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.

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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.