements, but not specific teaching methods. Teachers in secondary education thus have a great deal of autonomy. The reform committee therefore focused on updating the biological subject matter of the curriculum and on the formulation of new objectives and final requirements. However, meeting these new objectives and requirements will inevitably have pedagogical implications.

A context-based lesson is characterized by the use of a context which is relevant to students so that they can feel part of it. Also, students are encouraged to direct their own learning process and work around a central question that follows from the context. Especially in the higher grades there has to be a strong emphasis on the decontextualized concepts of biology that need to be learned. It is therefore important for teachers to spend part of their lesson on the reflection of the decontextualized concepts (Bennett,

Lubben, & Hogarth, 2007; Bennett, Grasel, Parchmann, & Waddington, 2005; Boersma, 2011; Bulte, Westbroek, de Jong, & Pilot, 2006).

3.4.4 Procedure

When constructing the MECI protocol we first tried out the interviews on four secondary-school biology teachers (Pre University Education n=3, General Secondary Education n=1) to test its practical and internal validity. Based on the results, we adapted the interview protocol on issues such as order and phrasing of the questions.

Before the MECI, we first conducted a baseline test (t=0) in which we introduced the participating teachers (n=9) to the reform by using official reports from the reform committee. These reports are the main source of information for any biology teacher in the Netherlands confronted with this educational reform. In this baseline test teachers were asked in what way they would like to implement context-based education in their own teaching practice. Next, this was formulated as an intention to change. Teachers then indicated the strength of the intention on a 1-7 Likert scale (1=low to 7=high).

After that, we conducted the MECI. For the full MECI protocol we refer to Appendix 3 and in what follows we will briefly explain the main steps. We first asked the participants to describe their regular teaching practice. We then asked the participants if they could represent the same regular teaching practice in the given lesson segments. When the meaning of a lesson segment was unclear from the list (see Table 3.2), the interviewer gave additional explanation. After this, the interviewers presented the following two main approaches to context-based lesson structures to the participants: (1) Context with central question – Answering questions – Explain; (2) Context with central question - Explain – Answering questions. Next, solution-focused questions were asked to find earlier successful experiences with parts of context-based education (e.g., what could take your regular teaching practice one step towards the goal situation? did you ever have success with this, however small?). The intentions to change were the answers to the following open question: What could take your regular teaching practice one step towards the goal situation?

After collecting the intentions, teachers were asked to indicate the strength of their new intentions on a 1-7 Likert scale (1=low to 7=high). This method of rating intentions was previous described by Fishbein & Ajzen (2010).

After completing the MECI, the final step was to elicit specific beliefs about the new intention or intentions. We therefore posed questions on behavioral beliefs (advantages and disadvantages), normative beliefs (people that approve or disapprove), and control beliefs (enabling and hindering factors). Interviews lasted between 1 3/4 and 2 hours and were recorded using voice recording technology.

3.4.5 Data gathering and analysis

To determine the development of the strength and specificity of biology teachers' intentions, we gathered several data. First, we gathered all the intentions and their strengths, both from the baseline test and after using the MECI. We also listened to the recorded interviews to copy the exact phrasing of the intentions in order to determine the specificity of an intention. This specificity of intentions was then determined by analyzing to what extent an intention is specific about the how, when, and where (Gollwitzer, 1999). There was a clear goal for the teachers; i.e., the two sequences of lesson segments that represent context-based education. This restricted the formulation of intentions, so that in fact all intentions were aimed at the goals of the context-based reform. However, teachers could choose the aspect or aspects of context-based education they were most motivated for.

To determine the mechanisms underlying the developments, we analyzed the specific role of the two tools in this research and looked into the underlying beliefs of the intentions. We expected that earlier successful experiences helped teachers to think back to situations where they were able to execute the required behavior and see the benefits of the goal behavior. We expected the set of lesson segments to assist teachers in recombining and adapting their regular teaching practice in order to propose a change towards the goal situation, in this study being context-based education. On the basis of these hypothesized outcomes, we specifically looked into data from the interview recordings where teachers spoke about a. earlier successful experiences;
b. their regular practice and the sequence of lesson segments that represented this;
c. the rearrangement or adaptation of the sequence or content of these lesson segments and d. their beliefs about the intention or intentions. For each participant we made a document with an overview of these data, which was then sent back to the participant

for a member check to ensure internal validity (Miles & Huberman, 1994). After all teachers had approved the documents as good representations of the interview, the first and second author further analyzed this. We first checked whether the intentions were formulated in terms of rearranging and/or adapting lesson segments. Also, did teachers refer to specific successful experiences when formulating intentions to change? If so, were these successful experiences helpful in predicting hindering and enabling factors, advantages and disadvantages and/or people that approve or disapprove due to the fact that they already executed the required behavior?

3.6 Results

Performing the MECI yielded several distinctive outcomes. Regarding the development of teachers' intentions, the first thing to note is that all teachers scored their intentions higher after the MECI (see Table 3.3). Important here is that intentions in the baseline test (t=0) are often different from those formulated after teachers had used the MECI technique. Our comparison of these intentions also showed that teachers formulated more intentions after using the MECI technique.

Table 3.3

Survey of the intentions pre- and post-test

	Baseline test (t=0)		After the MECI	
Name	Intention	Strength	Intentions	Strength
Walter	I want to choose a subject that is spread over several chapters of the textbook and teach this in a more coherent way	3.5	I want to start the lesson with an example or situation, which I normally plan at the end of the lesson. From this example I will formulate central questions for the pupils. After that, I will explain the topic and give notes. With this explanation and the textbook pupils will have to answer the central questions	6.5

	Baseline test (t=0)		After the MECI	
Name	Intention	Strength	Intentions	Strength
Anne	I want to do something with the pupils' prior knowledge by constructing something together	5	I want pupils to be actively searching information to answer the central question	7
			I want to start the lessons by using a context	7
Ryan	I want to be able to help students to learn specific contents	5.5	I want the pupils to look for and find out the required specific knowledge themselves on the basis of specific questions	6
			I want to start the lesson with a context more often	6
			I want to use more student-centered activities	6
Kathryn	I want to start the lesson by presenting a context	6	I want to start the lesson by presenting a context followed by a central question	7
			I want to give pupils a more prominent role in reflecting on the lesson	7
			I want to demonstrate first how to answer questions	7
Howard	I want to focus the lesson on the concepts to be learned	6	I want to use a context to motivate students for practical work in the next week	6
			I want students to be involved in designing contexts	6.5
Becky	I want to start the lesson by presenting a context	6	I want to construct contexts from the questions that pupils asked in previous lessons. After that, I want the pupils to answer the questions themselves	7

	Baseline test (t=0)		After the MECI	
Name	Intention	Strength	Intentions	Strength
Mark	I want to connect student activities to the subject within a context	4	I want to start the lesson with a context, working from the examples and movies I normally show separately	6
			I want to pose a central question that follows from the context and have students find the answers	4
			I want students to work in small groups on solving the central questions	4
Julia	None	-	I would like to start the lesson with a context, for which I will use application exercises that I normally hand out later in the lesson	5.5
Ivy	I want to have pupils work together on a certain problem within a context	6.5	I want to start the lesson by presenting a context, for which I will use adapted assignments which I would normally hand out after the explanation phase	6.5
			I want the pupils to look up and find out the required information themselves	6.5

A second result of the MECI technique is that it indeed resulted in intentions that are more specific than those found in the baseline test. Mark, for example, first formulated the intention: "I want to connect student activities to the topic within a context". After the MECI, he however formulated the intention: "I want to start the lesson with a context, working from the examples and movies I normally show separately". Another participant, Anne, formulated the following intention in the baseline test: "I want to do something with pupils' prior knowledge by constructing something together". After MECI, she was able to be more specific in the how: "I want to start the lessons by using a context" and "I want the pupils to be actively searching information to answer the central question".

As to the mechanisms underlying the MECI, it seems that the two tools each functioned to assist teachers in specific ways. First, teachers were indeed able to represent their regular teaching practice in a specific sequence of lesson segments, which made comparison with the sequences of context-based education possible. This made visible for participants that sometimes, they had already implemented a certain part of the context-based education in their regular practices. This in turn stimulated feelings of ability (control beliefs). Second, teachers were also able to formulate intentions using the terminology of the lesson segments, which implies that seeing the reform represented in lesson segments helped them to devise ways in which they could change towards the reform. Third, participants were all able to think back to relevant successful experiences with parts of the new behavior. Because they envisioned situations in which they had already successfully implemented parts of the reform, teachers were able to predict the specific advantages and disadvantages (behavioral beliefs) of the change proposal. This however also led to high feelings of control (control beliefs). In the remainder of this section we will describe two cases of participating teachers in which we try to visualize the process and outcomes of the MECI technique and the way in which the intentions interrelate to certain beliefs. We selected the participants for these cases to represent teachers who at first do not see the benefits of the reform (Walter), and teachers who find it hard to direct their change (Ivy).

3.6.1 The case of Walter

Walter is a 40-year old biology teacher with ten years of teaching experience. He is an enthusiastic biologist with a huge collection of prepared bird skeletons, who would like to convey his passion for biology to the students. His reasons for participation in our research were his curiosity about what the context-based reform proposal would mean for his everyday practice and the opportunity to expand his teaching repertoire in a broader sense. His most common approach to instruction is to present biological topics in a traditional classroom setting. He really feels that he has to emphasize the most important terms from the textbook and show the students how these relate together. In his lessons (50 minutes) he would regularly lecture most of the time and have the students do reproduction (sometimes application) exercises for the last ten minutes of

the lesson. He is not very enthusiastic about the reform proposal. On the basis of the reform materials provided by the researchers in the baseline test, he recognized the notion about the little coherence within biology lessons. Because of this he formulated the following intention in the baseline test: "I want to choose a subject that is spread over several chapters of the textbook and teach this in a more coherent way". He rated the strength of this intention 3.5 (1-7 Likert scale, 1=low and 7=high). In the subsequent interview he represented his regular teaching practice in the following lesson segments: *Orientation → Explain → Reflect → Reproduction and/or Application → Answering questions.*

During the MECI the interviewer showed the context-based lesson sequences, represented by the same set of lesson segments (see Method). We then asked Walter whether he had ever had a successful experience related to the goal behavior. He stated that he had already tried to engage pupils by using examples from pupils' everyday lives, for example by presenting the ADH-hormone in relation to the maximum amount of alcoholic drinks on a night out. He also had had some experience with teaching thematic units and at the time had found pupils to be active learners. However, pupils had also said to him that he could explain subjects really well and that his notes were excellent and helpful. He stressed the importance of giving notes and the central role of the textbook in his lessons. However, he also admitted that students were quieter and more engaged when he asked them an interesting question, for instance about the role of the liver in the breakdown of alcohol. After reflecting on such examples, he exclaimed: "So if the reform program proposes a context to engage and motivate students to find information themselves, this means that I sometimes already apply part of the reform within my regular lessons?" On the basis of his successful experiences he formulated the following intention to change his lesson sequence in line with context-based education: "I want to start the lesson with an example or situation, which I normally plan at the end of the lesson. From this example I will formulate central questions for the pupils. After that, I will explain the topic and give notes. With this explanation and the textbook pupils will have to answer the central questions." Strength of this intention is 6.5.

Next, we asked questions concerning his beliefs about this intention. As behavioral beliefs (advantages and disadvantages) he mentioned that he saw advantages in creating increased relevance for the students by connecting to the students' experiences in the context; in the idea that he could still explain the topic at hand

before the phase of finding answers; and in the idea of being able to use students' questions in his explanation. As disadvantages he expected a slower pace throughout the lessons and negative reactions to the students' task to find information. As normative beliefs (people that approve or disapprove) he mentioned no persons or groups in particular that he thought would approve or disapprove. As control beliefs (enabling and hindering factors) he mentioned the limiting aspects of not having enough time to let students find the necessary information themselves; the fact that not all information needed to solve a task can be found in the students' textbooks; and that not all topics are suitable for starting with a context because sometimes the necessary pre-existing knowledge is lacking. Finally he considered an enabling factor the fact that he already had some experience within a thematic unit in which he started the lesson series with an example from everyday life.

3.6.2 The case of Ivy

Ivy is a 42-year old biology teacher with a PhD in immunology. She has been teaching upper secondary level for ten years. The reason for her participation in our research was that she was worried about the students' lack of motivation and her own growing discontent with the quality of her teaching. She said: "Actually, in my everyday practice I am appeasing my conscience with a sense of security that I at least mentioned all the important textbook terms. Pupils cannot come to me after a test and say that I did not address this or that issue, even though I noticed in tests that they learned little of what I said." She had read the reform materials and formulated the following intention in the baseline test: "I want to have pupils work together on a specific problem within a context." She rated the strength of this intention 6.5. Her regular teaching practice is represented as follows: *Orientation* → *Explain* → *Reflect* → *Reproduction and/or Application* → *Answering questions.*

When confronted with the two sequences of context-based education and asked for ideas and successful experiences, Ivy mentioned that she had made pupils work in small groups centered around stories from cancer patients. Another time she started the lesson with some questions about dissimilation and let pupils work together to answer the questions. She found that pupils were more motivated during such lessons.

However, she also said that it depended on the class level and the pupils themselves whether such an approach worked or not. She further stressed that she felt like there was little time to experiment in lessons, due to the many topics she is required to cover in a year. But she does think that students are better prepared for university when they are regularly encouraged to find the required information themselves. On the basis of her successful experiences she formulated two intentions, of which we will elaborate one: "I want to start the lesson by presenting a context, for which I will use adapted assignments which I would normally hand out after the explanation phase", strength 6.5. As behavioral beliefs she mentioned that the use of a context could increase the relevance for students; she expected students to participate in the activities more intensively, and she believed that adopting this model would enhance her professional performance within the school. She saw no disadvantages. She held two normative beliefs: (1) the school board would approve her intention because they had asked her for a portfolio on the process of personal growth and (2) at her school, working from the textbook generally had a negative image. As control beliefs she mentioned doubts about her creativity to design contexts and her lack of preparation time for each lesson.

3.7 Conclusions and implications

Professional development aimed at the implementation of an educational change proposal often focuses on the skills and knowledge that have to be improved and/or changing the environment in which teachers work. In literature on behavioral change, however, there is another very important condition for successful change: the formulation of strong intentions to change (Fishbein & Ajzen, 2010). Before any successful attempt at change teachers first need to develop strong intentions for change. However, formulating strong intentions to change is often not included in professional development programs. In this chapter, we reported on our research into the development of teachers intentions to change in the direction of context-based biology education after using a 'motivating-for-educational-change' interview (MECI). The MECI comprises two tools: building on earlier successful experiences and using lesson segments to rearrange lesson structures. The results show that intentions to change were positively influenced by the MECI technique. After the MECI, all participating

teachers formulated intentions that were stronger than those in the baseline test (see Table 3.3). The intentions were also found to be more specific in their description on how to enact the reform. Eight out of nine teachers also formulated more intentions to change after the MECI. The ninth teacher (Julia) could not think of any intention to change her teaching behavior in the baseline test, but was able to formulate in what way she wanted to change after the MECI.

Both MECI tools seem to have contributed to the results, with a partial overlap. The first tool used in this research was explicitly intended for teachers to look back on past successful teaching experiences. From literature, we expected that successful experiences would positively influence both control and behavioral beliefs. Although we did not measure beliefs in the baseline test, the data show that thinking back to earlier successful experiences resulted in positive beliefs about the new behavior in several ways. For example, participants thought back to earlier successful experiences such as working around stories from cancer patients (Ivy) to understand in what way the reform would affect both their teaching practice and their materials. Teachers also discovered personal strengths such as talent to design relevant contexts (Mark), which they used to formulate intentions to change. Thinking back to situations in which they already successfully enacted parts of the reform, teachers generally saw the direct benefits for their students (positive control beliefs) and possible ways to implement the reform (control beliefs). However, they also mentioned limiting factors (control beliefs) of the proposed reform such as extra preparation time, a lack of creativity in designing contexts, or problems with directing students towards the scheduled topic.

The second tool in the MECI technique was the use of lesson segments to rearrange lesson structures. Our expectation for this tool was that it would enable teachers to better compare their regular practices with context-based education, and understand how to reach that reform by rearranging and adapting their regular practices. The results show that teachers were able to formulate an intention to change towards the reform proposal in terms of rearranging or adapting lesson segments. This is illustrated in the following intention, formulated by Anne: "I want pupils to be actively searching information to answer the central question", whereas in the baseline test she had stated that she "wanted to do something with the pupils' prior knowledge". When asked to describe their regular practice, all participating teachers would normally

design a lesson with reproduction or application exercises at the end. Eight of the nine teachers in our sample extended such exercises into a context and moved that lesson segment to the start of the lesson. In this way, teachers made an important step towards the essence of the proposed reform, i.e., achieving appealing curricula in which the subject matter is taught and organized through contexts.

To come back to the literature on the implementation of educational reforms, we emphasize that the aspect of teachers' willingness needs more attention. Many attempts at change pay attention to the knowledge and skills that teachers have to learn and/or creating a supportive environment (Borko et al., 2010). However, as stated before, these are only two of the three known conditions for behavioral change. The condition that teachers need to have strong intentions to change needs more attention. In this study, we have shown that combining a set of lesson segments with a focus on earlier successful experiences within a MECI can be successful to stimulate strong and specific intentions to change in the direction of an educational change proposal. At the start of PD programs, MECI can be administered to find out for what part of the change proposal teachers are motivated. Next, teachers could start their development in the direction of the proposed reform on the basis of their specific intention and pre-existing knowledge gained through the MECI. In this way, teachers start off with strong and specific intentions to change in the direction of a change proposal, which prevents failure of the reforms' implementation (Fullan, 2007). Secondly, MECI offers teachers the possibility to take their regular teaching practice as starting point for change, which is an important feature of effective PD (Borko et al., 2010). Finally, MECI offers teachers the possibility to use their personal strengths while proposing changes to their teaching practices towards a change proposal.

Appendix 3

The MECI protocol

1. Could you describe a lesson as you regularly teach it in your classes? Can you represent this same lesson using the set of lesson building blocks?

Interviewer shows sequence of building blocks that comprise context-based education:

A: Context with central questions – Answering questions – Explain

B: Context with central questions - Explain – Answering questions

2. Did you ever have positive experiences with context-based education or aspects of context-based behavior? Even something small? Why was this successful?
3. When you compare your regular lesson sequence to that used in context-based education, can you think of anything that could take your own regular lesson sequence (see question 1) one step towards context-based education?
4. Could you rephrase these proposed changes into intentions and rate them on a Likert-scale from 1-7 (1=low to 7=high)?

Additional questions for eliciting beliefs

5. What are the advantages and disadvantages of performing the intended behavior?
6. Are there any individuals or groups that approve or disapprove on performing the intended behavior?
7. What factors or circumstances would enable you of make it difficult for you to perform the intended behavior?

Chapter 4

LEARNING TO DESIGN AND ENACT CONTEXT-BASED EDUCATION: A PRACTICAL APPROACH TO TEACHERS' PROFESSIONAL DEVELOPMENT[1]

Abstract

Educational reforms generally aim to optimize student learning. Teachers, however, primarily appear to assess reform proposals according to their practicality. In this chapter, therefore, we discuss three design principles for practicality and test to what extent these were effective for the professional development of teachers in the setting of a reform. On the basis of these principles, a professional development (PD) program has been executed on learning to design and implement the context-based educational reform that was proposed for Dutch biology education. The elements of the PD program in this study were: learning from success; using lesson segments to innovate; and grounding teacher learning in teachers' own practice. The results showed that, using this approach, participating biology teachers (n=8) were able to change their regular teaching practice in a rather independent and step-by-step way towards the educational reform while preserving the essence of the reform. Teachers also appeared to have strong intentions for each step in their development. Starting from teachers' regular teaching practices, there appeared to be a certain learning path in learning to design and implement context-based education.

1 This chapter has been published in adapted form as: Dam, Janssen & Van Driel (2013). Concept-context onderwijs leren ontwerpen en uitvoeren – een onderwijsvernieuwing praktisch bruikbaar maken voor docenten. *Pedagogische Studiën, 90*(2), 63-77.

4.1 Introduction

The implementation of the context-based educational reform is scheduled to take place in secondary biology education in the Netherlands over the next few years (Boersma et al., 2007). Research shows that teachers play a crucial role in the success of an educational reform (Fullan, 2007; Van Driel, Beijaard, & Verloop, 2001). It proves to be hard for teachers to translate the objectives and starting-points of an educational reform into teaching behaviors and concrete teaching activities and materials, often resulting in a negative attitude to the reform and a lack of implementation success. If an educational reform is to be implemented successfully, teachers however do need to adopt the educational reform in their own regular teaching practice and must learn to translate the objectives and starting-points into teaching activities and materials.

Doyle (2006) showed that teachers primarily assess educational reforms on their practicality. Three practical criteria determine the likelihood that teachers will actually implement a reform: they need to know how they can work with a particular idea in the classroom; it should fit in with what they are already doing; and it should cost little extra time and resources.

In this study, we focused on bridging the gap between regular classroom practice and the context-based reform proposal by making the reform practical. We formulated three design principles for practicality and used these to develop and test a professional development program in which teachers learned to implement context-based education into their own teaching practice in a step-by-step approach. As this involved a behavioral change, we chose to study the strength of the teachers' intentions, as intentions to adopt a particular behavior are known to be the best predictors of the actual implementation of the behavior. In this study, therefore, we studied the strength of the teachers' intentions to implement the reform. In addition, we also explored the developments in the teaching repertoire of the participating teachers. Our research question is the following:

How do the strength of teachers' intentions and their teaching repertoire develop in the course of a professional development program focusing on practicality in designing and implementing context-based education?

4.2. Theoretical framework

4.2.1 Implementing educational reforms

The Committee for Innovating Biology Education (CVBO) identified three bottlenecks in secondary biology education in the Netherlands (Boersma et al., 2007): too little relevance for students, too little coherence in biological knowledge, and program overload. To address these bottlenecks, the CVBO proposed to introduce the context-based approach in biology education. This approach aims to develop attractive curricula, in which course contents are taught and learned by using contexts. The underlying idea is that this will stimulate students to acquire knowledge in a more independent way and that it will help them to grasp the important role of the natural sciences in society and in secondary education. For their definition of a context, the CVBO committee looked at the tradition in cultural-historical psychology (Vygotsky, 1978), in which a context is defined as a practice. In such a practice, participants perform activities in order to reach objectives that are relevant in that practice (Boersma, Kamp, Van den Oever, & Schalk, 2010). Concepts (biological knowledge) acquire meaning in these practices because they are functional in reaching objectives. This context-based approach was predominantly designed to modernize the content of biology education, but it also has certain implications for teachers' instructional approaches at classroom level that should help to meet the new objectives and examination requirements. These new objectives and examination requirements will be introduced nationally, but the implications of the reform in terms of instructional approaches are largely up to teachers themselves. In this research, we focused on these developments in teachers' instructional approaches.

How the reform is to be accomplished in teaching practice is largely dependent on the implementation method. It is known that teachers play a crucial role in implementing educational reforms (Borko, Jacobs, & Koellner, 2010; Fullan, 2007; Van Driel et al., 2001). Teachers that are confronted with reforms such as the context-based reform, will need to adjust their knowledge base to the new content or the new examination requirements. Moreover, they will also need to adjust their repertoire of instructional approaches to this new approach. This is not an easy matter.

The implementation history of educational reforms has shown that the way in which teachers implement reforms into their teaching practice may differ from how they were designed by developers (Van den Akker, 2003): whereas developers, for instance, may aim to achieve higher learning results or greater student participation, teachers primarily appear to assess a change proposal on its practicality (Doyle, 2006; Doyle & Ponder, 1977). Practicality is here defined as follows: "an expression of teacher perceptions of the potential consequences of attempting to implement a change proposal in the classroom." (Doyle & Ponder, 1977).

Three practical criteria determine how teachers assess the practicality of a reform proposal. The first criterion is *instrumentality*, focusing on teachers' ability to translate the ideas of a reform proposal into teaching activities and teaching materials. The second criterion is *congruence*, focusing on similarities and differences between the objectives and assumptions of the reform and what teachers already believe and do. The final criterion focuses on the *costs* aspect, with the benefits in terms of learning outcomes and student involvement being set off against more preparation time and other investments. In this final criterion, a low-cost implementation means convenience for teachers and immediate advantages for teaching practice. In implementing educational reforms, this principle of practicality is often ignored. Day-to-day practice with all its limitations and challenges, however, is an important determinant of what teachers are able and willing to implement (Kennedy, 2010) and, hence, of the success of the implementation of an educational reform.

In this study, we explored how the context-based approach could be made practical for biology teachers while preserving its essence. On the basis of three design principles, therefore, we designed and implemented a professional development program. This program focused on improving practicality while exploring developments in both the strength of teachers' intentions and teaching repertoires. We collected intentions because these are the most important predictors of the likelihood that someone will actually adopt new behavior (Fishbein & Ajzen, 2010). If a reform is experienced as being practical by teachers, the strength of their intention to teach their classes in line with the reform is likely to increase.

Improving practicality related in this study specifically to the following three design principles for professional development: allow teachers to build on earlier

successful experiences (2.2); allow teachers to accomplish the reform by recombining and adjusting their existing lesson segments (2.3); support teachers from a distance and according to their individual needs (2.4).

4.2.2 Allow teachers to build on earlier successful experiences

Teacher learning often centres on eliminating deficiencies, which appears to result in low willingness to implement actual change. Instead of pointing out deficiencies, the first design principle in this study focuses on teachers' strengths and earlier successes. To frame the design principle in which teachers build upon earlier successful experiences, we made use of the ideas and starting points of positive psychology (Seligman, 2002). These do not first focus on addressing problems but focus right away on someone's strengths and talents. Based on same idea, psychotherapy has come up with an approach that focuses on helping people with persistent problems. This approach does not start with an analysis of complaints and problems but focuses right away on someone's aims and skills, taking solutions rather than problems as its central principle. This solution-oriented psychotherapy (De Shazer, 1985; Miller, Hubble, & Duncan, 1996) starts with an analysis of the target situation and proceeds to check if there have been any successful experiences in the past in which the problem did not occur or less so and part of the solution was already present. These experiences are then converted into solutions and elaborated in a step-by-step approach until the target situation has been achieved. In our study, we applied this solution-focused approach in the setting of implementing the context-based educational reform. As teachers can already have executed parts of the context-based reform successfully in their existing practice, thinking back to such earlier successful experiences could have a positive influence on the strength of teachers' intention to implement the change proposal. In such, this design principle relates specifically to the *congruence* criterion of practicality (Doyle, 2006; Doyle & Ponder, 1977).

4.2.3 Allow teachers to accomplish the proposed reform by recombining and adjusting existing lesson segments

Teachers often feel there are major irreconcilable differences between their regular, everyday teaching practice and the methodological implications of an educational reform. To reduce these perceived differences, we concurred with Holland (2000), who showed that innovations often involve the recombination of existing segments. Similar work by Merrill (2001) states that only a few segments of lessons (*tell*, *show*, *ask*, and *do*) are needed to design many different approaches to direct instruction. A similar set of lesson segments as used in this study had been composed and validated by the author in previous research (Dam, Janssen, & Van Driel, 2010). The complete set of lesson segments that was used in this study (see Table 4.1) was designed so as to be able to represent a wide range of teaching approaches, which may vary from traditional and teacher-driven teaching approaches to more activating and student-driven ones (Anderson, 2007). The point of departure for the design of the lesson segments in our study was the primary methodological structure of a lesson as commonly taught by teachers (Merrill, 2001), encompassing a sequence of main activities that shape the learning process of a lesson (e.g., explanation, application, reflection). In this study, the same set of lesson segments was used to represent both teachers' regular practices and the methodological implications of the context-based reform. This made comparison possible and teachers could see those aspects of the reform they already mastered. By recombining and adjusting these existing lesson segments, the teachers could accomplish the reform themselves. In such, this design principle helps to diminish the gap between the reform and teachers' regular practices. It also helps teachers to understand how the ideas of the reform can be translated into concrete teaching activities and/or materials. This design principle, therefore, is particularly related to the practicality criteria of *congruence* and *instrumentality*.

4.2.4 Support teachers from a distance and according to their individual needs

Although the first two design principles (Sections 4.2.2 and 4.2.3) together are likely to improve practicality, the manner of the implementation also appears to contribute to practicality and, hence, to the effectiveness of professional development programs. This

requires the implementation to be situated in teachers' own classroom practice (Borko et al., 2010). Evaluations of development programs located externally, have shown that teachers do not sufficiently implement such programs in their teaching practices (Vink, Oosterling, Nijman & Peters, 2010). In our PD program, we supported the participating teachers from a distance and according to their individual needs. The participants designed their lessons in their regular environment and taught them in their own classrooms, which allowed them to decide when they would design, execute, or reflect on these lessons. The program supervisors only supported the teachers according to their needs by e-mail. Such supervision from a distance and according to need is fully grounded in the teacher's everyday environment. This manner of providing support specifically relates to the *costs* criterion of practicality theory (Doyle & Ponder, 1977).

Table 4.1

Survey of the lesson segments as used by the participants in this study

Lesson segment	Description
Orientation	Introducing a lesson's topic, formulating objectives, activating prior knowledge, and planning of time and activities
Context with central question	Introducing the context and the central question
Answering the central question	Answering the central question
Explanation	Explaining/presenting the general subject matter (knowledge and/or skills)
Reflection	Evaluating the learning process and the learning results, accounting for success or failure, and defining improvements for next time
Testing	Assessing to what degree the learning process and the learning results match the objective set in advance
Reproduction	Formulating a question or assignment that forces students to reproduce the knowledge or skills they acquired

Note. The regulation for each lesson segments can be done by the teacher, the students, or shared between teacher and students (shared regulation).

4.3 Method

4.3.1 Participants

The context-based reform proposal was scheduled to be introduced in secondary education in September 2013. This is why we targeted biology teachers from secondary schools for participation by sending an opening invitation to well-known schools to the institute, former participants in teacher training programs, and teachers who had previously indicated they were willing to engage in training in the setting of the reform. Out of approximately 30 teachers that were invited, eight registered. All of these were working in upper general secondary education or pre-university education. This sample of eight teachers varied in terms of characteristics such as gender, age, teaching experience, lower or upper school teaching, and experience in teaching context-based education (see Table 4.2). Upon first acquaintance, not all teachers had a positive attitude towards the reform.

Table 4.2

Survey of participants in this study

Participant	Gender	Age	Teaching experience (in years)	Lower school (LS) Upper school (US)	Teaching experience in context-based education (in years)
Henk	M	49	11	US	3
Anna	F	52	4	LS	0
Astrid	F	46	10	LS	0
Cora	F	49	12	US	0
Remco	M	34	5	US	4
Maarten	M	28	3	LS	0
Iris	F	42	10	US	0
Willem	M	40	10	US	0

4.3.2 Operationalization of the reform

The CVBO committee does not prescribe any choices in teaching methodology (Boersma et al., 2010, p. 75). But some teaching methodologies are obviously more likely that others to meet the set targets. Methodological implications have been described by Boersma (2011), amongst others, and/or have been detailed by designated biology curriculum development schools[2] in example materials in the following way: a. biological knowledge (content) is offered in a context; b. this context is derived from practice, that is, a part of social reality that can be delimited and in which people realize shared goals (Boersma, 2011); c. the CVBO committee distinguishes three classes of practices: everyday life practices, professional practices, and scientific practices; d. in the classroom situation, practices are offered as realistic contexts; e. contexts give meaning to concepts, which is why the explicit discussion of biological knowledge away from the context is an important component; f. students must learn to use concepts in several practices (recontextualization); g. particularly in upper general secondary education classes and pre-university classes, contexts are a means and not an end, and hence there needs to be a sharp focus on biological knowledge; h. there needs to be a central question that is attractive to students and that follows logically from the context (Kamp, 2010).

In order to enable teachers to implement the educational reform in their teaching practice and to facilitate practicality, some choices were made in this study that may deviate slightly from the above-mentioned implications. These deviations particularly concerned the definition of a context and the process of recontextualization. The main reason for doing so was that, in this study, teachers were beginning to change their teaching practice while taking their regular practice as a starting-point; they needed to have the possibility, therefore, to define contexts in a way that remained close to their often traditional regular teaching practices (Gage, 2009), using concrete situations or cases to introduce biological knowledge. Recontextualizations were not included in this study because each lesson plan concerned a single lesson, and as recontextualizations were therefore rarely applied, they were not included in our analysis.

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2 A CVBO publication: *Examples of the context-based approach in biology education*, January 2010.

In this study, a clear target situation was formulated for the participating teachers by operationalizing the methodological implications of the proposed reform into two sequences of lesson segments:

1. Context with central question - answering the central question - explanation;
2. Context with central question - explanation - answering the central question.

The second methodological implication of the proposed reform concerns the definition of a context: the context raises a central question, which requires activities to be undertaken, which induces students to acquire biological knowledge (concept). Hence, the definition of a context may vary from a case in which biological knowledge is being offered, to a realistic context in which students themselves need to perform an action, as when they are required to take the role of a natural scientist and need to decide whether or not to deploy large herbivores in a particular forest. The third methodological implication concerns the way in which segments are defined, which can be done by the teacher, be shared with students, or be done by the students themselves. These variations allow students considerable scope to influence elements of the lesson plan (Anderson, 2007).

4.3.3 Procedure

All participating teachers were interviewed at the beginning and at the end of the study; in between, each teacher designed four innovative lessons for his or her own classroom practice. These lessons were given to the teachers' own classes. Each teacher chose a class and gave his/her lessons to that same class throughout the study. In the initial interview, a teacher's regular practice was first mapped with the aid of lesson segments. This regular practice was then compared with the context-based method as operationalized in this study. Then the participating teachers themselves, using the solution-focused questions from this study, identified and scored the changes they proposed to make (intentions). After that, their intentions were developed into complete lessons. The procedural steps in this study were the following:

1. The regular teaching practice was mapped and jointly translated into lesson segments.
2. The regular teaching practice was compared with the operationalization of context-based education as described in lesson segments in Section 4.3.2.

   We then asked several questions:

3. What would you like to change in your regular teaching practice so as to bring it more in line with the proposed reform? This frames the teacher's intention.
4. Have you had any earlier successful experiences with this? If so, what were they? How could these experiences contribute to the concrete design of your lesson?
5. The strength of the intention was collected through the participant's response to the statement: 'In the period ahead, I'm going to carry out this intention.' To do so, the participants scored their response on a Likert scale from 1 to 7 (1=low and 7=high).
6. Teachers developed their intention into a complete lesson composed of lesson segments. Teachers also predicted learning outcomes by expressing the expected number of correct answers to the student assignment in percentages.
7. The lesson was then given and videotaped. The learning outcomes were determined in a student assignment that was incorporated into the teaching materials. An example of such an assignment pertaining to the working of the ear might be: 'Describe how you know which music is being played in class; in your answer mention all elements of sound reception including structures in the brain.'
8. After the lesson had been given, teaches reflected with the aid of an Internet questionnaire. This Internet questionnaire was based on the success-oriented methodology, inviting teachers to reflect on their own experiences with any possible successes or problems, the obtained learning outcomes (as collected in the student assignment), or anything that might help to bring their teaching closer to the targeted type of education (see from step 2 above).

The intention formulated in step 5 was developed into a complete lesson by the participating teachers. This lesson was then given. After that, participants reflected on this lesson, following the procedure from step 2. Each intention generated a lesson, and each lesson given was followed up by reflection. Reflection, in its turn, gave rise

to the next intention, which was developed into another lesson, and so on. In total, all participating teachers formulated an intention, designed a lesson based on their intention, and reflected on their lesson afterwards four times.

The supervisors (first and second author) and the participating teachers only met in person for the initial and final interviews. Videos and questionnaires were exchanged by mail or email. In the intermediate period (approximately three months), the teachers were supervised from a distance. This supervision mainly amounted to answering procedural questions and giving tips by e-mail. Supervision was performed by a biology teaching methodologist and the researcher (second and first author, respectively). The procedural steps were designed in an Internet environment, in which teachers reflected on their lesson after they had given it. When necessary, they could ask for tips and suggestions by e-mail relating to lesson design and execution. The numbers and kinds of tips are represented in section 4.5. As a consequence of this type of supervision, lesson design, execution, and reflection took place in the teachers' everyday environment.

4.3.4 Data collection and analysis

The collected data predominantly consisted of intentions that were formulated for each lesson, the attested strength of these intentions, the lesson designs expressed in lesson segments, video recordings of the executed lessons, and answers to the Internet questionnaires that were used for reflection by the teachers.

Intentions

In psychology literature, it has repeatedly been asserted that intentions are the most important predictors of behavior (Fishbein & Ajzen, 2010): the stronger the intention, the greater the likelihood that someone will actually perform the behavior. To monitor intentional strength, the intentions were scored by the participants on a Likert scale from 1 to 7 (1=low and 7=high), as described by Fishbein and Ajzen (2010).

Changes in the teaching repertoire

The way in which the teaching repertoire developed towards context-based education was assessed with the aid of the following procedures.

1. To determine the starting situation – the regular teaching practice – the description of the most prevalent teaching situation was translated into lesson segments during the initial interview. This sequence was then immediately submitted to the teachers for validation.
2. In order to construct the development route of individual teachers, a survey was made of all their intentions, the strength of these intentions, and the sequence of lesson designs in the entire program
3. The video recordings were used to verify whether lessons were executed in accordance with the lesson design. The changes in the participants' teaching repertoire were determined on the basis of both the video recordings and the development route from point 2 above.
4. To be able to analyse the Internet questionnaires that were used for reflection, these were transferred into a spreadsheet program. Then we verified which teachers mentioned successful experiences in previous lessons or explicitly continued to build upon successes in the previous lesson of the program.
5. In the final interview, each participant was handed back a paper version of their individual learning route, aiming to enable the participants themselves to validate the observed changes (Miles & Huberman, 1994). We specifically asked what aspects of the program had contributed most to these changes.
6. Five months after the final interview, a telephone interview was conducted to determine to what extent aspects of the proposed reform had become part of the participants' regular teaching practice. Questions were for example: 'What have you done after the program to design and teach lessons in line with the context-based approach?' and 'To what extent has your teaching practice changed after the program?'

4.4 Results

4.4.1 Strength of intentions

Table 4.3, representing intentions and example lessons, shows that the teachers had strong intentions right from the start. For the majority of teachers, these intentions remained strong throughout the program.

4.4.2 Changes in teaching repertoires

Starting situation

A striking result from the initial interviews is that, in their regular practice, most participating teachers said they started out with the 'Explanation' segment, followed either by the 'Reproduction' segment or 'Context(s) with questions'. As a ground for this sequence, all participating teachers mentioned lack of preparation time, and some teachers mentioned preparation convenience for the teacher.

During the second step in the initial interview (i.e., the comparison with the given sequences of lesson segments for context-based education), participants were purposely asked for earlier successful experiences. All teachers were able to give examples of when they had worked with a concrete example or authentic context for students to work with. Astrid, for example, observed: 'In a recent project, I used the situation in a nature reserve to study the subject. Students had to decide what they would do with the large herbivores that had not survived the winter: leave the cadavers in the ecosystem or remove them because they might shock visitors or cause new problems?' Another participant, Iris, said: 'I launched a lesson with personal stories from cancer patients about the disease and their experiences. Students then had to find out how cancer actually arises and what the consequences are.'

Changes in the teaching repertoire

The intentions formulated by teachers throughout the program are represented in Table 4.3. After the strength of their intention had been determined, each teacher translated his/her intention into a lesson for the class involved in the study. In designing lessons, teachers used the set of lesson segments as represented in Table 4.1.

Analysis of the lessons showed that the first change that was introduced by seven out of eight teachers was to shift the 'Context with central question' segment from the end to the beginning of the lesson. In their subsequent lessons, the teachers maintained this change. As a second step in the process of change, most teachers wanted students to find the answers to questions themselves, using their prior knowledge. So where these teachers, in their first lesson after 'Context with question', provided explanation or a lot of help and tips, their second step was to give students a more active role in the 'Answering the central question' segment or to put it before the 'Explanation' segment. Examples from Table 4.3 are Anna's second intention and the Willem´s example lesson plan.

Table 4.3

Intentions throughout the entire program and examples of lessons designed and taught

Participant		Sequence of intentions	Strength	Lesson plan
Henk	1	Start with a context, preferably one chosen by students	6	*From intention 1: Start with the context of a scientist*
	2	a. Leave it entirely up to the students to answer the central question	6	*who reads about the discovery of new bacteria that do not use carbon*
		b. Limit reflection to those questions the students had difficulty answering	6	*but arsenic as their basis for metabolism. Is this really possible?*
	3	Get the students themselves to reflect on the answers	6	*To answer this central question, you need to devise an experiment*
	4	Strengthen the connection between the context with the central question and the concepts that need to be learned	6	*that would allow you, while taking the reproductive speed of bacteria into account, to discover whether these bacteria really build their biomass from arsenic or whether they do use carbon after all.*

Participant		Sequence of intentions	Strength	Lesson plan
Anna	1	a. I want to start the lesson with a context b. I want the students themselves to answer the central question I want the students themselves to search for the knowledge they need and to be actively engaged in doing so	7 7	*From intention 4:* *Start with the context of a general practitioner and brief explanation about a brochure. Today there is a special surgery to inform patients about contraceptives. Six patients come to surgery with different preferences and situations.* *Answer the questions from the context using information from your textbook, the teacher's brochure, or the Internet.* *What contraceptive(s) is/are a good choice for these patients?* *Explain why.*
	2	My intention is not to assist students in answering the question. They should enlist each other's help	6	
	3	Get the students themselves to come up with a context and central question	6	
	4	I first want to introduce a context involving a genuine profession and provide some explanation about the concepts before I raise the central question	7	
Astrid	1	I want to use contexts that I work out from the questions students asked me. After this, students have to answer the central questions	7	*From intention 3:* *Start with the context of a concert and play very loud music at the start of the lesson. Ask some students if they have their Ipods with them and at what volume they listen to music. Measure decibels using the sound sensor. Central question: how can you explain where damage to the ear arises? Is it permanent? The objective is to discover the structure of the ear. Students present their conclusion and explain how they came to their conclusion.*
	2	I want to control what concepts students learn	6	
	3	I want to connect the central questions more clearly to my learning objectives	5	
	4	Unknown	n/a	

Participant		Sequence of intentions	Strength	Lesson plan
Cora	1	a. I want to start with a context and first show students how to go about working with a context	7	*From intention 2: Start with the context of a newspaper article comparing the tipping-point in a political climate to that in an ecosystem. The central question is then about the use of models and how a tipping-point arises.*
		b. I want the students to present their answer to each other	7	
	2	I want to start with a context again and formulate questions for the students to answer. I am not going to show them how to go about it	5	
	3	a. I want to start with a context again and first get students to refresh their existing knowledge. Then I want them to look up the subject matter in the chapter	7	
		b. With the context, I want to formulate questions for students to answer that force them to grasp the subject matter in detail; they really need to go into the detail of the learning objective	7	
	4	For the next lesson, I want to present another attractive and detailed context and get the students themselves to formulate what they want to learn from it	6	
Remco	1	a. Start with a context more often.	6	*From intention 2: The context is about frogspawn: observing it with a stereomicroscope and feeling it. The central questions are: what do you notice? What are the external differences between the tadpoles and what causes these differences? Students study the stages of human embryology in their textbook and compare these with tadpole development. In what stage are the tadpoles now? Name the other biological processes involved.*
		b. Use student-driven elements more often	6	
	2	I want to put the 'lesson orientation' segment after the 'context with question' segment so students themselves can decide how they will search for or come up with the answer. I want to formulate my learning objectives more clearly	5	
	3	I want to convey the learning objective clearly by making the central question link into the learning objectives	4	
	4	I want to make the 'reflection' segment more student-driven	5	

Participant		Sequence of intentions	Strength	Lesson plan
Maarten	1	I want to start with a context and a central question to activate students with an example or video I usually present at the end of my lesson	6	*From intention 4:* *The context is a video about the 'Iceman' who claims he can regulate his autonomous nervous system.*
	2	I want to discuss the context with the central question students must answer with greater effectiveness. To do so, I would like to come up with a group assignment in which students discuss the assignment amongst themselves and explain the answer to each other	5	*Is this really possible? Students test if they can do this themselves: for example, can they influence their heart rate themselves during exertion? Students use heart rate monitors.*
	3	I would like to get students to come up with an answer to a question, preferably in groups, and then have a classroom discussion about the answer, with explanation on the smart board	6	
	4	I would like to start with a context, followed by relevant assignments that stimulate them to work seriously on these assignments	6	
Iris	1	a. I want to start with contexts that are based on assignments that I usually present at the end of my lesson	6.5	*From intention 2:* *Context 1: In her garden, your grandmother has an old oak tree next to some rowan trees. She asks you if it would do any harm to spray the oak tree with a pesticide to control plant lice.* *Context 2: Students apply what they have learned in the first context in an exam assignment, dealing with the consequences of intervening in an ecosystem.*
		b. I want the students themselves to look up knowledge	6.5	
	2	I would like to select a context that is relevant to students, which helps to really motivate them	6.5	
	3	I would like students to have enough time to discuss the answers, which requires strict time management	6	
	4	Unknown	4	
Willem	1	I want to start with an example or context with a question that I usually present after my explanation (either one I made up or one from the textbook). Then I present the explanation and invite students to answer the question	6.5	*From intention 2:* *You are a scientist specializing in cloning. The Argentinean Football Association would really like to have a football team consisting of at least 8 clones of Lionel Messi, the world's no.1 football player (video).*

Participant		Sequence of intentions	Strength	Lesson plan
	2	a. I want to enliven the context with an animation or a video rather than orally, to boost the students' interest and motivation	6	*How can you get this done? Step 1: discuss this question with your neighbour and make suggestions. Step 2: use your textbook and information provided to discover how you can make exact copies of an individual.*
		b. I want students themselves to answer the central question immediately after the context	6	
	3	I am going to try a similar lesson because I was very happy with the previous one. I want to know if this will also work with a less attractive subject	6	
	4	I want the students themselves to discover a process by using several contexts in a row	7	

As a third step, two directions can be distinguished: half the participating teachers focused on linking 'Context with central question' with the learning goals that needed to be attained, that is, how a teacher can get students to attain their learning goals with the aid of student activities and central questions. For example, this is shown in Cora's third example and in Astrid's example lesson plan (see Table 4.3). The other direction is about making the context relevant for students. Successful experiences in the participants' first and second lessons showed that relevance is important in motivating students. This second group of teachers also wanted to design a context lesson to activate their students for less attractive concepts or for difficult classes or awkward hours. Examples in Table 4.3 include Iris's second intention, Cora's fourth intention, and Maarten's example lesson plan. Other changes predominantly pertained to adaptations to the way segments were handled. An example here is that students took a more active role in devising the 'Reflection' segment. The lesson designs show that the contexts that were chosen varied considerably in terms of their proximity to the CVBO definition (see section 4.3.2). There appears to be a trend for participating teachers to start with contexts that are close to concrete examples and, in the course of the program, to develop these contexts into more realistic ones. Anna, for example, set out with a context involving an old oak tree and, for her fourth lesson, chose a context involving an actually existing profession (intention 4); she settled on the profession of

general practitioner, with the task for students to advise on possible contraceptives and the way they worked (see Table 4.3).

Two teachers (Henk and Remco) had already had some experience in teaching context-based education at the start of the program. Their intentions and taught lessons show that, at the start of the program, they were already focusing more clearly on the learning objectives. Remco formulated his reason for participating in the study as follows: 'I do not want a party first and sober explanation next; in my classes, I want there to be a straight connection between the context and the concepts that need to be learned by way of good questions and activities.' Both teachers, therefore, appeared to be skipping the first two development steps and to start straight away with the third step in the above-mentioned development plan in learning to design and implement the proposed reform.

In the telephone interview five months after the final interview, the majority of the teachers said to have continued to use contexts or captivating examples that are attractive to students and that motivate them. Several teachers also indicated that they had given students a more active role to play in various parts of lessons. In addition, teachers mentioned that, as a consequence of the program, they were working with clearer learning goals and were working towards them in more direct ways. Nevertheless, three teachers also said they did not always incorporate changes into their lesson structure as they had learned to do in the program because of the convenience of their traditional lessons.

4.5 Conclusion and discussion

In this study, we made a context-based educational reform more practical on the basis of three design principles (Sections 4.2.2, 4.2.3, and 4.2.4). These principles were incorporated into a professional development program on learning how to design and implement context-based education in the domain of biology. The results show that the participating teachers had strong intentions and that these intentions remained strong throughout the entire program. In addition, we found that the participating group of teachers was indeed able to develop their teaching repertoire towards that of

the context-based reform in a fairly independent manner. In this development, there proved to be a certain learning path with a number of sequential steps for teachers to change their teaching practice towards the context-based educational reform (see section 4.4.2).

The design principles in this study appear to be contributing to improving the practicality for teachers, which, in its turn, may help to improve the success of the educational reform. The results show that the design principles have each had their specific impact. The first design principle, 'allow teachers to build upon earlier successful experiences', appears to have had a clear influence on the strength of the intentions. At the reflection points between lessons, virtually all teachers were able to mention earlier successful experiences with their intention, sometimes in this program and sometimes in previous lessons or projects. What teachers mention in particular as a successful experience is increased student motivation and ability to work independently, which improves learning results. The more experienced teachers (Henk, Willem, and Cora), moreover, appear to be able to mention successful experiences more easily than the less experience teachers (Maarten and Anna), which would be a logical consequence of their greater teaching experience. In this study, building upon earlier successful experiences explicitly occurred in the initial interview and during reflection. Not only focusing on successes, but also a step-by-step approach and using solution-focused questions are ways of working with a teacher's strengths. All in all, this appears to foster strong intentions for the next lesson. This first design principle taps into a teacher's regular views and actions and, hence, relates specifically to the congruence criterion of practicality (Doyle & Ponder, 1977).

The second design principle, 'allow teachers to accomplish the proposed reform by recombining and adjusting existing lesson segments', was described by teachers as being highly practical. In the final interviews, the lesson segments proved to be considered by everyone as an important instrument in designing lessons and in really coming to grips with the methodological implications of the proposed reform. The target situation in this study consisted of two sequences of lesson segments that were used to operationalize the context-based approach in terms of teaching methodology (Section 4.3.2). As participants were also able to represent and design regular lessons with the same set of lesson segments, these proved to be an important instrument in

their development. Recombining and adjusting existing lesson segments with a view to realizing the proposed reform diminishes the gap between innovative and regular teaching practices and helps to shape the proposed reform in teaching practice in concrete terms. In this way, this second principle contributes both to congruence and to instrumentality.

The third design principle, 'support teachers from a distance and according to their individual needs', prevents pressure from arising due to class cancellations or added time investments. The main engine driving support in this study appears to be the Internet environment that was used to reflect on lessons taught. The steps in this reflective process are based on learning from success and using lesson segments (see section 4.3.3). In addition, this also allowed teachers to ask for additional tips or help by e-mail when necessary. This form of additional support, however, was barely required and mainly consisted of help in making contexts relevant, formulating relevant central questions ensuing from the context, and answering clarification questions about the questionnaire that was to be submitted. The majority of participants experienced this kind of support in their own environment and working situation as very pleasant and not burdensome.

Not every teacher, however, managed to develop without additional tips and help. Two teachers (Iris and Astrid) would have benefited from support being offered in the implementation of their plans beyond the reflection points. Iris's video observation, for example, showed that she was clearly having difficulty handling the uproar that arose when she introduced the contexts. Her regular teaching practice was deeply entrenched, which made it hard for her to adjust her teaching methodology to the new sequence. Support at a distance and according to individual need predominantly appears to lower the *costs* within the concept of practicality.

Existing literature on effective professional development of teachers (Borko et al., 2010; Van Veen, Zwart, Meirink, & Verloop, 2010) points out the importance of active teacher learning, of building upon the existing situation, and of situating professional development in the workplace. These design principles, however, have been formulated in fairly general terms and provide little guidance on how to develop and design a professional development program. Practicality, moreover, plays no role of any significance in these principles (Desimone, 2009; Kennedy, 2010).

On the basis of our research results, we can elaborate and supplement these design principles from literature. We can specify, for instance, that teachers in this study, in building upon their existing situation, are hesitant to introduce major changes all at once: they first want to experience whether such changes are genuine improvements. A small change that leads to success results in strong intentions to introduce subsequent changes. This indicates that, in building upon the existing situation, teachers like to work in small steps and on the basis of evident success. In such a step-based method of implementation, teachers have more time to grasp the essence of a proposed reform and to discover the advantages for their teaching practice than they would in a single major reform. In building upon the existing situation, the use of practical lesson segments also proves to diminish the gap between the proposed reform and regular practice. When teachers witness how elements of the proposed reform work successfully in their own teaching practice and that they only need to shift or adjust these elements, they get a feeling of ownership and a toolbox at the same time to change their own lessons step by step.

With regard to the design of professional development in the teachers' workplace, we can specify the design principle from the literature by showing that, for the majority of the eight teachers participating in this study, a made-to-measure program supervised from a distance can lead to changes that are in line with the proposed reform. Offering support in the teachers' own working situation and at a time convenient to them also helps to make professional development less time-consuming and more cost-effective for supervisors.

Another addition to the literature on effective professional development appears to be that, in this study, professional development took place without changing inhibiting factors. The influence of the existing situation is often considered an impediment to innovation, and it is often advised to give teachers more time or to increase their knowledge. This professional development program, however, shows that it is feasible to motivate a group of teachers to develop themselves towards a proposed reform within the confines of time, knowledge, and means.

The study we performed also has several limitations. In our study, we intensively monitored the development of a group of eight teachers; within this group of teachers, there was a diversity of expectations and opinions with regard to the proposed reform.

It is recommended, however, to repeat the mentioned methodologies in a bigger group so as to be able to generalize and quantitatively confirm the outcomes. In this study, the design principles were limited to the methodological implications of the context-based approach (see section 4.3.2). As yet, their practicality does not extend to the reform in the entire domain of biology because the new program and the new textbooks were not yet being used in secondary schools. Through the methodological approach in this study, however, teachers developed themselves towards designing more realistic contexts, focusing on learning objectives, and making course content more relevant for students. This would appear to indicate that this methodological approach may help to prepare teachers for the context-based reform in its entirety. As recontextualization was not included in this study, subsequent professional development programs will need to pay explicit attention to recontextualization (see section 4.3.2), including the underlying epistemological idea that the significance of concepts is co-determined by the context.

In the study we performed, the teachers' regular lesson sequences appeared to start with an explanatory phase, followed by a reproductive phase or by using contexts with questions. This ties in with large-scale studies showing that regular teaching practice is dominated by the view that teaching means to present knowledge and learning means to reproduce and apply presented knowledge (Gage, 2009). In addition, all teachers involved in our study proved to be using contexts with questions, to a greater or lesser extent, at the end of their regular lessons. The first step in the development of virtually all teachers involved in this study (Section 4.4.2) was to upfront the context with the central question. This might also be a first step for larger groups of teachers in their implementation of the context-based educational reform. This is also made possible by the structure of this practical program and by offering support from a distance according to need.

Chapter 5

FOSTERING TEACHERS' PROFESSIONAL DEVELOPMENT IN THE CONTEXT OF EDUCATIONAL REFORM BY THE PRODUCTIVE USE OF STUDENTS' DATA

Abstract

Students' data are commonly used for accountability purposes by school leaders and teachers. Such data can also be used to inform teachers about possible changes. However, teachers generally have little time and possibilities for such data-driven change processes and they have been shown to encounter significant problems in using the data for change. In this chapter, we put forward that such problems can be avoided by offering teachers practical tools that are aimed at the interpretation and productive use of their students´ data. Participating teachers followed a professional development (PD) program in the setting of an educational reform, that is, the introduction of a context-based curriculum in biology education. In this PD program, participants (n=5) used multiple 'Plan-Do-Check-Act' (PDCA) cycles in which they collected, interpreted, and used students' data to make changes to their instructional practices. During this process, we provided the participants with practical frames that were designed to enable them to better understand students' data and make productive changes. We examined to what extent and in what way participants used these practical frames and the influence of using students' data on participants' professional development. The results showed that participants were able to use the frames to implement change in significant ways. Using the frames, participants reflected thoroughly on their students' data and were able to change in a rather independent, cyclic way.

5.1 Introduction

Measuring students' data is considered to be of critical importance. In the United States, for example, the recent "Race to the Top" (RTTT; McQuinn, 2012) reform proposal was centered around using standardized tests to measure student performance and building data systems on student results to inform teachers and principals on what to improve. Students' performance data are commonly used, for instance, to move students up or in order to be accountable to school stakeholders. Such data can, however, also show the strong and weak points of teaching practices and point out areas for improvement. A major obstacle is that such productive use of students' data by teachers to change their teaching practices has proven to be difficult (Ingram, Louis, & Schroeder, 2004). What is needed is a systematic approach to teacher learning in which teachers come to know the effects of their teaching approaches by looking at students' data and become able to productively use these data to change their practices. Recent work by Borko et al. (2010) supports this call for a strong focus on students' data by stating that PD is most likely to be effective when attempts at PD are strongly focused on the use of students' data. A systematic approach to PD is required, especially in the context of educational reform, where teachers continuously improve their practice in their own schools with a strong focus on measuring and using students' data (Wilson, 2013). Work in the field of data-driven decision making has shown that designing such a productive approach can be difficult, as teachers mostly have no experience in the use of students' data and daily school life has also found to be hindering (Ingram et al., 2004). Besides such technical problems, research has shown that teachers sometimes get stuck in a cycle of measuring data and designing lessons without significant change (Schildkamp & Kuiper, 2010). When students' data, for example, reveal that a teacher doesn't reach the required outcomes, that teacher may not know how to improve. In more general terms: teachers' own experiences and knowledge are often inadequate to enable change (Bransford, Derry, Berliner, & Hammerness, 2005). There is a call for techniques and tools that facilitate systematic internal improvement processes (Ingram et al., 2004).

This study explored ways in which teachers could be facilitated to productively use students' data. For this purpose, teachers reflected on their students' data within an individualized PD program. This PD program was performed in the setting of a national

biology education reform in the Netherlands, that is, the introduction of a context-based curriculum in secondary biology education. The participants in the PD program were specifically assisted in the interpretation and productive use of their students' data. This support was based on ideas from Klein et al. (2006) who state that new information is always examined through "frames" that act as lenses or perspectives that give meaning to the information. Teachers in our research were provided with such frames that could help them understand data or propose change. In the PD program examined in this study, participants designed lessons, collected data on learning outcomes and perceived regulation of learning processes, and reflected on these data to propose changes in the subsequent lesson, and so on. Our objective was to explore to what extent and in what way the frames were used, and to monitor the participants' professional development when using students´ data for change. This research aims to answer the following research question: How do practical frames contribute to teachers' interpretation and productive use of students' data on learning outcomes and regulation of learning processes in the setting of a PD program, and what are the influences of using such students´ data on teachers´ professional development?

5.2 Theoretical framework

One of the most important factors in teachers' PD is the way in which it is woven into and applied in the teacher's daily practices (Borko, Jacobs, & Koellner, 2010). Teachers have to make many decisions on a daily basis; for example on what to teach and how to teach. Teachers rarely make these decisions on the basis of specific data, and in recent years, there has been an urgent call for more use of data in teachers' decision making. Such data-driven decision making is described as the systematic collection and use of external students' data to inform practices in educational settings (Mandinach, 2012). Data on student learning can provide insight into the strong and weak points of instruction, and can also point out directions for possible areas of improvement. Sadly, students' data in most cases predominantly serve as information for school leaders or teachers for, e.g., accountability purposes, and the directions for improvement are left untried (Schildkamp & Kuiper, 2010; Stecker, Fuchs, & Fuchs, 2005).

Data-driven decision making can be understood as an application of the well-known Plan-Do-Check-Act (PDCA) cycle (Deming, 2000; Shewhart, 1931). In this cycle, teachers start by designing a lesson (Plan), which they teach in their own class (Do). In this Do phase teachers collect data on student learning (outcomes and processes) to investigate the particular effects of their teaching (Ingram et al., 2004). The data on student outcomes reveal how much was learned from the lesson and the data on the learning processes inform teachers about how students perceived their teaching and whether or not they were involved in particular parts of the lesson. Next, teachers reflect on these students' data and compare the data with the standards or expectations in order to determine whether a change was successful or not (Check). After this, teachers can propose a new change (Act) and incorporate this in their new lesson design (Plan).

This PDCA cycle may seem straightforward, but the result of several studies on data-driven decision making show significant problems. Teachers struggle with time constraints and have been found to have several technical problems in collecting students' data (Young, 2006). In addition to such practical problems, teachers also have problems in understanding what students' data mean and how they can propose change (Ingram et al., 2004; Schildkamp & Kuiper, 2010). Teachers might not even have enough knowledge or experience to propose change (Bransford et al., 2005). Because of such problems, more attention has been given to the concept of data literacy in recent years. Data literacy is defined as "the ability to turn numbers and statistics into decisions to change" (Mandinach & Honey, 2008). However well defined, there is still no agreement on what exactly it means to be data literate or the procedures which could make someone more data literate (Mandinach, 2012). These problems focus attention towards the ways in which teachers can be assisted to become more data literate. How can we assist teachers so that they do not end up in a vicious cycle, but are able to understand what their students' data mean and propose productive changes?

For an answer to this question, we looked at reviews of research on how experts make decisions (Duffy, 1995; Klein, Moon, & Hofman, 2006; Schon & Rein, 1995). This made clear that experts use their earlier experiences and knowledge to form some kind of perspective or viewpoint to understand data and propose changes in a certain setting. Klein et al. (2006) called such perspectives "frames". Klein et al. (2006) built upon insights from the philosophy of science, where, for example, Popper proposed

his similar 'search light' theory (1972). In this theory, Popper showed that learning does not start with experiences or perceptions, but rather with expectations. These expectations can be seen as searchlights that guide the interest and understanding of the learner. Whenever people want to study the world around them, they use their earlier expectations, experiences, and knowledge, which together form a frame which determines the way in which they interpret and predict the world around them. An example of such a frame is the way a physician can take person's puzzlement away by explaining that all the symptoms (data) a relative has are caused by one easily treatable pathogen (frame). Without the frame that the physician offered, the person was not able to understand the data. With the frame, things became clearer, understanding increased, and even choices became possible. In the data-frame theory proposed by Klein et al. (2006), frames are used to shape and define the relevant data. If there is no frame suited to understand the data, existing frames are adjusted or new frames are added to understand and make sense of the data. As Klein et al. (2006) wrote, "Making sense of data is the process of fitting data into a frame and fitting a frame around the data". In an educational setting, teachers often have frames that are inadequate (Bransford et al., 2005). For example, teachers are known to attribute their failures to external sources such as the time of the day or the class setting, and explain their successes by pointing to very concrete actions that cannot be replicated in other classes or for other topics (Janssen, De Hullu, & Tigelaar, 2009). To assist teachers in their interpretation and understanding of the data and subsequent decision making, we developed and tested several frames that they could use in both the analysis and use of students' data in order to become more data literate.

The question remains what kind of frames should be offered to teachers. Most importantly, the frames should be aimed at the goal of assisting teachers in interpreting their students' data and giving options for change. But as teachers are known to have little time or options for using new tools, the frames also have to function within the teacher´s own environment, time and settings (Doyle, 2006). In their teaching practices, teachers have to meet several goals simultaneously (e.g., student learning, keeping up the momentum, covering the textbook) with limited time and resources (Fullan, 2007; Janssen, Westbroek, Doyle, & Van Driel, 2013b). Frames for sensemaking in these circumstances should be useable in the teacher's context and connect with their regular

practice (Borko & Putnam, 1996; Breiter & Light, 2006). Doyle & Ponder (1977) found that teachers will only use something new if it is perceived as being "practical". They proposed three categories that determine the level of practicality of any change proposal in educational settings: it has to be instrumental for teachers, it needs to be congruent with what a teacher normally does, and it must be easy to implement (low cost). Taking this into account, the frames in this research were not fixed or proposed as a "one-size-fits-all" solution. Instead, we designed frames that can be seen as adaptable segments and can used in many different teaching practices. We designed the frames with a focus on enabling teachers to understand the effects of their instructional approaches on their students' learning outcomes and processes. Therefore, the adaptable frames had to consist of the most important segments of instruction, being the segments of the primary teaching-learning strategy (Merrill, 2009). As teachers' teaching practices and school settings can vary enormously, is should be possible to use a frame to describe many forms of instructional approaches. This ranges from more traditional, teacher-centered instruction to more constructivist, learner-centered instruction (Anderson, 2007). With these requirements in mind, we proposed frames based on the concept of lesson segments. Lesson segments are small parts that together form a single lesson, which a teacher gives many of every day (e.g., Explanation, Application). Such lesson segments can be put in many different sequences to represent all kinds of instructional approaches. Because the lesson segments provide a tool to analyze instructional approaches, they may well serve as a frame that assists teachers in attributing the effects of their instruction to certain choices they made in designing the lesson. In other words, teachers can use this frame to better understand students' data by, e.g., pointing to the sequence or content, or both, of their lesson segments. Particularly in the context of an educational reform, where teachers are required to change their instructional approach towards that of the reform, the lesson segments may be used to understand which changes may lead to more reformed instructional approaches. Lesson segments can then be used to represent both teachers' regular approach to instruction and the reformed approach to instruction (in this study context-based education). By adjusting the sequence or specific content of lesson segments, teachers are enabled to change their regular approach to instruction towards the reformed approach to instruction.

The extent to which these proposed lesson segments are practical can best be determined by estimating their instrumentality, congruency and costs. First, the lesson segments are supposed to be useable by teachers to see directly what aspects of their lesson design may have influenced the students' data. This implies that lesson segments are instrumental for use in teachers' practices. Considering the implementation of educational reforms, the lesson segments may be used to understand how a change proposal would work out in a concrete lesson design, which also refers to the instrumentality criterion. Using the lesson segments, teachers can also be supported to build on their regular approach to instruction, which can help them to understand how a change proposal connects with their regular teaching practice and how they can approximate the proposed reform in their own teaching practice. This specifically relates to the congruency criterion. Finally, teachers can work with that which is already present and do not have to spend much time and effort on designing something completely new, which refers to low cost. The concept of lesson segments is further elaborated in the methods (section 5.3.4).

In our research, we investigated (1) to what extent and in what ways teachers can use frames to interpret and productively use students' data and (2) how using students' data influenced teachers' professional development. We explored the use of frames both in the interpretation and the productive use of students´ data because teachers can choose to use the frames in both steps. Once a frame helps in making sense of the data, this frame can also be used to inform teachers about possible future changes. Suppose that a teacher expects 60% of the students to answer a test question correctly and he/she finds that 80% answered the question correctly. He/she might explain this success by pointing to the well-orchestrated explanation phase (frame). Asked which change would increase the learning outcomes even more in a PD setting, the teacher can again choose to use this frame and predict that when he/she aims to organize the explanation phase even better, the outcomes will increase as well. In this way, frames can be used in the setting of data-based decision making to improve the interpretation of students' data, and to propose change, both of which are thought to make a teacher more data literate.

5.3 Method

5.3.1 Participants

The PD program examined in this study was performed in the setting of a national biology education reform in the Netherlands, that is, the introduction of a context-based curriculum in secondary biology education. As this reform was primarily intended for secondary education, it was important to invite biology teachers who taught in secondary education to participate in this research. We sent an invitation to approximately 20 secondary biology teachers from the institute's network of schools. Five biology teachers responded positively and participated in this study. These participants worked at four different secondary schools in the west of the Netherlands (see Table 5.1). The participants varied in characteristics such as age, gender and teaching experience. Four teachers taught upper classes and one lower classes. Two teachers taught in general secondary education and three in pre-university education.

Table 5.1

Survey of participants

Participant	Age	Teaching experience (years)	Grade Level [a]	Upper/Lower secondary level
Bob	28	3	GSE	Higher
Kimberley	49	12	PUE	Higher
Paula	52	4	GSE	Lower
George	40	10	PUE	Higher
Vincent	49	11	PUE	Higher

Note. [a]PUE - Pre-university education, GSE - General secondary education

5.3.2 The context-based reform proposal

For information about the context-based reform proposal, we refer to specific parts in other chapters in this dissertation, such as section 1.3.1.

5.3.3 PD program

Participants in this study followed a PD program that was aimed at the development of teachers' instructional approaches towards context-based education. The foundations of this PD program were the data-driven steps of a quality improvement cycle known as the "plan-do-check-act" cycle (PDCA) (Deming, 2000; Shewhart, 1931). This cycle starts with a lesson plan (P), which is enacted (D). In the lesson, teachers collected data using two student questionnaires, after which these data and compared with expectations (C), and new intentions are formed (A). These intentions to change are then elaborated into a new plan (P) and so on.

Participants were instructed to perform certain actions in each step of the PDCA cycle (see Table 5.2, left column). In the Plan phase, participants set learning goals for a single lesson, designed a lesson on the basis of their intention, and made up a small test questionnaire for students (SQ 1) aimed to determine the extent to which students met the learning goals. In the Do phase, participants gave the designed lesson in which they collected students' data by administering SQ 1 and SQ 2. The second questionnaire (SQ 2) was designed by the researcher and aimed at determining the perceived regulation of learning processes. SQ 2 was constructed as follows: each time participants designed a lesson, they emailed their lesson plan to the researcher (first author). On the basis of the lesson plan, the researcher provided the participant with a short questionnaire to investigate the students' views on the sequence of lesson segments and the regulation for each of the lesson segments (see Figure 5.1 for an example). In the Check phase, the participants summarized their students' answers to SQ 1 and SQ 2 and compared these to their expectations set in the Plan phase. The guiding question in the PD program for this comparison was, "Did the students answer the assignment according to the expectation you set beforehand?" and the important question for sensemaking: "Do you think that your adapted lesson has had influence on the learning outcomes, and if so, how?" Participants then completed the PDCA cycle

by proposing change (Act), which we named "intentions" (Fishbein & Ajzen, 2010). The guiding question for eliciting these intentions was, "Which next change in your practice would increase the students' outcomes?" Participants then designed a new lesson (Plan phase) on the basis of this intention and moved on in their next PDCA cycle. In the last two steps of the PDCA cycle (Check and Act), we provided participants with frames that could assist them in understanding the outcomes of the questionnaires and proposing productive changes (see Table 5.2, middle column).

The participants completed four PDCA cycles in total, in which they designed and reflected on four lessons. The participants worked independently and wrote down all the above-mentioned steps in an online structured reflection format. Researchers (first and second author) and participants only met at the start and at the end of the PD program. In the first meeting, the researchers and individual participants jointly compared the participants' regular practice with the proposed reform, both represented in lesson segments. The researchers then asked: "What change would take your regular teaching practice one step towards the reform proposal?" This change proposal was phrased into an intention to change and served as a basis for the first lesson design (Plan phase). At the end of the PD program, participants attended a group meeting in which they evaluated the PD program and member-checked their individual developmental path.

Table 5.2

Survey of the PDCA cycle

PDCA cycle	Participants actions	Procedures of the PD program	Research data
PLAN	-Set learning goals -Design lesson -Design SQ 1 -Set expectations for learning	-Instruct teachers how to design SQ 1	-Lesson designs
DO	-Teach lesson -Gather students' data using -SQ 1 and SQ 2	-Researchers design SQ 2 (for example, see Figure 5.1)	
CHECK	-Summarize the students' data -Reflect on the lesson using the students' data	-Offer frames -Reflection questions in the online reflection format	-Answers from reflection questions in the structured reflection format ("Do you think that your adapted lesson has had an influence on the learning outcomes, and if so, how?")
ACT	-Propose intention to change	-Offer frames -Reflection questions in the online reflection format	-Intentions from structured reflection format ("Which change in your practice would increase the students' outcomes?")

Note. SQ 1- student questionnaire 1, which aims to collect data on students' learning.
SQ 2 - student questionnaire 2, which aims to collect data about students' perception of the regulation of the learning processes.

Figure 5.1 An example of a student questionnaire (SQ 2) (taken from George's lesson)

1. Your teacher started this lesson by writing down the planning on the whiteboard
   a. He determined what was going to happen this lesson
   b. He consulted with us about what was going to happen this lesson
   c. I had great influence on what was going to happen this lesson

2. Your teacher then showed you a short movie starring Lionel Messi and asked you to start a company that makes identical copies of this football player
   a. He chose the movie and made up the questions about it
   b. We jointly chose the movie and/or made up the questions about it
   c. As a class, we chose the movie and topic of today and/or made up the questions

3. Your teacher then offered you the opportunity to answer the questions on cloning Lionel Messi
   a. He showed me how to answer the questions
   b. He helped me quite a lot in answering the questions
   c. I answered the questions on my own, without any help from my teacher

5.3.4 Lesson segments

We offered participants in this study three frames which were all based on the concept of lesson segments. Using a specific set of lesson segments, teachers could describe their regular teaching practice, context-based education, and many steps in between. The use of segments in understanding innovation has earlier been described by Holland (2000), who defined innovations as, "the rearrangements of already existing building blocks". Whenever trying to propose innovations, the first step is to come to know the predominant building blocks in a certain area and then re-arrange them to propose an innovation. Such building blocks to propose innovation should be derived from the setting in which change takes place. In our research, we supported teachers to reach fundamental changes in their instructional approaches. Decomposing instruction into segments, Merrill (2009) showed that the most effective parts of instruction are the main teaching-learning activities like presentation, practice or demonstration. In our research, we therefore based teacher support on segments of lessons that can be ordered to represent lessons as teachers give many every day. Teachers should be able to use the lesson segments to (1) represent their regular practices and (2) represent

context-based education. Starting from their regular practice, teachers should then be able to accomplish context-based education by recombining and/or adjusting the lesson segments that make up their regular practice. The one-lesson sequence for context-based education was earlier described in section 5.3.2. In international classroom studies, the most common approach to instruction was found to be a lesson that starts with the presentation of knowledge by the teacher, followed by a phase where the teacher assigns application or reproduction exercises. After this, students have to find information and answer the assigned questions (Gage, 2009). We used these two sequences for the construction of the set of lesson segments to be used in this study (see Table 5.3).

5.3.5 Frames used in this study

All frames in this research were based on the concept of lesson segments. The first frame is viewing a lesson as a specific sequence of lesson segments. By changing the sequence of the lesson segments, participants can adapt their lessons with a specific aim. For example, when participants are used to starting a lesson by presenting knowledge, changing the sequence into starting with an application question could have a specific effect on student learning. The second frame is based on the amount of regulation that is given to the students in each lesson segment. Students' self-regulation has become more and more important in constructivist views of teaching, such as the reform in this study (context-based education). From a teachers' perspective, several teaching activities can support students' self-regulated learning, like giving students freedom of choice in subject matter or having students make connections with prior knowledge (Vermunt, 1998). In more general terms, the *regulation* of each lesson segment can be done by either the teacher, or the students, or shared. The third and final frame is focused on understanding the content and purpose of a context. Following Gilbert's notion of contexts (Gilbert, 2006), contexts can vary from the application of concepts to being authentic and having students participate in a community of practice (Gilbert, 2006; Van Oers, 1998). As all types of contexts have the potential to positively affect learning (Bennett, et al., 2007), participants in our research were free to use any type of context they wanted.

Table 5.3

Survey of lesson segments

Lesson segment	Definition
Orientation	Introducing the subject, formulating goals, activating prior knowledge, and planning time and activities
Test	Assessing to what extent the learning outcomes and/or processes match the pre-set goals
Reflect	Looking back on results or processes, finding explanations for success or failure, finding improvements
Explanation	Explaining or presenting the content
Context with central question	Introducing the context and attendant central questions or problems
Reproduction and/or Application	Reproduction: assigning questions or tasks for which knowledge or skills learned earlier have to be literally repeated Application: assigning questions or tasks in which knowledge acquired earlier has to be applied in new settings
Answering questions	Answering the questions

5.3.6 Data collection and analysis

In this study, we collected research data to determine a. how teachers used the frames to interpret and productively use students' data, and b. the development of teachers´ practices when using students' data (see Figure 5.1, right column).

To determine how participants used frames to interpret their students' data, we collected the explanations and phrases of causal effects that participants wrote down in the online reflection format. For this purpose, we explicitly asked the following question in the Check phase: "Do you think that your adapted lesson has had influence on the learning outcomes, and if so, how?" Next, we investigated whether they used the new frames to do so, and how they did this (e.g., the learning outcomes are high because starting with a context motivated students to work on the assignments).

To determine how participants used frames to productively use their students' data, we collected all the participants' intentions. We explicitly focused on collecting intentions by asking the following question "Which next change in your practice would increase the students' outcomes?" Next, we investigated whether they used a frame to

do so and how they did this. Analysis on the use of frames was done by two researchers (i.e., the first and second author). For both the interpretation and the use of data to propose change, we investigated if they used the ideas or terminology of the frames that were offered in the PD program. For examples of this analysis, see Table 5.4.

To determine how students' data influenced the participants' developments in teaching practices, we first summarized all the lesson designs and intentions for change in a chronological overview. In the final session with all the participants, we had the participants member check these summaries (Miles & Huberman, 1994). All participants replied that they were good representations of their development. In this final session, we also asked participants about the strengths and weaknesses of the entire PD program. We analyzed the development in teaching practices by looking at how the teachers dealt with problems and successes. How did the participants deal with problems? And upon having a successful experience, did the participants choose to repeat the change, propose a change in the same direction or choose a complete different direction for change?

Table 5.4

Illustration of how the analysis on the use of frames was done

Frames [a]	Interpretation	Use
Frame 1	"The learning outcomes were high because I changed the sequence of my lesson; I started with a context"	"I want to start with a context" or "I want to present the concept before the answering phase"
Frame 2	"Students had a role in the reflection phase; they had to present their answers to the rest of the class"	"I want students to find information themselves, without my help"
Frame 3	"Starting with a good, challenging context made students very active in answering the questions and resulted in high learning outcomes"	"I want a good, authentic context that motivates students to find information"

Note. [a] Frame 1 - Lessons can be seen as specific sequences of lesson segments. Frame 2 - Regulation of the learning process can be done by either the teacher, or the students, or shared. Frame 3 - There are different types of contexts and these can have different functions.

5.4 Results

The results of this study are the basis for an answer to the following research question: *How do practical frames contribute to teachers' interpretation and productive use of students' data on learning outcomes and regulation of learning processes in the setting of a PD program, and what are the influences of using such students´ data on teachers' development?*
In this results section, we will first use a case study to describe the way in which one teachers' teaching practice was influenced by students' data on learning outcomes and perceived regulation of learning processes (section 5.4.1). We chose Paula for this case study, because her development follows a pattern that is most representative of all cases. Next, we describe how often and in what way teachers used the frames that we provided to interpret and use the students' data (section 5.4.2).

5.4.1 Case study Paula

Paula is a 52-year-old biology teacher who teaches mainly in the lower general secondary education grade level (ages 13-15). Before becoming a teacher, she worked as a teaching assistant for several years. She is an enthusiastic, but rather shy person who wishes to participate in this research in order to expand her teaching repertoire and get to know the context-based reform. At the start of her professional development program, she outlined the way that she regularly teaches a 50-minutes lesson. This was as follows: a. the lesson starts with checking homework for approximately 10 minutes; b. explanation of new topics or students make a summary of the new topics using the textbook, 30 minutes; c. students work on exercises from their textbooks (mostly reproduction exercises) for the final 10 minutes. When she compared her regular teaching practice to the proposed reform, she intended to start by using a context with central question and have students work out the answer themselves. Her first lesson design (Plan) started with a context in which an old woman wants to get rid of the aphids in her oak tree. Can she combat aphids using chemicals without negative consequences for other organisms in the food web? She denoted the sequence of lesson segments in her lesson design as follows: *Context with central question (teacher)* → *Answering questions (students)* → *Test (Shared)*. She expected 80% of the students to answer the test questions correctly, and indeed 80% of the students did (see Appendix 5A). She also investigated the perceived

regulation of the learning processes and found that students felt as if she helped them a lot in answering the questions. She answered positively to the following question in the structured reflection format: *"Do you think that your experimental lesson has had influence on the learning outcomes, and if so, how?"* (Check). She answered (quotes): "Starting with a context had a positive influence on the learning outcomes" and "Designing a lesson in which students answered the questions relatively independent had a positive influence on the learning outcomes". In her first explanation, she clearly attributed the good learning outcomes to the changed lesson sequence and introduction of a context. She uses the frame "Lessons can be seen as specific sequences of lesson segments" to explain the expected positive learning outcomes. In the second explanation, she also attributed the high learning outcomes to the students' relatively independent search for answers. With this explanation, she used the frame "Regulation of the learning process can be done by either the teacher, or the students, or shared". The next step in the PDCA cycle was to propose change by answering the following question in the structured reflection format: *"Which next change in your practice would increase the students' outcomes?"* (Act). She answered as follows (quote): "I want to let students answer the questions from the context completely by themselves, without my help". In this intention, she again used the frame "Regulation of the learning process can be done by either the teacher, or the students, or shared".

To discuss her first lesson design and subsequent reflection in a more general way, Paula learned that her first lesson design didn't support students in working independently at the level she intended it to be, but that starting the lesson with a context and letting students find information themselves indeed increased student outcomes. On the basis of that, she decided to design a new lesson (Plan) that started with a context, where students had to answer the questions without her assistance. She then moved on in the PDCA cycle by teaching that lesson, collecting students´ data and so on (see Appendix 5A).

5.4.2 The use of frames

Appendix 5B shows how the other participants used frames in the Check and Act phases of their PDCA cycles. We chose to show the Check and Act phases because

in these phases, participants could use frames to either interpret their students' data (Check) or formulate intentions to change (Act). It is clear from Appendix 5B that all participants used one or more frames to interpret their students´ data. This is illustrated, for example, by Kimberley when she reflects on her successful first lesson by saying: "By using a context, I noticed that their thinking skills were addressed more than before. They started asking questions more deeply." In this way, Kimberley interpreted the expected positive learning outcomes by pointing to the important role of starting with a context and thus used the frame "Lessons can be seen as specific sequences of lesson segments". The participants also used frames to formulate an intention to change in their subsequent lesson. To illustrate how teachers did this, we will illustrate George´s interpretation and intention after teaching his first lesson. The lesson started with a context, after which he explained the main concepts. In his interpretation of the students' data (Check), he stated that using a context helped students to understand the concept and had a positive influence of students' participation in the subsequent activities. When asked for a next change to optimize student learning, he formulated two intentions, for which he used two frames.

Table 5.5 shows how often participants used frames in the Check and Act phases of their PDCA cycles. In the beginning of their professional development, participants mainly use frame 1: i.e., that a lesson can be seen as a series of lesson segments and frame 2: i.e., that regulation of the learning process can be done by either the teacher, or the students, or shared. They showed to use the third frame later in their development.

Table 5.5

Survey of the numbers of frames used in this study to interpret (Check phase) or use (Act phase) of students' data

Lessons	PDCA phase	No frame	Frame 1*	Frame 2	Frame 3
	ACT **		5	4	
1	CHECK		4	3	
	ACT		1	5	1
2	CHECK		2	3	1
	ACT	2		4	
3	CHECK	2	1	1	
	ACT	1	1	1	3
4	CHECK **	2	1	1	1

Note. *Frame 1 - Lessons can be seen as specific sequences of lesson segments. Frame 2 - Regulation of the learning process can be done by either the teacher, or the students, or shared. Frame 3 - There are different types of contexts and they can have different functions.

**The PD program started by eliciting an intention (Act phase) and, therefore, the first Check phase is not included in this table. The PD program ended with the interpretation of students' data from the fourth lesson (Check) and, therefore, the final formulation of an intention (Act phase) was not included in this table.

Finally, teachers were also motivated to persist in their development. As can be seen in Table 5.6, the participants were mostly successful in their attempts to make changes and build further upon evident successes. Once participants experienced that their students' data were not as expected (problem), they tried out a new direction to make their lessons successful (see 5.6). This contrasts with findings in other research, were motivation to proceed in development was low once problems were encountered.

Table 5.6

Summary of the development directions after experiencing success or problems in the lessons

Lessons	Succes (S) or problem (P)	Maintains the changes, intentional change in new direction	Maintains the changes, intentional change in same direction	Maintains the changes, intentional change to repeat the success	Does not maintain the changes, intentional change in new direction	Stops developing
Bob						
1	S	X				
2	S		X			
3	P	X				
4*	S					
Kimberley						
1	S		X			
2	S		X			
3	S		X			
4	S					
Paula						
1	P		X			
2	S		X			
3	S	X				
4	S					
George						
1	P		X			
2	S			X		
3	n/a	X				
4	S					
Vincent						
1	S	X	X			
2	P		X			
3	S	X				
4	S					

Note. *The PD program ended after the interpretation (Check phase) of the fourth lesson. The formulation of intentions after the fourth lesson (Act) is therefore not included in this study.

5.5 Conclusion and implications

In this study, we explored the influence of students' data on teachers' development in the setting of an educational reform, that is, the introduction of a context-based curriculum. Participants followed a PD program in which they used multiple PDCA cycles to change their teaching practices on the basis of their students' data. Teachers designed lessons, gave the lessons and collected data about students' learning outcomes

and the perceived regulation of the learning process in those particular lessons. Next, teachers interpreted and used these data to propose change. As teachers are known to have problems in interpreting and using students' data in data-driven decision making, we provided the participants in this study with three frames that they could use when reflecting on their students' data, and help them to become more data literate: (1) Lessons can be seen as specific sequences of lesson segments; (2) Regulation of the learning process can be done by either the teacher, or the students, or shared, and (3) There are different types of contexts and these can have different functions. The research question was aimed to determine (1) how frames contributed to teachers' interpretation and productive use of students' data and (2) the influences of using such students' data on teachers' development.

First, the results show that participants indeed used the frames that we offered. By using the frames in our research, participants were able to overcome the known problems of not knowing how to interpret and productively use students' data for implementing change (Ingram et al., 2004; Mandinach, 2012). This contrasts with findings from the literature about the reticent attitude of many teachers towards the use of PD tools to change their practices (Janssen et al., 2013b). Teachers are known to simply bypass or reduce the use of tools and materials that they are offered in a PD setting and keep on using their own experience and routines (Borko, Elliott, & Uchiyama, 2002). One reason for the effective use of the frames in the present study can be found in the design of the frames. We provided the participants with frames that comply with the criteria for practicality (Doyle & Ponder, 1977). The frames in this study offered teachers concrete procedures on classroom level, connected with teachers' existing practices and had low cost in terms of time or effort to implement. The frames were also tailored to the needs of teachers who have to teach many classes every day and who want comprehensible, useable and effective tools at little cost. When we asked participants about the most important and effective parts of the PD program, four out of the five participants replied that they thought that the frames were most helpful in their development.

Second, the results also show how the use of frames led to a good interpretation of the students' data and productive proposals for change. To understand the processes by which this took place, we will first look at how experts use and organize their

knowledge. Zeitz (1997) argues that experts' knowledge is represented at an intermediate level of abstraction. Knowledge too concrete would not be readily transferable, and knowledge too abstract not directly useable. In our research, the content of the frames that we designed was therefore represented at an intermediate level of abstraction. They were designed at a level of knowledge that is directly useable for teachers, but not so concrete that teachers could use them only in specific situations. When provided with the frames in the PD program to interpret their students' data, participants were offered concrete options to attribute their data. In most cases, a teacher attributes, e.g., specific learning outcomes to external and uncontrollable factors (Janssen, De Hullu, & Tigelaar, 2009; Weiner, 2010). However, the frames in this research were designed in such a way that allows students' data to be attributed to a specific part of the lesson design. These are internal and controllable factors instead of the earlier-mentioned external and uncontrollable factors. When an effect is controllable and the reasons for success or failure lie internal, it is also known to be easier to formulate productive change proposals (Weiner, 2010).

The influence of using students' data on the development of the participants in the PD program can best be understood by looking at how the data from one lesson influenced the next lesson. When students' data showed that a lesson was successful (e.g., that the learning outcomes were higher than expected), participants used one or more frames to reflect on why it was successful. Next, participants tended to maintain their successful changes in their next lesson design and proposed new changes in the same direction (using the same frame) or in another direction (possibly using another frame). Interestingly, the participants also persisted in their development when confronted with problems. When the data indicated that a certain instructional approach had failed compared with their expectations, participants used that information. They could then, either using frames or not, propose new changes. This rapid feedback on problems and/or success is very different from a regular classroom setting, where teachers only find out if their students´ learning outcomes are insufficient during an end-of-period test. By then it may be too late to apply a remedy. In our research, teachers reflected thoroughly on the learning outcomes and perceived regulation of learning processes one lesson at a time. In this way, our PD program not only offers rapid feedback, but is also closely coupled to student learning and has a strong link to the school setting,

both of which are thought to be important characteristics of effective professional development (Borko et al., 2010).

This research was performed in the setting of an educational reform, where teachers were asked to change their practices significantly. Without effective professional development of teachers, reforms are doomed to fail (Borko et al., 2002). However, there can be several ways to design PD approaches. In literature, there seems to be a consensus about the most important features of effective PD such as situating PD in teaching practices or taking teachers' regular practices as starting point, but also to be focused on student learning. This latter feature for effective PD can however be elaborated in many different ways, ranging from simply knowing the students' learning outcomes from a certain teaching approach to using such students' data to make decisions for change. In the latter, so-called, data-based decision making (Schildkamp & Kuiper, 2010), students' data serve to make decisions on improvements. However, a major obstacle is that such use of students' data to make decisions for improvement has proven to be difficult (Ingram, Louis, & Schroeder, 2004). Two problems were reported: (1) having technical problems and (2) not knowing how to interpret and productively use such data to change effectively (Ingram, Louis, & Schroeder, 2004; Young, 2006). In our research, we showed that technical problems can be avoided by collecting students' data directly in the lesson and assisting teachers in their development (e.g., by providing or helping them with SQ 2). We are aware that we as researchers made a questionnaire for the participants and that this could have had an influence on their development. When we asked the participants about this in the final meeting, they replied that this was helpful, but that they could have done it themselves when provided with a specific format and examples. In regard to the second problem in data-based decision making: i.e., not knowing how to interpret and use students' data, we have shown that these problems can be resolved by providing teachers with practical frames that are based on the concept of practicality (Doyle & Ponder, 1977). In conclusion, this exemplary research can provide directions for (1) further conceptualization of data-driven decision making in terms of what data should be collected, how these should be collected, and, especially, how teachers should be supported in their interpretation and use of students' data and (2) fostering PD in the setting of educational reform

Appendix 5A

Paula's development

	PLAN		
Lessons in the PD program	Lesson design	Results SQ 1 compared with expectations	Results SQ 2 compared with the lesson design
Regular practice	Explain (teacher) → reproduction and/or application (teacher) → answering questions (shared)	n/a	n/a
1st lesson	Context (teacher) → Answering questions (students) → Test (Shared)	80 % of the students answered correctly, just as I expected	This was scored as I intended the lesson, but half the class felt as though I helped them a lot in answering the questions
2nd lesson	Context (teacher) → Answering questions (students) → Test (Shared)	50 % completely correct, 50 % for 2/3 correct. This was above my expectations	This was scored as I intended the lesson
3rd lesson	Orientation (teacher) → Context (students) → Answering questions (students)	Above my expectations	Most students answered that they were indeed responsible for the context and answering of the questions
4th lesson	Context (teacher) → explain (teacher) → answering questions (students) → test (shared)	As I expected	Mostly as designed, but students answered that they regulated the Test phase, where I intended it to be a shared regulation

CHECK		ACT	
Interpretation	Frame use	Intention	Frame use
n/a	n/a	I want pupils to be actively searching for information to answer the central question	Regulation
		I want to start the lessons by using a context	Lesson segments
"Starting with a context had a positive influence on the learning outcomes"	Lesson segments	I want to let students answer the questions from the context completely by themselves, without my help	Regulation
"Designing a lesson in which students answer the questions rather independently had a positive influence on the learning outcomes"	Regulation		
"Starting with a relevant context and let them answer the questions independently involved them in the learning process and increased learning outcomes	Lesson segments and Regulation	I want the students to design a context with central questions	Regulation
By allowing them to come up with a context, the relevance of the topic increased. This had a positive influence on the learning outcomes	Regulation	For the next topic, I would like a context with a real profession and I would like to introduce a little bit about the profession myself	Context type
By first presenting the doctor-context they have been paying attention to the explanation of the contraceptives. This had positive learning effect	Regulation and Context type	n/a	n/a

Note. Paula's regular teaching practices was included to show her starting point for change.

Appendix 5B

Survey of the frames used in the interpretation and use of students' data in the Check and Act phases of the PDCA cycles

	CHECK		ACT	
Lessons	Interpretation	Frames	Intentions	Frames
		Bob		
	n/a	n/a	I want to start the lessons by using a context. I will create a context by elaborating on the application questions I normally assign at the end of the lesson	Lesson segments
Lesson 1	I think that starting with a context made students more active and serious this lesson. They also seemed to be more focused and involved	Lesson segments	I want the students to work in groups when answering the questions, so that they can help each other	Regulation
Lesson 2	I think that the learning outcomes were high because they worked together in answering the questions	Regulation	I would like the students to answer the questions in groups and give them a role in the reflection phase	Regulation
Lesson 3	There was not much of a working atmosphere due to the absence of many students who were on a study week. But because they had to exchange their answers and reflect as a class, they did their job	n/a	I want to start with a relevant context, followed by relevant attendant questions so that students are challenged to study and learn	Context type
Lesson 4	I think that the students were engaged in the topic of the lesson because of the relevant movie I showed and the funny attendant questions	Context type	n/a	n/a
		Vincent		
	n/a	n/a	I want to start with a context and I would like students to think of one	Lesson segments and Regulation
Lesson 1	I think that due to the context, the students were immediately focused on the topic. For some students, it seems hard that I'm not presenting everything before they start answering the questions	Lesson segments and Regulation	I want students to answer the questions independently, without my help	Regulation
			I want to limit the reflection to the problematic questions	n/a

	CHECK		ACT	
Lessons	Interpretation	Frames	Intentions	Frames
Lesson 2	I think that the students have high learning outcomes because they had to find information themselves. In this way, the students started to think more deeply about the topic	Regulation	I want students to reflect on their answers themselves	Regulation
Lesson 3	The students seemed to get trapped in the context. I think that because of this, mainly the students' discussion skills have been enlarged. Still, the results were good enough	None	I want a tight connection between the context with central questions and the learning goals	None
Lesson 4	The students clearly learned new concepts due to the tight questions I gave them in class. In addition, I was surprised that they discussed in class on the relationship between evolution and classification	None	n/a	n/a
		Kimberley		
	n/a	n/a	I want to start with a context and first demonstrate how to proceed in such a context	Lesson segments
			I want students to present the answers to each other	Regulation
Lesson 1	Through using a context, I noticed that their thinking skills were addressed more than before. They started asking questions more deeply. I also noticed that the students made connections with other biological topics. All of this had a positive effect on the learning outcomes	Lesson segments	I want to start again with a context and formulate attendant questions myself, but this time I won't demonstrate first	Regulation
Lesson 2	The use of a context and giving students more independence in answering the questions had a positive effect on the learning outcomes, even though it was hard for students to concentrate at that late hour of the day	Lesson segments	I want to start by using a context again. After that, students will have to think of their pre-existing knowledge, followed by a students' task to find information in the textbook	Regulation

	CHECK		ACT	
Lessons	Interpretation	Frames	Intentions	Frames
			I want to formulate good central questions with the context, so that students really have to find the details of the learning goals and learn enough	n/a
Lesson 3	As a result of using a context and formulating good central questions, they learned what I wanted them to learn	Lesson segments	I want a relevant, interesting and detailed context and have students formulate the learning goals	Context type and Regulation
Lesson 4	n/a	n/a	n/a	n/a
		George		
	n/a	n/a	I want to start by using a context that I normally present after my explanation. This will be followed by my explanation and then the students can find information in their textbooks	Lesson segments and Regulation
Lesson 1	Starting the lesson with a context and my presentation really helped students to understand the complicated concept. I also think that students were more active in the lesson	Regulation	I want to present the context by using an animation or short movie to get students interested and motivated	Context type
			I want students to find information directly after the presentation of the context, without my explanation	Lesson segments and Regulation
Lesson 2	Starting with a relevant context helped the students to learn the concept	Context type	I want to try out the same lesson setup for a less appealing topic to see if I can make that more interesting	None
Lesson 3	n/a	n/a	I want to discover a process together with the students by using multiple contexts in a row	Lesson segments
Lesson 4	I think that I have to try harder to motivate the pupils to work. I found the topic boring. It wasn't "my day" today	n/a	n/a	n/a

Note. Frames: "Lesson segments" = Lessons can be seen as specific sequences of lesson segments (Frame 1), "Regulation" = Regulation of the learning process can be done by either the teacher, or the students, or shared (Frame 2) and "Context type = There are different types of contexts and these can have different functions (Frame 3). The interpretations and intentions are literal quotes from the participants.

Chapter 6

GENERAL CONCLUSION AND DISCUSSION

6.1 Aim and research questions

Research on the implementation of educational reforms has shown that successful implementation ultimately relies on teachers and how they work out the reform proposal in their classrooms (Borko, Jacobs, & Koellner, 2010; Fullan, 2007; Van Driel, Beijaard, & Verloop, 2001). Therefore, teachers should be given opportunities to learn how to work out a reform proposal in their everyday classroom practices. Such teacher learning is mostly facilitated through professional development (PD) initiatives. The biggest challenge is to design PD opportunities for teachers that can lead to fundamental changes in their teaching practices (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010). However, teachers' everyday classroom settings and programs of action can hold several limitations and challenges for teachers who wish to implement change (Doyle, 2006; Doyle & Rosemartin, 2012). For a successful implementation of change proposals into classroom practices, teachers should consider the change proposal to be practical (Janssen, Westbroek, Doyle, & Van Driel, 2013b). Practicality (Doyle & Ponder, 1977) refers to teachers' perceptions of the potential consequences of attempting to implement a change proposal in the classroom. The practicality of most educational reforms is considered to be rather low, as they are mostly formulated as visions or ideals and not as programs for classroom practice (Borko, 2004).

The aim of this research project was to make a context-based reform proposal in biology education practical for teachers and study the development of teachers' instructional approaches and intentions to change. Making an educational reform practical requires a focus on the three criteria for practicality first described by Doyle and Ponder (1977): Instrumentality focuses on the extent to which the proposal contains instrumental content such as procedures or methodologies which help teachers to envision how the change proposal would work out in their classrooms; congruency refers to the extent to which a proposed change is congruent with teachers´ perceptions

of their own situations; cost refers to the ratio between the investment in terms of time and effort and the return in terms of benefits in classroom practices or student learning. In this research project, the overall research question was:

How can the context-based approach to biology education be made practical for teachers?

Four studies were performed to answer this question. In these studies, the context-based educational reform was made practical using two approaches: First, a modular approach offered teachers the possibility of accomplishing the context-based approach to education by combining and adjusting lesson segments that they were familiar with in their regular instructional approach. Second, a success-oriented approach focused on teachers' possible earlier successful experiences with (parts of) the context-based approach. They could use such earlier successful experiences to propose changes to their regular instructional approach and bring it in line with the approach of the context-based educational reform. In this research, these two approaches were used in: (1) The design of a PD program aimed at assisting teachers in making changes to their instructional approaches in line with the requirements of the proposed reform (Chapters 4 and 5); and (2) The design of an interview technique (MECI) aimed at assisting teachers in formulating strong intentions for change (Chapter 3). Before conducting these studies, however, we first had to construct and validate a tool for the modular approach (Chapter 2).

6.2 Summary of conclusions per study

In the **first study** (Chapter 2), we focused on the construction and validation of a modular ID model to assist teachers in making changes to their regular practices and expanding their repertoire of instructional approaches. In the construction phase, we proposed that a practical approach to ID should be based on the concept of modularity (Baldwin & Clark, 2000; Campagnolo & Camuffo, 2010; Holland, 2000). A modular approach in educational settings refers to the possibility for designers to use a set of lesson segments. In this way, they can build upon that which is already present and construct several different designs using the same set of lesson segments. Following the initial model construction and a pilot, eleven experts on: a. teaching in secondary schools; b. teachers' lesson design; and c. the use of models to design lessons, gave their opinions and recommendations regarding the strong and weak points of the

initial ID model through a three-round Delphi study. In the study, the most important adjustments were made to the content of the lesson segments, the ways that teachers can design the regulation of each lesson segment (done by either the teacher, or students, or shared), and the addition of metacognitive elements to the model. The experts in the Delphi study reached consensus on a modular ID model that complied with the following criteria of internal validation: Comprehensiveness, expected practicality, and expected effectiveness.

The resulting ID model relates to the criteria for practicality (Doyle & Ponder, 1977) in the following way: (a) The resulting lesson segments and their regulation can easily be understood at classroom level (instrumental); (b) Teachers do not have to discard their existing approaches, but can take their most common instructional approach as a starting point for change (congruent); and (c) Teachers do not have to attend faraway meetings or get much training to use this model, but can use it immediately in their own setting and time (low cost).

In the **second study** (Chapter 3), we focused on teachers' intentions to implement the context-based biology reform proposal. Professional development aimed at the implementation of an educational change proposal often focuses on the skills and knowledge that have to be improved and/or on changing the environment in which teachers work. However, there is another very important condition for successful change: the formulation of strong intentions to change (Fishbein & Ajzen, 2010). Often, formulating strong intentions to change is not included in professional development programs. In this study, we studied the impact of a so-called 'motivating-for-educational-change' interview (MECI) technique on the intentions of nine biology teachers to implement the context-based reform proposal. We explored the teachers' intentions to change, and compared both the strength (scored on a 1-7 Likert scale) and the specificity of the intentions after using the MECI technique with a baseline test (t=0). The MECI technique comprised both the modular and the success-oriented approach; the teachers explicitly built upon earlier successful teaching experiences with context-based education and used modular lessons segments to propose changes to their regular approaches to instruction.

We concluded that the strength of the teachers' intentions to change was promoted by the MECI technique. Also, eight out of nine teachers formulated more intentions after the MECI than in the baseline test. The results further show that their intentions after using the MECI technique were more specific, as shown in their descriptions of how they planned to carry out the reform. This in turn may have had a positive influence on the strength of the intentions: Gollwitzer (1999) found that the more specific an intention is about the how, when and where, the more easily a certain goal behavior is attained.

What became apparent from the results of the MECI is that the technique manages to combine earlier successful experiences and the set of lesson segments in order to motivate teachers for change. All teachers were able to think back to relevant successful experiences using (parts of) the context-based approach, which had a positive influence on the strength of their intentions. For example, one participant (Ivy) mentioned that she had once made pupils work in small groups focused on personal stories from cancer patients. This had motivated her students to work hard during that lesson. As a result of envisioning how a particular form of context had worked out in her classroom in the past, she formulated a strong intention to use a context again in the future. Also, teachers mentioned that the rearrangement of lesson segments helped them to feel able to carry out the reform. Through comparing their regular approach to instruction with that of the context-based reform proposal, teachers were able to see that they sometimes already carried out the reform in a small, adapted way. Walter (participant): "So if the reform program proposes a context to engage and motivate students to find information themselves, this means that I sometimes already apply part of the reform within my regular lessons?" The findings of this study show that making the context-based reform practical by using lesson segments (modular approach) and focusing on earlier successful experiences (success-oriented apporach) can result in the formulation of strong and specific intentions for change. The MECI technique could be a useful tool to administer at moments such as the start of a professional development program, or when motivation is lacking to continue professionalization.

In the **third study** (Chapter 4), we designed and tested a PD program that was aimed at making the context-based educational reform practical. We designed this

PD program on the basis of the following three design principles: (1) Allow teachers to build on earlier successful experiences (success-oriented approach); (2) Allow teachers to accomplish the innovation by recombining and adjusting existing lesson segments (modular approach); (3) Support teachers from a distance and according to their individual needs. In the PD program, eight biology teachers were supported in changing their instructional practices towards the context-based reform proposal. The participating teachers each designed, taught, and reflected on four lessons for their own teaching practice. We studied the development of their instructional practices and also the strength of their intentions for each of the lessons designed in the PD program. We concluded that the participating teachers showed that they had strong intentions to start their development and that these intentions remained strong throughout the entire PD program. We also concluded that the participating teachers each had their individual processes of change, in which they developed their teaching repertoire towards the context-based innovation in a fairly independent manner. However, there proved to be a number of sequential steps for most teachers in changing their instructional approach towards the context-based educational innovation (see section 4.4.2).

The outcomes of this PD program showed that each element of the PD design had its own role. The success-oriented approach appears to have had an effect on the strength of intentions. Thinking back to successful experiences and working with one´s strengths appears to foster strong intentions for the next lesson. In this, the success-oriented approach also helps teachers to connect the proposed reform to their regular practices and, hence, relates specifically to the congruence criterion of practicality (Doyle & Ponder, 1977). The modular approach was described by teachers as highly practical. In the final interviews, the lesson segments were considered to be an important instrument in designing lessons and in understanding the methodological implications of the innovation. The participants were able to diminish the gap between the reform proposal and their regular teaching practice by recombining and adjusting their existing sequence of lesson segments. In this way, the modular approach relates to both congruency and instrumentality. The final principle underlying this study was the support of teachers from a distance and according to their individual needs. The majority of participants appeared to regard this as very pleasant and not as time-

consuming as group meetings. This final principle relates specifically to the cost criterion of practicality.

The **fourth study** (Chapter 5) was explicitly focused on ways in which teachers can use their students' data to evaluate their lessons, find successful experiences, and build on these earlier successful experiences to change their instructional approaches. In this study, participating teachers (n=5) used multiple Plan-Do-Check-Act (PDCA) cycles in which they collected, interpreted, and used students' data to make changes to their instructional practices. First, participants were asked to design a lesson in which they made a change towards context-based education (Plan). The second step was to teach that lesson and gather data on students' learning outcomes and regulation of student learning processes in the lesson (Do). The third step was to interpret these data (Check) and use them to propose new changes to their instructional practices (Act), which served as input for the next lesson design (Plan), etc. During the process of interpreting and using students' data, we supported participants using practical frames (Klein, Moon, & Hofman, 2006) that were designed to enable them to better understand students' data and make productive changes. These frames were the following: (1) Lessons can be seen as specific sequences of lesson segments; (2) Regulation of the learning process can be done by either the teacher, or students, or shared; and (3) There are different types of contexts and these can have different functions. We examined how the practical frames contributed to teachers' interpretation and productive use of students' data. We also studied how the use of students' data influenced participating teachers' development. The results showed that participants were able to use the frames that we provided to interpret students' data and make productive changes to their instructional approach. In this way, they were able to overcome the common problems of not knowing how to interpret data and productively use students' data for implementing change (Ingram, Louis, & Schroeder, 2004; Mandinach, 2012). Using students' data also influenced the development of the participants in several ways. For example, when students' data showed that a lesson was successful, participants used one or more frames to explain why it was successful. Participants also tended to maintain that successful change in their following lesson design, followed by another change proposal using the same frame or a different frame. In this way, participants used students' data to change their

instruction one step at the time. They started with their regular instructional approach as starting point and gradually changed their instructional approach towards that of the context-based reform.

6.3 General discussion

In the current research, a context-based reform was made practical using two approaches: a modular and a success-oriented approach. The results and conclusions from the various studies revealed that this supported teachers in (1) formulating strong and specific intentions for change in the direction of the reform and (2) changing their classroom practices in a stepwise manner towards the aims of the context-based reform proposal. The question remains how these two approaches functioned in making the context-based approach practical.

The modular approach seems to have made several contributions in making the reform practical, with reference to the specific criteria of practicality theory. First, it made the reform proposal easy to understand at classroom level, which specifically relates to the instrumentality criterion. Participating teachers were able to represent both the reform proposal and their regular instructional approach using the same set of lesson segments, which helped them to understand the methodological implications of the reform. Some participants mentioned that the modular lesson segments could be used by teachers in other settings to discuss and compare their approaches to instruction. As such, it may serve as a common language or shared terminology for teaching, which was found to be lacking in the area of teacher learning (Grossman & McDonald, 2008). Second, the modular approach made it possible to take one's regular instructional approach as starting point for change and make stepwise changes, which refers to the congruency criterion of practicality theory.

Having a success-oriented approach also seems to have made specific contributions to practicality. First, it enabled relating the proposed reform to what teachers already successfully accomplished in their classroom. As such, it specifically relates to congruency. Second, thinking back to successful experiences in concrete settings where the behavior was previously enacted made intentions more specific and also gave directions for change. This increases instrumentality. Third, when participants

identified successful experiences in previous lessons by, e.g., looking at their students' data, they maintained the successful change in their subsequent lessons. This shows that building on successful experiences also contributes to the stepwise manner of change, which was further facilitated by the above-mentioned lesson segments. This aspect of the success-oriented approach also relates to congruency.

The two approaches combined gave participating teachers the possibility to compare the proposed reform with their regular instructional approach at classroom level, to propose strong intentions for change on the basis of earlier successful experiences, and to make stepwise changes to their instruction in the direction of the proposed reform. The teachers were able to work in their own classroom settings, using the available resources and time. Because the teachers were able to see the benefits for their classrooms, and the costs in terms of time and effort were low, this aspect relates specifically to the low cost criterion of practicality theory.

Coming back to the literature on the implementation of educational reforms and the important role of PD, it is relevant to discuss the list of known features of high-quality PD (Borko et al., 2010; Garet, Porter, Desimone, Birman, & Yoon, 2001; Supovitz & Turner, 2001; Van Veen, Zwart, Meirink, & Verloop, 2010). Such features provide only a rough sketch of teachers' effective learning and they do not seem to take practicality into account. Practicality theory imposes certain requirements for the effective implementation of a change proposal; nevertheless, it does not specify how to implement a reform successfully. To do this, the practicality requirements need to be elaborated in specific approaches and learner programs that relate to these requirements and the above mentioned features of high-quality PD. The findings of the studies in this dissertation appear to give directions for such an elaboration of some of these features.

1. *PD content is situated in practice and addresses problems of practice.* The current findings have shown that it is not only important to design, teach, and reflect on concrete lessons (situated in practice), but that this should be done in a practical, success-oriented way. Most teacher learning uses a deficiency approach, in which teachers are expected to remedy their shortcomings, but the success-oriented approach used in this research has an opposite focus. By using earlier successful experiences, made visible using

lesson segments, attention is given to particular strengths of individual teachers and intentions to change that they already have or have yet to develop. The lesson segments used in this research can also be helpful for making stepwise changes towards a change proposal, with teachers' regular practice as starting point.

2. *The content of PD is focused on students' learning*. This is often elaborated by focusing on those aspects of teacher learning that immediately influence student learning, but this can be difficult due to the complex setting of the classroom which allows little time for such efforts and makes it hard to know which aspects of lessons influence students' learning. A following step is the productive use of students' data for implementing change, in which students' data , for example, learning outcomes, are used to propose changes to practices: data-based decision making. A major problem in data-based decision making, however, is that teachers have difficulties with both the interpretation and the productive use of students' data. The current research showed that both the process of collecting students´ data and the process of interpreting and using students' data can be facilitated by combining a modular and a success-oriented approach. When teachers collect students' data from a lesson they gave, the lesson segments can help them to interpret why the outcomes were higher or lower than expected and propose change. Taking a success-oriented approach helps teachers in a cyclic process of reflection, and especially helps them to formulate strong intentions to improve their students' learning even further.

3. *Teachers learn actively.* The outcomes of the present research indicate that teachers indeed have to learn actively, but that this should connect with their own tasks and challenges in order to obtain low costs in terms of time and effort.

4. *The PD setting is school based*. Situating teacher learning in schools can be done in several ways. The current research findings emphasize that teachers do not always have to attend workshops or meetings, but can also be supported from a distance and on demand whilst working in their own school environment. For this, they can use both a success-oriented internet environment that facilitates progression and motivation and a set of lesson segments that helps them to design lessons for their own practice, and make stepwise changes.

5. *Teachers preferably learn collaboratively and in professional learning communities*. In the present research, it became clear that teachers can also be individually supported in

changing their classroom practices. For a further elaboration, see section 6.5.

The findings of the present research have illustrated that reforms can be made practical by using two approaches: a modular approach and a success-oriented approach. These findings may provide a new perspective on how to successfully implement educational reforms. In describing the gap between the design and the enactment of educational reforms, Doyle and Rosemartin (2012) present two distinct perspectives on the implementation of reforms: the reformers' perspective and the teachers' perspective. The reformers' perspective mostly emphasizes the use of innovative materials and implies that PD should increase teachers' capacity to use those materials. The teachers' perspective emphasizes teachers' professional expertise and autonomy, which may lead to creative adaptation of a reform with the risk of losing the essence. Much of the research on the implementation of reforms is done from the reformers' perspective. Such research focuses on how teachers can best be trained to use materials associated with the reform according to their design, and often sees teachers as obstacles to successful implementation (Davis & Krajcik, 2005; Remillard, 2008). Neither of these two perspectives, however, will succeed in achieving the ultimate goal of educational reform: changed classroom practices in line with the essence and goals of the reform proposal. In the present research, a new perspective was introduced which is not so much grounded in the teachers´ or the reformers' perspective. Instead, it emphasizes both the teachers' complex classroom setting with its practical requirements, and has a strong focus on the essence and goals of the proposed reform, while aiming for changes in instructional approaches.

6.4 Limitations and recommendations

In the first study (Chapter 2), the ID model was found to be internally valid by the experts who participated. A possible future research question is the following: How can an ID model that supports teachers in continually expanding their repertoire of instructional strategies be externally validated? There are also limitations to the qualitative research that was performed; therefore, it is recommended that future researchers use larger numbers of participants. As regards the second study (Chapter 3), it is recommended that the MECI be tested in other settings, for other reforms,

and for other school subjects. A future research question following from the second study would be: What are the developments in teachers´ beliefs about a context-based reform when using a MECI interview? A future research question related to the third study would be: What are the important characteristics of an internet environment that supports teachers in independently changing their instructional approach towards that of a change proposal? From the fourth study: How can teachers collect students' data in an independent way? One of the other challenges of this research was to apply the modular and success-oriented approaches to the implementation as currently carried out. Therefore, we propose the following future research questions: What are the developments in teachers' intentions to implement the context-based educational reform in secondary biology education? And what are the impacts on the development of teachers' intentions and teaching practices of making the context-based educational reform practical? Another future research question relates to the development of beliefs during a PD program: How will teachers' beliefs about specific intentions develop in the span of a PD program for learning to design context-based education? It would also be interesting to study the role of traditional and reformed textbooks or sample materials in the implementation processes, as these can have specific promoting or hindering impacts on teachers' learning processes. It is also recommended that future research takes the process of recontextualization (Van Oers, 1998) into account, as this was not included in this study.

6.5 Implications

The first implication of this research concerns how educational reforms can be implemented successfully. A reform proposal should first be elaborated into a modular representation of the content. The smaller segments of the proposal should be formulated in terms of what teachers already do or know, and at classroom level. Following this, it is important to identify teachers' personal strengths and earlier successful experiences, for example, through a 'motivating-for-educational-change' interview (MECI). In this interview, teachers can formulate personal intentions to make changes to their regular instructional approach. This interview should be followed by offering teachers a PD program which can be carried out either by individual teachers

or by groups of collaborating teachers. In such a PD program, teachers should (1) build on earlier successes using (parts of) the proposed reform to maintain strong and specific intentions for change and (2) use a modular approach to make stepwise changes to their regular instructional approach. Furthermore, such a PD program should be school based and structured around teachers' own classroom settings and the available time and resources.

A second implication concerns the form of collaboration in PD initiatives. It is emphasized in literature that learning is most effective when teachers collaborate and form groups of learners (Borko et al., 2010). In this research, however, we have shown that teachers are also able to change their practices relatively independently, if supported with an internet-based reflection tool. Through this internet tool, teachers were supported from a distance and according to their individual needs. Such an approach can support the implementation of educational reforms particularly by giving learning opportunities to teachers who have no time, possibilities, or desire for collaboration. Furthermore, such an approach is less time-consuming than group meetings, because it allows teachers to decide when they wish to design lessons or reflect on their lessons.

A final implication concerns the role of teacher education in preparing teachers for the teaching profession. As teaching is never routine, and specific settings require specific lesson designs, teachers should be able to design a large number of instructional approaches, and not just a few. The modular approach used in this research states that lessons can be seen as specific sequences of lesson segments and that regulation of the learning process can be done by either the teacher, or students, or shared. As such, it can be seen as a tool to design many forms of instructional approaches. Teacher educators can teach pre-service teachers how to use this tool to design a large variety of instructional approaches for specific purposes, while taking the often complex and demanding context of the teaching profession into account.

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Summary

Teachers play a crucial role in the implementation of educational reforms. A successful implementation ultimately depends on how teachers work out the reform proposal in their everyday classroom practice. To implement the reforms the teachers need to translate the reform proposals to their everyday classroom practice. This is often a challenging task because educational reforms are usually formulated at a relatively abstract level, for example as goals or principles, instead of at the concrete level of the everyday classroom practice. This everyday practice with all its limitations and challenges strongly determines what teachers are willing and able to implement and hence the success of the implementation of the educational reforms. Teachers tend to adjust the proposed reform to match their own teaching practices, which often undermines the essence of the reforms.

The research in this dissertation focuses on ways in which reforms can be implemented, taking into account both the everyday practices of teachers and the goals and principles of a reform proposal. Literature emphasizes that the practicality of a reform should hereby be the focal point.

The specific educational reform proposal that was researched was the current educational reform for biology education in the Netherlands: the introduction of a context-based approach. This reform is proposed by The National Reform Committee for Biology Education (CVBO) to address three issues in biology education: a lack of relevance, a lack of coherence between biological concepts and an overloaded curriculum for the students. One of the main principles behind this reform is that biological knowledge is organised and offered in contexts that are relevant to students. The CVBO presented the context-based approach mainly as an update of the subject matter, whereby it is inevitable that there are implications for the everyday teaching practice.

The central question in this dissertation asks how the context-based approach can be made practical for teachers. To answer this central research question, it is important to know which criteria need to be met for educational reforms to be

considered practical by teachers. First, teachers should be able to envision how the reform would work out in their classrooms (instrumentality). Second, the content of the proposal should be connected to how teachers regularly teach (congruency) and third, the proposal should have high benefits and low cost in terms of effort and time (cost). In this dissertation, two correlated approaches are presented that are based on the above-mentioned criteria for practicality and aim to make educational reforms practical: a modular approach and a success-oriented approach.

The modular approach is based on working with lesson segments as building blocks for a lesson. An educational reform can be described in terms of already existing lesson segments. Hence a reform can often be realized through recombining and adjusting already existing lesson segments. The modular approach used in this study uses lesson segments to design lessons that teachers regularly teach. With the lesson segments the following steps were taken: (1) the usual, most observed lesson of a teacher was categorized into lesson segments; (2) this was evaluated by the teacher and compared with the educational reform, which was also split up into lesson segments; (3) the teacher could then change the order or the content of the lesson segments to adjust his regular teaching practice in the direction of the desired educational reform.

The success-oriented approach implies building on the foundations of earlier successful experiences to achieve a certain goal. A process of change is often started by identifying and analysing problems and followed by offering information or help to eradicate deficiencies. Using elements of solution-focused psychotherapy this research proposes a different approach: building on earlier successful experiences. The success-oriented approach in this research meant that teachers looked back on their previous lessons in which they had had a successful experience with aspects of context-based education (e.g., "I had a successful lesson a few years back in which students took the role of General Practitioner and had to educate others about contraceptives"). These earlier successful experiences with aspects of the reform were then used by teachers to propose changes in their own teaching practices that were in line with the reform. In this research the modular and the success-oriented approach for making an educational reform practical have been worked out in four separate studies.

In the **first study** (Chapter 2) an ID model was designed to structure the modular approach. The most important criteria for this instrument were that it

should contain lesson segments that allowed teachers to (1) identify all sorts of lesson practices and (2) change their lesson practices towards the given change proposal. After constructing an initial model, it was internally validated through a Delphi study, in which eleven teacher educators took part as experts in various school subjects. In three phases of individual responses and anonymous individual feedback, the experts reached consensus on a model that met the required criteria. The resulting model exists of a set of lesson segments with which, by selecting and rearranging, a wide variety of instructional approaches can be analysed and generated. The model relates to the criteria of practicality in the following way: it is instrumental, congruent and involves little cost because teachers can create new content with already familiar lesson segments, and through rearranging and adjusting can realize a proposed reform.

In the **second study** (Chapter 3) we focused on the way in which making the context-based approach practical influences teachers' intentions to change their everyday practice towards the reform. Both the modular and the success-oriented approach were used to develop a 'Motivating-for-Educational-Change' interview technique (MECI) that was used in interviews with nine biology teachers. After the interviews the strength and the specificity of the resulting intentions were compared with the baseline values (t=0). During the interviews it became clear that by comparing lesson segments, every teacher was able to think back of a successful experience that covered (an aspect of) context-based education. After the interviews it further became clear that participating teachers had more, stronger and more specific intentions. The reason that was given for this was that looking back on earlier successful experiences helped them to realize that they had already applied some aspects of the educational reform in their regular lessons. This led to a feeling of competence, but also to a better understanding of how the reform could be worked out in a classroom setting. Thus, the interview technique is a potential tool to motivate teachers for change at the onset of professionalization initiatives.

The **third study** (Chapter 4) describes the development and the implementation of a professional development program and analyses the way in which making the context-based approach practical, influenced the lesson practices and intentions of participating teachers (n=8). The underlying design criteria for this professional development program were both the modular and the success-oriented approach,

and also the support given to participating teachers, which was from a distance and according to their individual needs. The results show that teachers maintain their strong intentions to change during the process. Furthermore, there seems to be a more or less shared learning route that is followed when teachers start to change their regular teaching practice towards the reform. The success-oriented approach appears to have had specific influence on formulating strong intentions, which relates to the criteria of congruence. The modular approach, in which teachers worked with lesson segments, was mentioned as an essential part of the process by virtually all participants. Teachers indicated that this helped them to see how the reform is linked to their current teaching practice, but also how to practically work out the reform in a classroom setting. Hence this approach seems to be congruent, instrumental and involve low cost. The support for the teachers, from a distance and according to their individual needs, was experienced as positive, especially because preparing the lessons and reflecting on the lessons could be done in their own environment and in their own time. In this way this last design criteria adds to the practicality by its low cost.

In the **fourth study** (Chapter 5) the research focused on a different way of experiencing success. In general teachers reflect on problems and/or successes on the basis of their own subjective impressions of a comment from a single student. This chapter analyses the measure in which teachers could use more objective student data both to experience success and to change their lesson practice. Two problems needed to be taken into account: (1) technical problems such as not knowing how to collect students' data or not having time to collect these data and (2) problems to interpret and use these data to propose a change.

In this study, teachers collected data from students in a practical way by giving out short questionnaires in their own lessons to measure the learning outcome as well as the guidance of the learning process. Teachers each went through a 'Plan-Do-Check-Act' (PDCA) cycle four times, in which they prepared a lesson for 'Plan', they gave the lesson and collected data in 'Do', they interpreted data in 'Check' and they formulated intentions to change in 'Act'. In the 'Check' and 'Act' phase the teachers received support. Using the data-frame theory a few practically relevant 'frames' were developed. These frames were designed to help teachers allocate the student data to a specific part of their lesson and were based on the modular approach. Two elements were analysed:

(1) the way in which teachers used the frames to interpret and use their student data in the 'Check' and 'Act' phase and (2) the way in which the students' data can serve to objectify the successful experiences and the influence this has on the development of lesson practices of participating teachers.

The final chapter (Chapter 6) describes and discusses the findings of all the research. The separate studies show the measure in which a modular and a success-oriented approach have made context-based education practical for teachers. It showed that combining these two approaches can help teachers to (1) formulate strong and specific intentions to change and (2) gradually change their regular teaching practice towards the proposed reform.

Using the modular approach helped teachers to understand the proposed reform in relation to their own teaching practice. Furthermore, this approach helped teachers to take their own teaching practice as a starting point for their process of change. With this the modular approach relates to two criteria of practicality, namely instrumentality and congruence. The success-oriented approach proved to help teachers to relate the reform to something they had already successfully tried out in their own teaching practice, which relates to the criteria of congruence. Thinking back to earlier successful experiences also provided new ideas with regard to practically working out the reform, which in turn influenced the specificity of the intentions. This relates to the criteria of instrumentality. Both approaches combined helped teachers to experience the benefits of the proposed reform in a relatively short time and with little means, which specifically relates to the practicality criteria of low cost.

As with every research, this research has its limitations. In this research a choice was made to study the topic in a qualitative manner with a relatively small amount of participants. It is therefore recommended that the outcomes of this research be further explored in larger groups. Further research could also include aspects that were left out for this research, e.g.: How do teachers' beliefs develop during a professional development program that is aimed at teaching teachers how to teach context-based education? Another possible study could include analysing the development of the strength and specificity of intentions when the MECI interviews are held for different educational reforms.

This research project has given several suggestions for successfully implementing educational reforms. Firstly, educational reforms should be split up into smaller units (lesson segments) that are identifiable for teachers in their everyday practice. Secondly, for every individual teacher strengths and earlier successful experiences should be identified with the help of a 'Motivating for Educational Change' interview (MECI). In this interview teachers will be asked to formulate intentions for a first change in their teaching practice. Thirdly, this could be followed up by a professional development program that is based on both the modular and the success-oriented approach. In this program teachers can build on previous successes and gradually change their teaching practice towards the educational reform. In this way an educational reform can be made practical for teachers for implementation in everyday classroom practices, without losing the essence of the reform.

Nederlandse Samenvatting

Docenten spelen een cruciale rol bij het implementeren van onderwijsvernieuwingen. Uiteindelijk hangt het succes van de implementatie af van de manier waarop docenten de vernieuwing vormgeven in hun dagelijkse lespraktijk. Hiertoe dienen docenten de vernieuwingsvoorstellen uit te werken voor hun lespraktijk. Dit blijkt in veel gevallen problematisch, omdat onderwijsvernieuwingen meestal geformuleerd zijn op een relatief abstract niveau, bijvoorbeeld als doelen of uitgangspunten, in plaats van op het concrete niveau van de dagelijkse lespraktijk. Deze dagelijkse praktijk met al haar beperkingen en uitdagingen bepaalt echter in belangrijke mate wat docenten willen en kunnen uitvoeren en daarmee ook het succes van de implementatie van een onderwijsvernieuwing. Docenten passen vernieuwingsvoorstellen vaak zodanig aan zodat ze aansluiten bij hun lespraktijk, wat meestal ten koste gaat van de essentie van de vernieuwing.

In dit proefschrift zijn daarom manieren onderzocht waarop een vernieuwing geïmplementeerd kan worden, waarbij zowel de dagelijkse lespraktijk van docenten als de doelen en uitgangspunten van een voorgestelde vernieuwing serieus genomen kunnen worden. In de literatuur wordt benadrukt dat het accent dan moet liggen op de praktische bruikbaarheid van een vernieuwing.

De onderwijsvernieuwing die is onderzocht betreft de huidige onderwijsvernieuwing voor het biologieonderwijs: de introductie van een concept-contextbenadering. Deze onderwijsvernieuwing is voorgesteld door de Commissie Vernieuwing Biologie Onderwijs (CVBO) om antwoord geven op de drie geconstateerde knelpunten in het biologieonderwijs: te geringe relevantie van biologische kennis, te geringe samenhang tussen biologische kennis en een overladen programma voor de leerling. Het uitgangspunt van deze vernieuwing is dat biologische kennis wordt georganiseerd en aangeboden in, voor leerlingen relevante contexten. De CVBO heeft de concept-contextbenadering vooral bedoeld als vakinhoudelijke vernieuwing, waarbij het voor de hand ligt dat er relevante didactische implicaties voor docenten zijn bij de implementatie ervan.

In dit proefschrift staat de volgende onderzoeksvraag centraal: *Hoe kan de concept-contextbenadering praktisch bruikbaar gemaakt worden voor docenten?* Om antwoord te geven op deze algemene onderzoeksvraag, is het belangrijk te weten waaraan onderwijsvernieuwingen moeten voldoen om als praktisch bruikbaar te worden gezien door docenten. Ten eerste moeten ze instrumenteel zijn, hetgeen inhoudt dat het duidelijk moet zijn hoe de vernieuwing handen en voeten krijgt in de lespraktijk. Ten tweede moeten ze congruent zijn, wat betekent dat ze moeten aansluiten bij de reguliere lespraktijk van docenten. Ten derde moeten ze voor docenten gunstig zijn wat betreft kosten in termen van tijd, middelen en inspanning, en opbrengsten in termen van ingeschatte voordelen. Op basis van deze criteria van praktische bruikbaarheid worden in dit proefschrift twee samenhangende benaderingen voorgesteld om onderwijsvernieuwingen praktisch bruikbaar te maken: een modulaire benadering en een succesgerichte benadering.

De modulaire benadering is gebaseerd op het werken met lessegmenten als bouwstenen voor een les. Een onderwijsvernieuwing kan vaak worden beschreven in termen van reeds bestaande lessegmenten. Hierdoor kan een vernieuwing worden gerealiseerd door recombinatie en aanpassing van reeds bestaande lessegmenten. Omdat in dit onderzoek de focus ligt op het veranderen van de dagelijkse lespraktijk, betekende een modulaire benadering in dit onderzoek dat er gebruik gemaakt is van lessegmenten die samen een les kunnen vormen zoals een docent die dagelijks geeft. Met de lessegmenten werden de volgende stappen genomen: (1) de reguliere, meest voorkomende les van een docent werd in kaart gebracht met behulp van de lesbouwstenen; (2) deze les werd door de docent vergeleken met de onderwijsvernieuwing, ook vormgegeven in lessegmenten; (3) de docent kon vervolgens de volgorde en/of inhoud van de lessegmenten aanpassen om zijn/haar reguliere lespraktijk in stappen aan te passen in de richting van de vernieuwing.

De succesgerichte benadering betreft het voortbouwen op eerdere succeservaringen om een bepaald doel te bereiken. Veelal beginnen veranderprocessen met het analyseren van problemen en vervolgens wordt kennis of hulp geboden om deficiënties weg te werken. Voortbouwend op elementen van de oplossingsgerichte psychotherapie wordt in dit onderzoek een andere benadering voorgesteld: het voortbouwen op eerdere succeservaringen. De succesgerichte benadering in dit

onderzoek betekende concreet dat docenten terugblikten op hun eerdere lessen waarin ze al een succesvolle ervaring hadden gehad met aspecten van concept-context onderwijs ("ik heb een paar jaar terug al eens een succesvolle les gehad waarin leerlingen de rol van huisarts kregen en voorlichting moesten geven over anticonceptiemiddelen"). Deze mogelijke eerdere succeservaringen met aspecten van de vernieuwing werden vervolgens door docenten gebruikt om een verandering voor te stellen voor hun eigen lespraktijk, in lijn met de vernieuwing.

In dit onderzoek is een modulaire en succesgerichte aanpak voor het praktisch bruikbaar maken van een onderwijsvernieuwing in een viertal studies nader uitgewerkt en beproefd.

In de **eerste deelstudie** (hoofdstuk 2) is een ontwerpmodel ontwikkeld waarmee de modulaire aanpak kon worden vormgegeven. De belangrijkste eisen aan dit instrument waren dat het bouwstenen, lessegmenten, moest omvatten, waarmee docenten (1) allerlei lespraktijken in kaart konden brengen en (2) hun lespraktijk stapsgewijs konden ontwikkelen in de richting van een gegeven veranderingsvoorstel, waarbij gestart werd met de reguliere lespraktijk. Na het construeren van een initieel model heeft er vervolgens een Delphi-studie plaatsgevonden, waarmee het model intern gevalideerd kon worden. In deze Delphi-studie namen elf vakdidactici van diverse schoolvakken deel. In drie ronden van individueel reageren en anonieme individuele terugkoppeling van alle meningen, hebben de experts consensus bereikt over een model dat aan de gestelde eisen voldeed. Het resulterende model bestaat uit een set met lessegmenten waarmee door selectie, verandering van volgorde en sturing een groot repertoire aan lesaanpakken kan worden geanalyseerd en gegenereerd. Het model refereert op een aantal manieren aan de criteria van praktische bruikbaarheid. Het is instrumenteel, congruent en heeft lage kosten, omdat docenten met reeds bekende lessegmenten nieuwe ontwerpen kunnen maken, alsook door recombinatie en aanpassing een voorgestelde vernieuwing (stapsgewijs) kunnen realiseren binnen hun eigen beschikbare tijd en werkomgeving.

In de **tweede deelstudie** (hoofdstuk 3) is onderzocht in hoeverre het praktisch bruikbaar maken van de concept-contextbenadering invloed heeft op de voornemens die docenten hebben om hun lespraktijk te gaan veranderen in de richting van de

vernieuwing. Op basis van zowel de modulaire als de succesgerichte benadering is hiertoe een 'motivating-for-educational-change' interviewtechniek (MECI) ontwikkeld, die is toegepast in interviews met negen biologiedocenten. Na de interviews zijn de sterkte en specificiteit van de resulterende voornemens vergeleken met die uit de intake (t=0). In de interviews bleek dat iedere docent op basis van het vergelijken van de lessegmenten een succeservaring met (een aspect van) concept-context onderwijs kon benoemen. Na de interviews bleek dat deelnemende docenten zowel meer, sterkere, als meer specifieke voornemens hadden. Als reden hiervoor werd aangegeven dat het terugblikken op eerdere succeservaringen ze had geholpen om in te zien dat ze bepaalde aspecten van de vernieuwing al toepasten in hun reguliere lessen. Dat gaf niet alleen een gevoel van bekwaamheid, maar ook een beter begrip van hoe de vernieuwing uit kan werken in de lespraktijk. De interviewtechniek zou ingezet kunnen worden om docenten te motiveren voor veranderingen bij de start van professionaliseringsinterventies.

In de **derde deelstudie** (hoofdstuk 4) is een professionaliseringstraject ontwikkeld en uitgevoerd, waarbinnen is onderzocht in hoeverre het praktisch bruikbaar maken van de concept-contextbenadering invloed heeft gehad op de lespraktijken en voornemens van deelnemende docenten (n=8). De onderliggende ontwerpcriteria voor het professionaliseringstraject waren zowel de modulaire als de succesgerichte benadering, alsook het op maat en op afstand ondersteunen van deelnemende docenten. De resultaten laten zien dat docenten gedurende het traject sterke voornemens houden om te veranderen. Daarnaast blijkt er een min of meer gemeenschappelijke leerroute te bestaan om de reguliere lespraktijk te veranderen in de richting van de vernieuwing. De succesgerichte benadering bleek specifieke invloed gehad te hebben op het formuleren van sterke voornemens en aan te sluiten bij het congruentie criterium van praktische bruikbaarheid. De modulaire benadering, waarin docenten werkten met lesbouwstenen, werd door vrijwel alle deelnemers benoemd als een essentieel onderdeel van het traject. Docenten gaven aan dat ze hiermee niet alleen inzagen hoe de vernieuwing aansluit bij wat ze normaal gesproken doen, maar ook hoe de vernieuwing handen en voeten krijgt in de dagelijkse lespraktijk. Zo lijkt deze benadering aan te sluiten bij zowel de congruentie en de instrumentaliteit, als bij de lage kosten. Het op afstand en op maat ondersteunen werd als zeer prettig ervaren, vooral omdat zowel het ontwerpen van de lessen als de reflectie erop in de eigen omgeving en de eigen tijd gedaan kon worden. Hiermee draagt dit laatste ontwerpcriterium specifiek bij aan het vormgeven van praktische bruikbaarheid door lage kosten.

In de **vierde deelstudie** (hoofdstuk 5) is onderzoek gedaan naar een andere manier van het ervaren van succes. Veelal reflecteren docenten op problemen en/of successen op basis van hun eigen affectieve indrukken op een terloopse opmerking van een enkele leerling. In deze deelstudie is onderzocht in hoeverre docenten meer objectieve leerlingdata kunnen gebruiken om succes te ervaren en hun lespraktijk te veranderen. Hierbij moest rekening gehouden worden met twee soorten problemen die docenten kunnen hebben in het gebruik van leerling data: (1) technische problemen als niet weten hoe data verzameld kunnen worden of er de tijd niet voor hebben, en (2) problemen in het interpreteren en gebruiken van deze data om verandering voor te stellen. In deze deelstudie hebben docenten op een praktisch bruikbare manier leerlingdata verzameld door in hun eigen les korte vragenlijsten af te nemen om zowel de leereffecten als de sturing van het leerproces te meten. Docenten doorliepen ieder viermaal een 'Plan-Do-Check-Act' (PDCA) cyclus, waarbij ze in de 'Plan' fase een les ontwierpen, in de 'Do' fase de les gaven en leerling data verzamelden, in de 'Check' fase de data interpreteerden en in de 'Act' fase voornemens konden formuleren om te veranderen. Hierbij zijn de docenten in de 'Check' en 'Act' fase ondersteund. Op basis van de data-frame theorie zijn hiervoor een aantal praktisch bruikbare 'frames' ontwikkeld. Deze frames zijn ontworpen om docenten gericht te helpen om leerling data toe te wijzen aan bepaalde onderdelen van hun ontworpen les en waren gebaseerd op de modulaire benadering. Er zijn hierbij twee elementen onderzocht: (1) De wijze waarop docenten in de 'Check' en 'Act' fase de praktisch bruikbare frames gebruikten om hun leerling data te interpreteren en te gebruiken, en (2) de wijze waarop leerlingdata dienden voor het objectiveren van succeservaringen en de mogelijke invloed hiervan op de ontwikkeling van de lespraktijken van deelnemende docenten.

In het laatste hoofdstuk (hoofdstuk 6) worden de opbrengsten van alle deelstudies beschreven en bediscussieerd. De verschillende deelstudies hebben laten zien in hoeverre een modulaire en succesgerichte aanpak de concept-contextbenadering praktisch bruikbaar hebben kunnen maken. Het bleek dat het combineren van deze twee benaderingen docenten kan helpen bij (1) het formuleren van sterke en specifieke voornemens voor verandering en (2) het stapsgewijs veranderen van de reguliere lespraktijk in de richting van de vernieuwing.

Het gebruik van de modulaire benadering hielp docenten bij het begrijpen van de vernieuwing in relatie tot hun eigen lespraktijk. Daarnaast hielp deze benadering docenten om de eigen lespraktijk als vertrekpunt te nemen voor hun veranderproces. Hiermee sluit de modulaire benadering aan bij twee criteria van praktische bruikbaarheid: instrumentaliteit en congruentie. De succesgerichte benadering bleek docenten te helpen om de vernieuwing te relateren aan datgene wat ze al eens succesvol hebben uitgevoerd in hun lespraktijk, wat aansluit bij het congruentie criterium. Daarnaast gaf het terugdenken aan succesvolle ervaringen ook nieuwe ideeën over de concrete uitwerking van de vernieuwing, wat doorwerkte op de specificiteit van voornemens. Dit correspondeert met het criterium van instrumentaliteit. De beide benaderingen gecombineerd hielpen docenten om met weinig tijd en middelen snel de voordelen van de vernieuwing te ervaren en deze stapsgewijs te bereiken, wat specifiek refereert aan het lage kosten-criterium van praktische bruikbaarheid.

Zoals bij elk onderzoek kent ook dit onderzoek zijn beperkingen. Zo is in dit onderzoek gebruik gemaakt van een kwalitatieve aanpak met relatief kleine aantallen participanten. Het verdient dan ook aanbeveling om de uitkomsten van dit onderzoek in grotere groepen verder te onderzoeken. Daarnaast zouden in vervolgonderzoek enkele niet onderzochte aspecten verder uitgewerkt kunnen worden, zoals: Hoe ontwikkelen de opvattingen van docenten zich gedurende een professionaliseringstraject dat gericht is op het leren onderwijzen van concept-context onderwijs? Een ander mogelijk vervolgonderzoek zou kunnen zijn om de ontwikkelingen in de sterkte en specificiteit van de voornemens in kaart te brengen wanneer de MECI-interviews afgenomen worden voor andere onderwijsvernieuwingen.

Dit onderzoek heeft ook een aantal aanwijzingen opgeleverd voor het succesvol implementeren van onderwijsvernieuwingen. Ten eerste zouden onderwijsvernieuwingen uitgewerkt moeten worden in kleinere eenheden (lessegmenten) die voor docenten in hun dagelijkse praktijk herkenbaar zijn. Ten tweede zouden van individuele docenten de sterke punten en eerdere succeservaringen met aspecten van de vernieuwing in kaart gebracht moeten worden gebracht met behulp van een 'Motivating-for-Educational-Change'-interview (MECI). In dit interview kunnen docenten dan voornemens formuleren voor een eerste verandering in hun reguliere lespraktijk. Ten derde zou dit een vervolg kunnen krijgen in een professionaliseringstraject dat gebaseerd is op

zowel de modulaire als de succesgerichte benadering. In dit traject kunnen docenten voortbouwen op eerdere successen en stapsgewijs hun reguliere lespraktijk veranderen in de richting van de onderwijsvernieuwing. Op een dergelijke manier kan een onderwijsvernieuwing praktisch bruikbaar gemaakt worden voor de implementatie in de dagelijkse lespraktijk van docenten, zonder dat dit ten koste gaat van de essentie van de vernieuwing.

Scientific Contributions

Articles

Dam, M., Janssen, F. J. J. M., & Van Driel, J. H. (2013). Concept-context onderwijs leren ontwerpen en uitvoeren - een onderwijsvernieuwing praktisch bruikbaar maken voor docenten [Learning to design and enact context-based biology education – making an educational reform practical for teachers]. *Pedagogische Studiën, 90*(2), 63-77.

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Janssen, F. J. J. M., De Boer, E., Dam, M., Westbroek, H. B., & Wieringa, N. (2013). Design research on developing teaching repertoires. In T. Plomp & N. Nieveen (Eds.), *Educational design research – Part B: Illustrative cases* (pp. 757-780). Enschede, the Netherlands: SLO.

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Dam, M., Janssen, F. J. J. M., & Van Driel, J. H. (2013, April). Motivating teachers for educational change – how to generate strong intentions to change. In W. Doyle (Chair), *Bridging methodologies for making innovations practical.* Symposium conducted at the meeting of the American Educational Research Association (AERA), San Francisco, USA.

Dam, M., Janssen, F. J. J. M., & Van Driel, J. H. (2012, June). Succeservaringen en lesbouwstenen als input voor het leren ontwerpen van concept-context biologie onderwijs [Succesful experiences and lesson building blocks as input for learning to design context-based biology education]. In F. J. J. M. Janssen (Chair), *Professionalisering van docenten op het terrein van curriculumontwikkeling [Teacher professionalization in the field of curriculum development].* Symposium conducted at the Onderwijs Research Dagen (ORD), Wageningen, the Netherlands.

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Curriculum Vitae

Michiel Dam was born in Gouda, the Netherlands, on May 30th 1981. He attended Christelijk Lyceum (renamed Goudse Waarden) in Gouda, where he graduated in the year 2000. He then studied biology, first at Wageningen University (WUR) and later at Leiden University (2002-2005). His Master's thesis addressed the molecular interplay between PINOID, TOUCH3 and PHOT1 proteins in the regulation of phototropism (plants growing towards a light source). After obtaining both a Master's degree in biology and teaching of biology, he started to teach biology to pre-university students at Scala College in Alphen aan den Rijn. In 2008, Michiel started his PhD study at ICLON, Leiden University, as part of the DUDOC program, which was financed by the Dutch Ministry of Education, Culture and Science. While performing his PhD research, he continued to work as a biology teacher at Scala College for two days per week. His research focused on ways in which educational reforms could be made practical for teachers, applied in the setting of a context-based educational reform for biology education. Important elements in his research were ways in which teachers change their instructional approach towards a more context-based approach and teachers' intentions to implement a context-based reform.

Currently, he teaches biology at Scala College, where he also carries out a post-DUDOC research project that is aimed at examining ways in which teachers can be assisted to improve their everyday practices and achieve high learning outcomes and high student participation. In August 2013, he started working as a teacher educator at the ILO (interfacultaire lerarenopleiding) at the University of Amsterdam (UvA).

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