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Chapter 1

General Introduction
1.1 Introduction

All over the world, secondary school science curricula are frequently being updated, reformed and revised. Likewise, Dutch secondary school biology curricula have recently undergone an innovation which was based upon a context-based approach. The implementation of reform ideas at classroom level will generally differ from what policy makers originally envisioned (Fullan, 2007; Janssen, Westbroek, Doyle & Van Driel, 2013; Van den Akker, 1998). Whatever the aims of the innovation, the teachers who teach the curriculum are key to the outcomes (Fullan, 2007). Teachers interpret and appreciate new ideas while deciding whether and how to use them when designing, teaching, and reflecting upon their lessons. In this entire process, teachers’ practical knowledge (defined as the cognitions that underlie teachers’ actions (Meijer, 1999)) plays a central role. When studying teachers’ practical knowledge, two important problems arise: first, the knowledge of teachers often remains largely implicit (van Driel, Beijaard, & Verloop, 2001), and even when research tools are used to elicit aspects of a teacher’s knowledge, these often poorly explain the decisions teachers make when designing and teaching lessons (Borko, Roberts, & Shavelson, 2008; Fives & Buehl, 2012; Mathijsen, 2007). A second problem is that, as Kennedy put it, “educational research is at a stage in which we have strong theories of student learning, but we do not have well-developed ideas about teacher learning, nor about how to help teachers incorporate new ideas into their ongoing systems of practice” (Kennedy, 2016a, p. 29).

The aim of this thesis is to clarify the relation between teacher knowledge and the decisions they make while designing innovative lessons, in order to be able to effectively support teacher professional development in the context of curriculum reform. The reason why the focus will predominantly be on the process in which teachers design their lessons is that during this design process teachers make important decisions about the content and pedagogies of these lessons. The lesson design process also offers important opportunities to support teacher learning, for when designing lessons, teachers simultaneously use and create their knowledge (Aikenhead, 1984; Hashweh, 2005; Sanchez & Valcarcel, 1999). Before going more deeply into current research about teacher knowledge and their design of innovative lessons, I will first describe the background and implementation process of the context-based reform in the Netherlands.

1.2 Context-based biology teaching and learning

This research took place during a reform of the secondary school biology curricula. The aim of this innovation was to make the biology curriculum more relevant, more up-to-date and more coherent through the use of real-world contexts in class, a context being defined as
an authentic scientific, professional or life-world practice (Boersma, Kamp, Van den Oever, & Schalk, 2010). In the Dutch context, the terms “concept-context approach” (concept-contextbenadering) or “context-concept approach” are used to describe the pedagogy being promoted, depending on whether the speaker or writer wishes to stress the importance of the biological concepts or the importance of the context in which those concepts are used. However, because this thesis is composed of a collection of research articles which were written for an international audience, we have chosen to use the term “context-based education”, with which many international scholars of science education are familiar (Bennett, Lubben, & Hogarth, 2007; Gilbert, 2006; Sevian, Dori, & Parchmann, 2018).

The movement towards more context-based approaches in secondary science education in The Netherlands has a long history, which goes back to the 1970s (Kuiper, 2009). This movement initially took place in physics, and later also in chemistry classes, in cooperation with teachers of several experimental schools. In biology education, there had been no large-scale experiments such as in physics and chemistry classes. Nonetheless, there was considerable dissatisfaction about the biology curriculum, and in 2003, the Royal Academy of Arts and Sciences concluded in an influential report that the biology curricula suffered from a lack of relevance, a lack of coherence and an overload of biological concepts (KNAW, 2003). This report, together with similar analyses in the other science subjects, was the onset of the innovation process in science education, for which the context-based teaching approach was chosen as a leading principle. The innovation committees that were installed chose to involve a diversity of teachers in the process of curriculum innovation. In biology education, seven “biology development schools” (BOS) played an important role, in which teachers in cooperation with educational researchers developed and evaluated teaching and learning materials (Folmer, Ottevanger, & Bruning, & Kuiper, 2011). Their experiences were used to design experimental context-based syllabi and central examinations, which in turn informed the design of new lesson materials. At the same time, at many different places in the country, biology teachers experimented with the context-based teaching approach, and shared their experiences for instance during discussions at conferences and through publications. In 2013, the new context-based examination programs were officially launched. Data collection for our research took place from 2008 to 2012, that is, during the developmental phase of the innovation process. In our research, we focused on teachers who were not involved with the programs on the biology development schools, with the exception of one teacher (“David”), who participated in our first study, reported in chapter two.
1.3 The importance of teachers’ lesson design decisions in the context of curriculum reform

In the process of curriculum reform, the decisions teachers take while designing their lessons are critical (Davis, Janssen, & Van Driel, 2016; Fullan, 1991, 2007; Randi & Corno, 1997). Lesson design, in this thesis, is defined as all activities teachers undertake when planning and preparing their lessons, which can include adaptation of existing materials and/or the development of new teaching and learning materials from scratch. Designing lessons takes place in a cyclical process of planning, implementation and evaluation, in which goals and activities are continuously revised (Yinger & Hendricks-Lee, 1994). Sometimes, teachers need to design their own teaching materials, because high quality reform-based materials for teaching and learning are lacking. Even if relevant and high quality materials are available, teachers’ design decisions when using such materials can lead to crucial changes, which can either lead to a weakening or a strengthening of the reform ideas. When Van Berkel (2005) studied the development and implementation of a context-based chemistry method in Great Britain, he discovered that the changes teachers made resulted in lessons which were less context-based, because teachers added an explanation of the concepts before having students work on context-based activities. A related well-known phenomenon is the tendency many teachers have to reduce the cognitive demand of student tasks for students (Stein, Remillard, & Smith, 2007). On the other hand, teachers will strengthen reform ideas when redesigning existing materials to better accommodate their students’ needs (Wallace & Priestley, 2017) or to respond to the changing interests of themselves and their students, and to current developments in society and biological science (George & Lubben, 2002).

Whereas teachers always design lessons, designing innovative lessons is more challenging than routinely designing lessons of the kind that they feel familiar with. Former research shows, for instance, that teachers consider it difficult to translate a context into meaningful learning materials and to guide students’ learning processes while they work on context-based activities (De Putter-Smits, 2012; Stolk, Bulte, de Jong, & Pilot, 2009). Even for experienced educational designers, who have substantially more time available for the design of curriculum materials than the average science teacher, the design of context-based lessons is problematic, especially when it comes to the alignment of curriculum standards, learning activities and central questions within the contexts (Krajcik, McNeill, & Reiser, 2008). Innovative lesson design can be an important learning activity for teachers in itself (Hashweh, 2005; Sanchez & Valcarcel, 1999), whether existing reform materials are used (Davis, Beyer, Forbes, & Stevens, 2011) or new materials are developed (Sanchez & Valcarcel, 1999). It is to be expected, however, that teachers will need extra support in the process. Before we can decide what kind of support to offer teachers, we first need to understand more about how teachers think and act when designing and enacting their lessons.
1.4 An historical overview of thinking about teacher thinking and their actions

It is a persistent problem that we lack grounded and tested theories about how we can effectively support teachers to integrate new ideas into their systems of practice, despite that many before have studied teachers’ cognitions and their actions, and proposed ways to support teacher learning. In the history of the research on teacher learning one can recognize a pendulum movement in which the focus shifted from teachers’ actions to their cognitions and back to their actions, while the connection between teacher knowledge and their actions often remained understudied (Borko et al., 2008). In the 1960s and 1970s, the focus of educational researchers was largely on what effective teachers actually do in class, such as waiting a few seconds after posing a question in order to allow students to think of an answer or using predictable signals to get students’ attention. The idea was that teachers could be trained to demonstrate such behaviors in order to become effective teachers. While this line of reasoning, often called process-product research, is today still very present in teacher education, in the 1980s this line of research was criticized by Shulman for disregarding the importance of teachers’ knowledge and beliefs, and of the content matter of what is being taught and learned (Shulman, 1986b, 1987). What effective teachers do, he argued, depends on what those teachers know and believe about the content matter, general learning strategies, about the curriculum, student characteristics and thinking, possible representations of content matter and assessment. Since then, many have dedicated their research work to mapping and categorizing the special knowledge teachers need to teach (Kennedy, 2016b). Less attention was paid to teachers’ actions in everyday classroom practices, and to the connection between teacher knowledge and their actions in the classroom (Borko et al., 2008). More recently, attention has been redirected towards teachers’ actions. This time, researchers do not look at isolated actions such as posing questions, but to more complex practices, called “core practices”, within school contexts, such as “eliciting student thinking” or “pressing students for evidence-based explanations” (McDonald, Kazemi, & Kavanagh, 2013a; Windschitl, Thompson, Braaten, & Stroupe, 2012). The idea is that both novice and experienced teachers can be trained to effectively perform such practices. Kennedy (2016b) warns that too much attention for the training in core practices might again neglect underlying beliefs, and in particular, underlying goals that teachers hold. Such studies might delusively convey the message that for each learning objective, one “expert” strategy can be identified, while in reality the best strategy depends on the context and the teachers’ and students’ specific beliefs, needs and abilities. In our research, we will try to synthesize the insights from both more knowledge-oriented and action-oriented research lines. We will do this by adopting a perspective that has been tried and tested before, that of the teacher as decision maker.
In the early 1970s, three influential scholars independently concluded that decision-making was central to teaching and to understanding teaching practices (Bishop, 1976; Shavelson, 1973; Shulman & Elstein, 1975). As Shavelson (1973, p. iii) put it: “the basic teaching skill is decision making. What distinguishes the exceptional teacher from his or her colleagues is not the ability to ask, say, a higher-order question, but the ability to decide when to ask such a question” (underlining in original). Most of the research by Shavelson, Bishop and colleagues was focused on the decisions teachers make while teaching, but it also included decisions teachers make while planning their lessons. Such lesson planning studies were mostly linked to the nature and sequence of teacher’s decisions while planning their lessons, disregarding the content of those decisions. Information was collected, for instance, about whether and when teachers thought about learning goals, but not what those learning goals were. Still, these descriptive studies into lesson planning, in which thinking aloud methods were often used, yielded valuable insights. First, they showed that teachers’ planning behaviors deviated from what is prescribed by rational planning models, and that such models seldom effectively support teachers’ planning processes (Visscher-Voerman, Gustafson, & Plomp, 1999). Instead of starting by formulating learning objectives, many teachers start their design by selecting activities that have proven to be successful in past classroom situations (Clark & Peterson, 1986; Moallem, 1998). Second, teachers generally do not rationally consider alternative approaches but rely on routines and rules-of-thumb that have proven to be successful in past experiences (Schön, 1983; Shavelson & Stern, 1981). Other studies have shown that teachers, when designing innovative lessons, will not simply add reform goals and pedagogies to their existing teaching knowledge and repertoires. While reform ideas often have student learning as their sole goal, teachers need to find solutions that are practical within their own classrooms, that is, solutions that are instrumental (include procedures to reach the proposed goals), congruent with their perceptions of their own situation, and cost-effective (Doyle & Ponder, 1977; Janssen, Westbroek, Doyle, & Van Driel, 2013). The process of lesson design offers important possibilities to study this process in which teachers integrate new conceptions within their existing systems of knowledge and beliefs in ways that are practical within their own contexts. The relation between teacher knowledge and their design of lessons, however, has been remarkably understudied (Hashweh, 2005, 2013).
1.5 Research questions

The overall research questions in this thesis are:

1. What decisions do biology teachers make when designing context-based lessons for their own classroom practice, and how do these relate to their practical knowledge?
2. What are characteristics of an effective professional development strategy to support biology teachers when they design context-based lessons for their own classroom practice?

According to Clark & Peterson (1986), the lesson design process encompasses decisions teachers take and activities they perform before teaching (consisting mainly of lesson planning and organizing activities), decisions taken during teaching and decisions taken after teaching. The main focus in this thesis will be on the pre-lesson decisions teachers make when they design their lessons.

1.6 Thesis outline

Economist Victor Fuchs once described a social scientist as somebody who looks for something that works in practice, and then wonders if it will work in theory (Fuchs in personal conversations with Bernard Nelson, cited by Shulman & Shulman (2004)). I, being a biologist who had to learn to think as a social scientist, recognize this process in the journey we\(^1\) went while performing the research I report in this thesis. This thesis, then, can be read as a report of how our understanding about the relation between teacher practical knowledge and their design of innovative lessons developed throughout this journey. While we adapted and developed methods to talk with teachers about their practical knowledge, and while we designed and evaluated a strategy to support teachers in this process of innovative lesson design, we developed and refined our theoretical frameworks. Figure 1.1 gives an overview over the studies that were conducted. The studies reported in chapters 2, 3 and 4 were set up to answer the first main research question, while the study reported in chapter 5 was aimed at answering the second main research question. Chapters 2 and 3 were based upon six case studies of teachers who designed and implemented context-based lessons for their own classroom practice without the intervention of professional development activities. The studies reported in chapters 4 and 5 were situated in the context

\(^1\) This research, like all research, has not been done alone. I went the journey together with my advisors, with my colleagues and friends with whom I discussed theories and findings, and of course with the teachers who participated in the studies.
of a professional development program for 12 biology teachers who wished to learn to design context-based lessons for one of their own classes.

Figure 1.1 Overview over the studies reported in this thesis

The journey started with an explorative study in which we wished to learn what biology teachers do and think when asked to design innovative context-based lessons for their own classroom practice, and more specifically, what rules-of-thumb they use when designing their lessons (chapter 2). The research questions in this study were (1) What rules-of-thumb do biology teachers use when designing context-based lessons for their own educational practice? and (2) How do these personal rules-of-thumb relate to the formal innovative goals and lesson characteristics? Six in-service biology teachers with a variation of backgrounds and work contexts were asked to design context-based lessons for their own classroom practice, while thinking aloud. The implementation of the lessons was studied, and pre- and post-lesson interviews were conducted.

We were not the first to point at the importance of rules-of-thumb as part of practitioners’ practical knowledge. Rules-of-thumb play, for instance, an important role in the work of Donald Schön. In chapter 3 I therefore explore how Schön’s most influential work, his book *The Reflective Practitioner* (1983), could forward our understanding of the way teachers use their knowledge when designing lessons. The chapter has the format of a book review, which is combined with a short case study describing how one biology teacher uses his practical knowledge when designing a context-based lesson. This case study displays both the merits and limits of using Schön’s language, in which the concepts rules, types and
appreciations play a central role, when analyzing the process in which a teacher designs his lessons. One of the main aspects deserving further attention will be the relations between and interdependencies of a teachers’ rules, and the relation between rules and appreciations. Rules and appreciations both are strongly connected to a practitioner’s goals. Someone’s rules and goals, including their interconnections, can be represented in the form of a goal system (Carver & Scheier, 2001; Shah & Kruglanski, 2008). Goal system theory might be a valuable addition to Schön’s perspective of the reflective practitioner, and might enable us to do justice to both the nature of a teacher’s knowledge use when designing lessons and to the interdependencies of a teacher’s rules and goals.

In chapter 4 these ideas are further developed in an empirical study which took place in the context of a professional development project for biology teachers who wished to learn to design context-based lessons for their own classroom practice. The aim of this study was, to see in which way goal system theory could be used to explain and comprehend individual teachers’ understanding and implementation of an innovative context-based curriculum. Twelve teachers’ goal systems were constructed using the laddering interview technique (Fransella, 2005; Reynolds & Gutman, 1988). Analysis was specifically focused on core goals (defined as goals which have two or more links with lower or higher goals within the same system) and negative links (in which existing goals counteract the attainment of higher level goals) within a goal system, and how these are related to a teacher’s interpretation of the context-based reform.

In the study which is reported in chapter 5, the second main research question was taken up, namely: “what are characteristics of an effective professional development strategy to support biology teachers when they design context-based lessons for their own classroom practice?” We were specifically interested to learn how we could effectively build upon teachers’ existing goals and concerns, and how and to what extent design tools, heuristics and examples, in the form of exemplar curriculum materials and model lessons, might support teachers in their design of innovative context-based lessons for their own classroom practice. The research took place in the context of the same PD project as the research reported in chapter 4, and the same 12 teachers participated. A professional development strategy was developed, based upon existing literature and on the findings from the previous chapters of this thesis. Data from interviews, thinking aloud protocols, lesson plans, lesson recordings and registration of meetings were used to refine the professional development strategy and to give specific recommendations for future projects.

In Chapter 6, all findings are summarized and discussed in relation to the two main research questions and are situated in literature. Implications for research, for curriculum reform and for the education and professional development of teachers are explored.
1.7 The Dudoc Program

This research was part of and funded by the Dudoc Program, a program which was meant to give science teachers the opportunity to do educational research and thus make the teaching profession more attractive, widening career perspectives. It also aimed at narrowing the gap between research and practice at schools, bringing the perspective of the practicing teacher to academic research groups. Another aim of the Dudoc Program was to support the innovation of the secondary school science curricula from a scientific perspective. The Dudoc Program enabled me to spend two days per week to perform my PhD studies, alongside my job as a secondary school biology teacher. All Dudoc teachers/researchers formed a research community and regularly met for workshops and seminars (Bakx, Bakker, Koopman, & Beijaard, 2016; Knippels, Goedhart, & Plomp, 2008).