Learners in Dialogue

Teacher Expertise and Learning in the Context of Genetic Testing

Paul van der Zande

Van der Zande P.A.M.
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Lerenden in Gesprek
Expertise en Leren van Docenten in de Context van Genetisch Testen
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(met een samenvatting in het Nederlands)

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Paulus Antonius Maria van der Zande
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	Prof. dr. A. J. Waarlo
	Prof. dr. M. Brekelmans
Co-promotor:	Dr. S. F. Akkerman

Any speaker is himself a respondent to a greater or lesser degree.
He is not after all the first speaker, the one who disturbs
the eternal silence of the universe.

(Bakhtin, 1986)

When you start something, you better give it your best.

For my father

And besides, what is more enjoyable and instructive than a good conversation?

Socrates

Preface

This thesis was a refreshing dive into apprenticeship. After being a biology teacher and a teacher educator, I became a novice in research, knowing little of the art of social science, and completely unaware of the required intellectual sharpness in this branch. In my fifties I became the junior of my colleagues of 25 and 30 years old. Now I know that being a learner is not a phase, but a way of living.

As member of the Dutch Biology Curriculum Innovation Board (CVBO), I wanted to elaborate our concept-context approach in the exemplary context of genetic testing. Through dialogue with clients, genetic counsellors, ethicists, students and above all teachers, new perspectives became relevant and new questions arose. The goal became a means, the perspective changed from looking from the outside to trying to look from the inside, the focus shifted from what others had to learn to how a self-chosen personal development could change someone's identity. While working on this thesis, I was constantly faced with new choices and dilemmas. I had to make decisions about the theoretical framework, the concepts used and the methods applied. Through all sorts of dialogue I too became a learner, and not only as a researcher, which is normal for a PhD student, but also as a teacher educator, as a biology teacher, and as an ordinary citizen reflecting on all the possible ins and outs of ethically debated issues like genetic testing. At the end of my journey, comprehending that humans know who they are through narratives and stories, I found myself convinced of the inspiring effects of meaningful dialogue in education. I hope that through the story I present here I can convince you, the reader of this thesis, of the usefulness of dialogue in education.

I did not want to miss this and I thank all who made it possible.

Contents

Chapter 1

Introduction

In order to stimulate students to become autonomous individuals in our challenging world, we need teachers who are able, starting from the unique persons their students already are, to support and guide them on their road to become grown-ups well prepared to participate in our society. Teacher expertise development for this student support was one of the reasons behind this thesis. In the following, after briefly describing the research background of this thesis, I will introduce the theoretical framework and the focus of our research.

In this chapter and in the concluding chapter (chapter 6), "I" refers to the first author who, in these two chapters, introduces, summarises, and reflects on the studies. "We" refers to the team that executed the research and wrote the four articles this thesis comprises, included in chapters 2, 3, 4 and 5.

Research background

This research has been executed at the intersection of two different academic research programmes: the research programme of IVLOS-Institute of Education[1]: *Teacher learning and expertise throughout the professional career*, and the research programme of the Freudenthal Institute for Science and Mathematics Education (FIsme). The latter has four research themes of which two apply to this thesis.

The objective of the IVLOS research programme (IVLOS, 2008) is twofold: 1) to understand and explain the current and desired expertise and learning of teachers as well as 2) to know how expertise and learning of teachers can be optimised. These matters need to be investigated in the context of the educational field. This field is continuously being influenced by societal and political changes, leading to new perspectives on and expectations of the teaching profession and its practice. Given this dynamic field, there has been increasing attention on teacher learning and development throughout their professional career (Verloop & Lowyck, 2003; Vermunt & Endedijk, in press).

[1] Since 01-01-2011 at the Faculty of Social and Behavioural Science, Department of Education, Utrecht University.

In this thesis, we focus on the way in which one specific societal change, namely the increasing role of science and more specifically genetics in daily life, creates new challenges for biology teachers. Along with developments in genetics research and genetic testing practices in daily life, there is a call for new pedagogies and concepts in biology education. Consequently, the call for new pedagogies and new educational theory and politics requires new roles and expertise of teachers.

It is at this point where, specifically, two of the four themes within the FIsme research programme informed our study: 1) the learning of science and mathematics teachers in curriculum innovation and 2) context-based science and mathematics education. Regarding the first theme, the FIsme programme questions what professional development is needed in response to current innovations in science and mathematics education in the Netherlands. In considering the learning of biology teachers, we focused specifically on the second theme in the FIsme programme, the current innovation towards context-based science education. This research theme addresses how meaningful contexts contribute to students' learning of science and mathematics and how such contexts may lead to knowledge, abilities, insights and attitudes that are relevant for future activities of students in other contexts than they were acquired in. This plea is in line with increasing emphasis on situated learning approaches (Lave & Wenger, 1991) in the international literature on science education. Authentic practices are explored as contexts for gaining new knowledge about learning and teaching science and mathematics. We were interested in the way biology teachers could create a meaningful learning environment for students to learn about genetics. We focused on the clinical practice of genetic testing as an authentic context for teaching and learning genetics.

Theoretical framework

Following from the aforementioned background, this thesis focuses on teacher learning and the expertise of biology teachers in the context of genetic testing, and with that the thesis is an exemplary elaboration of the IVLOS and FIsme programmes. To further introduce our study, I will first describe how we took *situated learning* as a prescriptive theory for both biology teaching and teacher learning. Second, I will describe our focus on genetics in *the context of genetic testing*. Then, I explain how genetic testing is an example of a socio-scientific issue that enables students to learn science in relation to moral reasoning. Next, I describe how we broadly conceptualised what teachers need to learn in terms of four distinctive areas of *teacher expertise* and how this relates to *teacher identity*.

Finally, I will present our view on teacher learning and clarify the role of a teacher community in our study on teacher learning.

Situated learning

Since the beginning of the 21st century, there has been a growing emphasis in Dutch science education on teaching science in context. From 2004 onwards, the Dutch Biology Curriculum Innovation Board (CVBO) has been exploring what consequences the recent developments in biological science should have for secondary biology education. The board started from the premise that biology education should pay attention to contemporary life sciences and should be personally and socially relevant (Boersma et al., 2007; Boersma, Kamp, Oever, & Schalk, 2010). They formulated a so-called '*concept context approach*', which in this thesis is referred to as situated learning, as this aligns with how it is referred to in the international literature. One of the aims of an educational approach based on the situated learning theory (situated learning approach) is to show the students how science can and will play an important role in their (future) lives, and in doing so to make scientific concepts more relevant for students. This contemporary theory started from the social cultural premises that people learn through participation in real authentic practices (Lave & Wenger, 1991). These practices are formed by the learners and other participants along with available ideas, tools and physical resources (cf. Sadler, 2009; Van Oers, 1998). The relation between learning and practice is assumed to work in two ways: successful participation in practices requires knowledge and skills, and the applicability in practice of that knowledge and skills can make learning meaningful for the learners. Especially, the second way is of interest for teaching in secondary education. In this approach, the authentic practice becomes prescriptive and frames what is relevant to learn, thereby defining the concepts and knowledgeable skills in a meaningful way (Herrington & Herrington, 2006).

This thesis was aimed to contribute to an empirical basis for this approach in secondary biology education, by exploring what teacher expertise is needed when biology teachers want to apply a situated learning approach in their teaching. A logical consequence of an innovation is that teachers have to develop new expertise, hence the implementation of the CVBO concept context approach requires teacher learning. In line with our approach towards students' learning, teacher learning was also approached as a process of situated learning. In the case of teachers' learning, this meant that we assumed that biology teachers could best learn to teach by learning in close relation to their own biology classes.

To summarise, the situated learning approach was informative for our study in three different ways:

a) authentic practices can be used as contexts in lessons, giving relevance to the concepts taught;
b) authentic practices are the source of the relevant content to be taught,
c) teacher learning can be situated in their own practice, their classes.

The context of genetic testing

After adopting situated learning as the scope of the thesis, the authentic practice of genetic testing was selected as a context for teaching genetics in secondary biology education. Due to recent developments in genomics research, the content of teaching genetics has been changing (Waarlo, 2005). Classic genetics is concerned with the relation between different phenotypes in crossings and Mendelian patterns in heredity transmission. After the unravelling of the structure of DNA some 50 years ago, modern molecular genetics entered school curricula. Starting from a molecular basis, genomics researchers try to understand complex and dynamic living systems and their mutual connections.

Genomics research studies the structure and function of interrelated genes, the way genes and proteins interact in living cells, tissues and organs, and the way the environment influences those interactions (Netherlands Genomics Initiative, 2011; Zwart, 2005). Initially, most attention was paid to monogenetic traits with Mendelian hereditary transmission; nowadays, the focus is more on polygenetic and multifactorial disorders. This results in a rapidly increasing body of knowledge with important consequences for citizens. Scientists have sequenced the human genome and identified a number of genes associated with diseases. This knowledge has a huge impact on biological and biomedical science, for instance by tackling health problems such as cancer by developing new targeted therapies, personalised medicine (Strausberg, Gimpson, Old, & Riggins, 2004) and gene-based pre-symptomatic prediction of illness (Collins, Green, Guttmacher, & Guyer, 2003). One way or another, during the years yet to come, students are likely to be confronted with the applications and implications of these recent developments in genomics, if not as clients themselves, then perhaps as relatives of patients with genetic disorders.

During my previous work as a biology teacher, I experienced the high involvement of students in genetic education. Especially, the personal context of genetic testing is a suitable context for situated learning, as it illustrates to students how genetic concepts can have personal meaning to them in their (future) lives. The CVBO discerned three different types of authentic practices relevant for biology

education: the scientific context, the professional context and the life world context. We wanted our context to serve all educational levels, and because the CVBO reserved the first type for pre-university education only, and not all students see themselves as future science professionals, a life world context seemed most relevant for all students.

The new insights in genomics underline the possible benefits of teaching genetics in the context of genetic testing. In the past, there was a focus on monogenetic heredity in genetics education, and even in current education we sometimes encounter this focus. This focus, common in classical Mendelian genetics, is thought to hinder the necessary insight into the crucial role of variation and individuality in modern genetics (McInerney, 2002) and does not prepare our students for effective participation as medical consumers (Dougherty, 2009). Teaching students the notion that one gene results in a specific trait, for example, teaching with a focus on high-risk genes, can lead to a deterministic view on genetics (Jiménez-Aleixandre, 2010). Teaching students the new insights that originate from genomics research relativises this determinism (Waarlo, 2005). The conviction that one cannot influence one's fate, because it is all written in the DNA, often stems from this kind of education and hinders a possible change in behaviour, a change wished for in light of the multifactorial background of most genetic disorders. Enhancing individual agency through the realisation that a healthy lifestyle can reduce the chance of expression of multifactorial genetic disorders is one of the reasons for teaching genetic issues in the first place. Ten Have (1995) summarised the issue of genetic testing in a few words:

> The message of the gene appears to be equivocal. It promises both certainty, order, predictability, control and helplessness, limitation and acceptance of biological fate. It can stress both similarities and differences. It can discover human relations and at the same time break them off (Ibid, p. 29).

Along with choosing genetic testing practice as context for teaching genetics, we set the aim of exploring both authentic practices of genetic testing and the educational practice of expert teachers to find out what teacher expertise was needed for teaching in this context.

Socio-scientific issues and moral reasoning

Genetic testing is a socio-scientific issue. Controversial issues, such as genetic testing, that have conceptual as well as procedural connections to the sciences, and are viewed as socially significant, are labelled socio-scientific issues (Sadler, 2004).

Walker and Zeidler (2007) state that through teaching socio-scientific issues, students can be empowered to not only reflect on the physical and social world around them but also on the (moral) principles behind science-based issues, on the decisions made concerning them, and on what those decisions mean in their view of a virtuous life. Controversial socio-scientific issues confront students with dilemmatic situations in which they are invited to reflect on the moral decisions they would make. Discussing dilemmatic situations, and reflection on students' moral reasoning regarding dilemmas, is not a simple educational task. Research has indicated that scientific information is often either not understood or found to be irrelevant by people in dilemmatic situations (Dawson, 2003; Haidt, 2001; Layton, Jenkins, MacGill, & Davey, 1993). Recent psychological and neurobiological findings show that our moral decisions are based on intuition and emotion. We use our arguments only to justify our position, after this position is taken intuitively (Damasio, 1994; Dijksterhuis, 2007; Sunstein, 2005). These findings indicate that moral reasoning does not automatically involve connections to scientific reasoning. This was reason for us to question how we can empower teachers to trigger and guide students' moral reasoning on socio-scientific issues and reflection upon that reasoning. In this thesis, we build on the definition of moral reasoning proposed by Haidt (2001): "a conscious mental activity that consists of transforming given information about people or situations in order to reach a moral judgement", while moral judgements are "evaluations (good versus bad) of the actions or character of a person that are made with respect to a set of virtues held by a culture or subculture to be obligatory" (Ibid, p. 6).

Teacher expertise

Teacher expertise can be generally defined as the ability of teachers to teach successfully (cf., Cianciolo, Matthew, Sternberg, & Wagner, 2006; Sternberg & Horvath, 1995). If teachers have expertise, it means that they are able to adapt to task demands and to reorganise and refine their representations of knowledge and procedures for efficient application to everyday classroom practice (Ericsson, Chraness, Feltovisch, & Hoffman, 2006). Expertise is considered to be domain-specific, and this also applies in the profession of teaching (cf., Sternberg & Horvath, 1995; Tynjälä, 1999). An essential part of expertise is knowledge organisation, which improves with working experience (Dreyfus & Dreyfus, 2005). The expertise of expert teachers can be informative for the novice, and of help in teacher learning.

Teaching is a complex profession, in the sense that teachers often have to fulfil many functions at the same time, for example creating a safe and motivating learning environment, instructing students and organising learning activities (Doyle,

1986). According to Doyle, an important characteristic of daily classroom practice is its multifaceted nature. In this study, we aimed to study expertise in a descriptive way and we used a broad conceptualisation with four distinctive expertise areas in which teachers can develop themselves when they want to teach genetics in the context of genetic testing.

One central expertise area to consider when studying expertise is *subject matter expertise*. In biology education this category normally comprises only the biological content to be taught. When framing genetics in the context of genetic testing, not only knowledge of modern genetics and genetic disorders is needed, but also medical information on genetic tests and other relevant contextual information (e.g., ethical issues). A second important area of teacher expertise is *pedagogical content expertise*, which is about representing subject matter in such a way that it takes into account the learning difficulties and student conceptions concerning that specific subject matter (e.g., Shulman, 1986; Shulman, 1987). A third area of teacher expertise is *interpersonal expertise*, which is the ability to build good relationships with students (Wubbels, Brekelmans, Den Brok, & Van Tartwijk, 2006), and is of special interest when teachers want to discuss moral implications of genetic testing with their students. Finally, a fourth area, particularly relevant when it comes to teaching socio-scientific issues like genetic testing, is *moral expertise*, referring to the ability to clarify the normative component of socio-scientific issues and to discuss and reflect on norms and values at stake (Waarlo, 2005).

Following our situated learning approach to teaching controversial socio-scientific issues, we were interested in the required expertise as a whole. That is, what contemporary genetics should be taught, which teaching and learning activities might be appropriate in teaching this and how are the moral dilemmas in genetic testing, often matters of life and death, discussed in a safe atmosphere with students? These different areas of teacher expertise are often studied and discussed more or less separately.

The literature on science teaching is frequently either focused on subject matter concerning specific content topics or on general pedagogical content expertise (Bennett, Hogarth, Lubben, Campbell, & Robinson, 2010; Elliot, 2006). In the literature on biology education, topics such as genetics, evolution or osmosis and diffusion are often addressed (e.g., Ahern-Rindell & Cowles, 2010; Hott et al., 2002; Kiil, 2003). In most publications concerning biology education, we found reports on the relation between subject matter and pedagogical content expertise (e.g., Chinnici, Yue, & Torres, 2004; V. M. Dawson & Venville, 2010; Dittmer, 2006; Grace, 2009; Knippels, 2002; Odom, 1995; Shipley, 2010; Van Duin, 2003; Wong, Hodson, Kwan, & Yung, 2008). Sometimes, the focus is only on the area of moral

expertise in science education in general (Frazer & Kornhauser, 1986; Gearon, 2003; Jones, McKim, & Reiss, 2010), or on moral expertise related to a specific scientific topic (Asada & Tsuzuki, 1996), or combined with pedagogical content expertise (Brem, 2003).

In separate strains, we found literature on more general pedagogical issues such as interpersonal expertise or on moral education, the latter mostly discussed in broad perspectives such as education for citizenship or an intercultural perspective (Cherry & Cherry, 2003; e.g., Veugelers, 2007). Also the combination of pedagogical content expertise and moral expertise can be found (Levinson, 2006). Seldom have we found literature that touches on three of the four expertise areas. One example is the study of Lewis and Leach (2006) on the role of science content in the value-laden discussion of socio-scientific issues. For teaching English, the research of Den Brok (2001) is of interest. He combines the areas of subject matter, pedagogical content and interpersonal expertise. However, in science education, there is to the best of our knowledge hardly any literature on research that attends to all four expertise areas in an interrelated way. Due to our focus on teaching in the complex context of genetic testing, we felt such research could be of considerable value.

Teacher identity

It has been argued that different bodies of expertise relate to different parts of a teachers' identity (Beijaard, Verloop, & Vermunt, 2000). The question is whether learning specific additional expertise as a biology teacher influences how teachers understand who they are as a teacher. For three reasons, the way teachers would cope with their professional identity was of extra interest. First, the expected teacher dialogue on the controversial issue of genetic testing in the community, and second, the value-laden dialogue the teachers were supposed to have with their students might both challenge teacher beliefs and influence their professional identity. But also more generally, Akkerman and Meijer (2011) have described how 'teachers implicitly construct and negotiate their identity in relation to the various people they meet and the communities they are or become engaged in' (p. 7).

For describing a possible change in teacher identity, we adopted a recent classification by Kelchtermans (2009) who described five components of teachers' self-understanding as: a) *Self-image*; b) *Self-esteem*; c) *Job motivation*; d) *Task perception* and e) *Future perspective* (see p. 96 of this thesis).

Teacher learning and the teacher community

In this thesis, we understand teacher learning as: *an active process in which teachers engage in activities that lead to a change in knowledge and beliefs (cognition)*

and/or teaching practices (behaviour) (Bakkenes, Vermunt, & Wubbels, 2010). In the model for teacher learning our research group uses (Vermunt & Endedijk, in press), the learning activities that teachers employ play an essential role. On learning activities, Vermunt and Endedijk state the following:

> These learning activities are initiated by regulation processes, which are in turn influenced by teachers' beliefs about their own learning (metacognitive knowledge and beliefs, learning conceptions, etc.) and their motivations to learn about teaching. These four components, especially their inter-relationships, together constitute a learning pattern. The learning activities teachers employ influence the learning outcomes that they attain, and these learning outcomes form input for new learning processes. Learning patterns are influenced by personal and contextual factors.

With regards to how the teachers learn the new expertise for teaching genetics, we will give notice of their most reported learning activities, in order to find out which activities could be promoted in future interventions.

In contrast to findings in the field of teacher workplace learning (Eraut, 2002; 2004), research on teacher learning places a great deal of emphasis on collaborative learning, often referring to the term *teacher communities* (Grossman, Wineburg & Woolworth, 2001; Little, 2003; Hammerness et al., 2005). Teachers themselves experience collaboration as an important source of learning (Kwakman, 1999), and several authors have suggested that teacher communities can be fruitful settings for teacher learning in educational innovations (cf., Hammerness et al., 2005). Several studies have confirmed the benefits of collaboration between teachers for their professional development (e.g., Meirink, Meijer, Verloop, & Bergen, 2009; Shank, 2006). According to Wenger (2000), communities are considered to be valuable as 'they produce a shared repertoire of communal resources-languages, routines, sensibilities, artefacts, tools, stories, styles etc. (…) they offer an opportunity to negotiate competence through an experience of direct participation' (p. 229). In the scope of this thesis, we decided to explore how this applied to biology teachers who aimed to learn to teach genetics in the context of genetic testing.

As we explained above, genetic testing is a socio-scientific issue. Day and Bryce (2010) stated that science teachers are generally unfamiliar with teaching socio-scientific issues. We want to explore whether a teacher community can be an effective environment for learning to teach socio-scientific issues.

Aim and main research questions

Given the situated learning approach in Dutch biology education and the recent developments in genomics, our aim was to contribute to an empirical basis for this approach in secondary biology education and to determine how biology teachers could develop expertise in order to teach genetics in the personal health context of genetic testing.

We formulated two main research questions[2] (Van der Zande, Brekelmans, Vermunt, & Waarlo, 2006):

1. What is the teacher expertise needed for teachers who want to teach genetics in the personal health context of genetic testing?
2. How can teachers develop the expertise for teaching genetics in the personal health context of genetic testing?

Determining teacher expertise

The first step towards our aim was to find out what expertise teachers need. In line with the socio-cultural background of situated learning, we started with exploring relevant authentic practices for describing the sought-for expertise. In our first study, we focused specifically on the knowledge that teachers needed and formulated the following questions:

1.1. What content knowledge do biology teachers need to teach genetics in the personal health context of genetic testing?
1.1.1. What is the content knowledge experienced teachers use when they teach genetics in the personal health context of genetic testing?
1.1.2. What is the content knowledge that can be derived from participants in the authentic practice of genetic testing?

As we explained above, we wanted our findings to be relevant for all levels of secondary biology education. We deliberately chose a life world context, which is the personal health context of genetic testing. This way, the students placed themselves in the perspective of future clients. In order to inform teachers on how to prepare their students for learning in this context, we explored three contexts that relate to genetic testing: a) the life world context of the clients, b) the

[2] In this introducing chapter, the research questions are numbered under the related main research question. In the chapters on the four different studies, they are numbered separately.

professional context of the clinical geneticist and the genetic counsellor and c) (part of) the scientific practice of the medical ethicist.

For our first research question, nine experienced teachers were questioned about the content they taught in their genetic lessons and which concepts or knowledge became relevant in the classroom because of the context of genetic testing, and whether they discussed the ethical or other aspects of the test situation with their students in their lessons. For the second question, we explored genetic testing practices to find out what subject matter expertise, including contextual knowledge, is needed. We interviewed respondents representing clinical genetic practices (clients, medical professionals and medical ethicists) about the biological concepts and the ethical, legal and social aspects of genetic testing they considered relevant to empowering students as future health care clients. The details and outcomes of this study are presented in chapter 2.

Next, we wanted to find out what expertise is needed in the other three expertise areas, and again we explored the educational practices of biology teachers. Experienced teachers are supposed to provide us with suggestions for this needed expertise and they could probably indicate what expertise still needs to be developed. In the beginning of our research, we could not expect to find teachers who were already experts in situated learning as meant by the innovation of the CVBO. We use the term expert not only in the way Ropo (2004) suggested, i.e. expert teachers who have taught at least 10,000 contact hours. But, as we explain in chapter 2, we also asked the biology teacher educators of the four biggest teacher education institutes in The Netherlands to provide us with the names of teachers who were known for their expertise in teaching biology in relevant societal situations or for discussing socio-scientific issues with their students. Based on their suggestions, we selected our experienced teachers. To find out what these participants in educational practise could tell us about the necessary expertise, the following research question was formulated:

1.2. What expertise do experienced teachers show in the pedagogical content expertise area, the interpersonal and moral expertise areas concerning how to teach genetics in the personal health context of genetic testing?

For these more teacher-related expertise areas, we consulted experienced teachers. We interviewed nine experienced biology teachers and observed the lessons of five of them in order to learn from them how a situated learning approach can be put into the practice of biology teaching. This second study is presented in chapter 3.

Insight in moral reasoning required for developing teaching and learning activities for reflection on moral reasoning is part of the sought-for teacher expertise. We not only explored theoretical notions of moral reasoning for teachers who wanted to teach socio-scientific issues, but also specified the following research questions:

1.3.1. What kind of reasoning do students use in discussing controversial genetic issues prior to any education on this subject?
1.3.2. What is the knowledge of experienced teachers about student moral reasoning?

Because we consider the answer to the first question prior knowledge of teachers who want to teach genetics in the context of a socio-scientific issue, we also wanted to know to what extent teachers already knew about student's moral reasoning, and whether or not they applied that knowledge in their lessons (question 2). To investigate students' reasoning, 15 high school students, 14-15 years of age, were interviewed individually, and for the exploration of teacher expertise, we interviewed nine experienced biology teachers. The findings of this study are described in chapter 4.

Exploring a teacher community for teacher learning

A second step towards our aim was to search for a way in which teachers can develop the required expertise. In line with our theoretical framework, we searched for an intervention that enabled the participating teachers to learn in close connection to their own educational practice. Besides studying biology teachers' learning in terms of the four expertise areas and required expertise derived from the authentic practices, we looked at possible changes in teachers' self-understanding. In order to study these developments, we initiated a teacher community, and the following research question was formulated:

2.1. In what way can a teacher community contribute to biology teachers' learning to teach a socio-scientific issue, such as genetic testing?

We initiated a teacher community consisting of eight biology teachers who gathered outside their schools to discuss, practice and evaluate the different elements of expertise, and who experimented in their classes with what they developed.

Chapter 5 reports on the learning processes and outcomes of the teachers in this teacher community. For describing the learning processes of teachers, a narrative approach was taken. Through constructing narratives, we were able to take into account the temporal, personal, social and contextual aspects of teacher learning (Craig, 2007).

The remainder of this thesis consists of four chapters reporting on the studies introduced above. Following this, chapter 6 presents the general conclusions and a discussion of the research.

Chapter 2

A Knowledge Base for Teaching Biology Situated in the Context of Genetic Testing*

Abstract

Recent developments in the field of genomics will impact the daily practice of biology teachers who teach genetics in secondary education. This article reports on the first results of a research project aimed at enhancing biology teacher knowledge for teaching genetics in the context of genetic testing. The increasing body of scientific knowledge concerning genetic testing and the related consequences for decision-making indicate the societal relevance of such a situated learning approach. What content knowledge do biology teachers need for teaching genetics in the personal health context of genetic testing? This article describes the required content knowledge by exploring the educational practice and clinical genetic practices. Nine experienced teachers and 12 respondents representing the clinical genetic practices (clients, medical professionals, and medical ethicists) were interviewed about the biological concepts and ethical, legal, and social aspects (ELSA) of testing they considered relevant to empowering students as future health care clients. The ELSA suggested by the respondents were complemented by suggestions found in the literature on genetic counselling. The findings revealed that the required teacher knowledge consists of multiple layers that are embedded in specific genetic test situations: on the one hand, the knowledge of concepts represented by the curricular framework and some additional concepts (e.g. multifactorial and polygenic disorder) and, on the other hand, more knowledge of ELSA and generic characteristics of genetic test practice (uncertainty, complexity, probability, and morality). Suggestions regarding how to translate these characteristics, concepts, and ELSA into context-based genetics education are discussed.

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Introduction

In the last decennia, science teachers witnessed a shift of focus in science education. Dominant was a disciplinary approach where teaching the structure of science and disciplinary content were the main goals (Aikenhead, 2006; Roberts, 1988). However, not all students show affinity to academic science (Sadler, 2009), and the focus shifted to education relevant for the student's personal life and their preparation for future citizenship, i.e. science lessons that will help them to function in the complex 21st century (Aikenhead, 2006; Kolstø, 2001; Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003; Ryder, 2002). Roberts (1988) discerns a number of meta-perspectives on science teaching. Three of them are perspectives suitable within this focus on relevance for students: a) everyday coping, b) science, technology, and decisions emphasis, and c) self as explainer.

Situated learning, or teaching science in context, provides a theoretical framework for supporting student preparation for their future role as citizens (Boersma et al., 2007; Gilbert, 2006; Ratcliffe & Grace, 2003; Sadler, 2009). However, if science teachers adopt a situated learning approach, they need to be aware of the current state of the art in the authentic practice. This article aims to determine what secondary teachers need to know about the field of genetic testing to teach genetics and prepare students for situations in which they may become clients in genetic testing practice.

Shulman (1986; 1987) distinguished seven categories of teacher knowledge. One of these categories is pedagogical content knowledge (PCK), which should enable experienced teachers to represent content in such a way that it takes into account the learning difficulties and student conceptions concerning that specific content knowledge. Another category is content knowledge, referring to knowledge about the content to be taught. From a situated learning perspective, it is important to determine the content knowledge of teachers not only by looking at current school subjects, but also by including recent insights from the authentic field, in this case the field of genetic testing. This study explores both the educational practice for the currently used content knowledge on genetic testing, as well as the authentic practice for the needed content knowledge.

Before introducing our study, we elaborate in the following sections on situated learning, describe how genetics is currently addressed in secondary education, and briefly review some important developments in authentic genetic test practice.

Situated Learning

In his recent review, Sadler (2009) described how the idea that knowing and learning are situated in social practice gained renewed attention at the end of the last century. The situated learning approach connects to social–cultural theory by assuming that humans develop through participation in social cultural practices. Successful participation in practices requires local knowledge and the appropriate use of artefacts that can make learning meaningful for students. In such a social practice, people interact with each other and with materials and concepts (Greeno, 1998).

Situated learning affects educational practice in at least two ways. First, in this approach the authentic practice becomes prescriptive and frames what is relevant to learn, thereby defining the concepts and knowledgeable skills in a meaningful way (Herrington & Herrington, 2006; Lave & Wenger, 1991). Second, in the situated learning approach students' learning takes place in relation to a situation that is deduced from the authentic practice. The fact that the authentic practice informs both the content to be taught and the situational framing of this content is based on the idea that the authentic context supports the specification of the concept's meaning and brings about the coherence of concepts within a larger whole (Herrington & Herrington, 2006; Van Aalsvoort, 2004; Van Oers, 1998). Moreover, because students experience how the concepts can be applied in a recognisable situation, a situated learning approach aims to provide relevance to the learned content and promote student motivation (Boersma et al., 2007; Sadler, 2009).

Given our interest in content knowledge, the question arises what knowledge can be derived from authentic practices as the basis for the required knowledge base of teachers concerned with situated learning. The required knowledge base needs to include concepts that are relevant to genetic testing practice as well as knowledge of the situational framing of these concepts. The latter means that teachers should be able to select and discuss genetic test situations in terms of how they represent the nature of decision-making processes in genetic testing practice. This is needed to guide students when they imagine themselves being clients[1] in a prenatal or pre-symptomatic test situation as the basis for learning about genetics.

To determine the required knowledge base of teachers, it is necessary to acknowledge that 'the authentic practice' actually includes multiple social practices. The recent Dutch Biology Curriculum Innovation Programme distinguished three categories of authentic practice for secondary education: scientific practices,

[1] Most citizens involved with genetic testing are not ill (yet) and are not referred to as patients but as clients. In this article, the word client will be used.

professional practices, and life-world practices (Boersma et al., 2007). This study aims to derive the required content knowledge of teachers by approaching people from each of these three practices about relevant concepts and decision-making in genetic test situations.

Situated Learning, Education for Citizenship, Socio-Scientific Issues, and Nature of Science

The situated learning approach indicates *how* learning takes place, assuming that learning is an integral and inseparable aspect of social practice (Lave & Wenger, 1991). The situated learning approach converges with teaching socio-scientific issues and nature of science (NOS), two approaches that focus more on the *why* and *what* of teaching, stressing that education is meant to prepare for citizenship (Aikenhead, 2006; Osborne et al., 2003; Ryder, 2001; Ryder, 2002) Education for citizenship should lay the foundations for decisions and actions in adulthood in relation to society's controversial science-based problems (Ratcliffe & Grace, 2003).

In a school version of the authentic practice as suggested by Van Aalsvoort (2004), biology lessons can confront students with controversial issues where they have to learn to clarify their own position (Aikenhead, 2006; Levinson, 2006; Waarlo, 2003). Controversial issues that have conceptual as well as procedural connections to sciences, and are viewed as socially significant by the students, are labelled socio-scientific issues (Sadler, 2004). Walker and Zeidler (2007) state that through teaching socio-scientific issues, students can be empowered to not only reflect on the physical and social world around them but also on the (moral) principles behind science-based issues, the decisions made concerning them, and what those decisions mean in their view of a virtuous life. Authentic situations do not necessarily reflect socio-scientific issues. For example, if we discuss animal nutrition in the context of keeping pets at home, this does not reflect a controversial issue or 'ill structured problem that are the hallmark of most socio-scientific issues approaches' (Sadler, 2009, p. 19).

In a broader sense, when learning is situated in contexts such as the personal health context of genetic testing, it also relates to NOS. Although the latter is a complex and contested field (Alters, 1997; Helms & Carlone, 1999; Lemke, 2001), Osborne et al. (2003) discern nine themes within the field of NOS. Some of these themes fit well in a situated learning approach to genetic testing. For example, the theme of *science and certainty* is concerned with the notion that much scientific knowledge is well established and beyond reasonable doubt, but that other scientific knowledge is not. Knowledge is the current 'state of the art' and is still in progress. For instance, the medical knowledge used in genetic testing is still

developing and will change in the near future because of new evidence or new interpretations of old evidence.

Another aspect of NOS mentioned by Osborne et al. (2003) that is even more appropriate in the health context of genetic testing does not belong to the abovementioned nine themes, namely *moral and ethical dimensions in the development of scientific knowledge*. Students who discuss possibilities within the genetic test practice should realise that some of those choices, although explained in scientific medical terms, are not value free and can conflict with their moral and ethical values. Although some authors suggest to include more aspects of NOS in teaching genetics in context, as will be discussed later, NOS defined in the way of Osborne et al. (2003) is focused on 'science in the making'.

Within the life-world practice of genetic testing, the focus of the educational study reported here, i.e. the moral and uncertain implications of scientific knowledge for the personal lives of students, is of particular interest. Then, the focus is more on personal meaning in the student learning process, which is more in line with a socio-cultural perspective on teaching NOS (Helms & Carlone, 1999; Lemke, 2001), that is students who give meaning to knowledge through internal and external dialogue about their own beliefs, values, and socio-cultural position towards genetic testing issues. In terms of NOS this can be seen as a mixture between distal and proximal knowledge of NOS. Distal knowledge of NOS can be operationalized as the understanding of NOS 'as students' explicit knowledge about the standards, practices, and products of the professional scientific community' (Hogan, 2000p. 53), and proximal knowledge is concerned with 'understanding students' notions about their own process of learning science' (op. cit., p. 54). This idea of personal meaning and decision-making relates again to the domain of socio-scientific issues (Kolstø, 2006).

Needs for Expanding the Curriculum on Genetic Testing

Genetics in secondary education includes the knowledge of relevant curricular genetic concepts and heuristics such as Punnett squares and genealogical family trees. Recently, it has been argued that the biology curriculum should shift from focussing on single gene disorders to polygenetic disorders (Dougherty, 2009), and there is a growing awareness of the need to align the content of genetic teaching practice with the developments in the authentic practice (Boerwinkel, Verhoeff, & Waarlo, 2008).

The current focus on monogenetic heredity, common in classical Mendelian genetics, is thought to hinder the necessary insight into the crucial role of variation and individuality in modern genetics (McInerney, 2002), and does not prepare our

students for effective participation as medical consumers (Dougherty, 2009). Other authors suggest the introduction of NOS aspects such as collecting and interpreting data or the uncertainty of scientific information (Ryder, 2001). Although the number of publications on teaching genetics in this controversial genetic test practice is substantial, the majority of the work focuses on higher education (Challen, Harris, Benjamin, & Harris, 2006; Guttmacher, Porteous, & McInerney, 2007; Hott et al., 2002; McInerney & Collins, 2007; Plass, Baars, Beemer, & Ten Kate, 2006). Moreover, most of these studies concentrated on the context of one or two diseases only, e.g. breast cancer, and most used Mendelian concepts such as gene, mutation, and family-related heredity chances(Richards, Hallowel, Green, Murton, & Statham, 1995). For high school teachers, the relevant knowledge for teaching genetics in context is still to be explored. In doing so, we should keep in mind the advice of McInerney (1995):

> In genetics especially, the rate at which new knowledge is generated is so staggering that the pre-college curriculum often is overwhelmed by the accretion of isolated details and extensive vocabulary that do little to help students form a conceptual picture of genetics or of biology (p. 786).

Curriculum documents can help determine the content that is addressed by teachers. We will focus on the formal and the operational curriculum according to Goodlad (1979). The former can be found in official national or institutional documents, whereas the latter deals with the way teachers implement the curriculum into their classrooms. For a description of the currently used content knowledge on genetic testing these two levels will be our reference points during the exploration of educational practice.

The Authentic Practice of Genetic Testing

Assuming that authentic practices can inform teaching practice and that not only the described educational shift in focus challenges science teachers, scientific developments also concerning the authentic practice itself are a major challenge for science teachers since they have to keep their disciplinary content knowledge up to date and position themselves towards new technological applications.

This study elaborates on teaching biology in the personal health context of genetic testing. Recently, there has been a rapidly increasing body of knowledge in the field of genomics with important consequences for citizens. Scientists have sequenced the human genome and identified a number of genes relevant for identifying heritable diseases. This knowledge has a huge impact on biological and

biomedical science, for instance by tackling health problems such as cancer by developing new targeted therapies, personalised medicine (Strausberg et al., 2004), and gene-based pre-symptomatic prediction of illness (Collins et al., 2003).

The practice of genetic testing also makes things complex because genetic testing is a complex process itself. Mostly, genetic testing is a so-called 'fact-and-value' issue, and these issues require an analysis that reflects different disciplines and perspectives (Yesley, 2008). Test situations differ from other medical situations because of the independency of the actual medical status, for instance one does not have to be ill at the time for a test to be useful. Moreover, the permanency of the genetic traits, implications for relatives, and problems clients possibly face with identity adds to the complexity (Nyrhinen, Leino-Kilpi, & Hietala, 2004). Consequently, clients are faced with an increasing number of decisions, each with its own ethical, legal, and social implications. More and more, society expects its citizens to be capable of making reasonable decisions on these kinds of controversial issues. Therefore, one must be able to weigh scientific and biotechnological information together with ethical or legal considerations (Gearon, 2003) in a complex social setting (Veugelers & Vedder, 2003). Thus, if teachers want to prepare their students for future decision-making, they do not only need an accurate knowledge of concepts but also knowledge of the situational framing of these concepts, e.g. the ethical, legal and social aspects (ELSA) of genetic testing.

In the literature, several systematic process descriptions of handling controversial issues, medical consultations in general, and the genetic testing process in particular can be found (Decruyenaere, 2003; Nyrhinen et al., 2004; Pin & Gutteling, 2005; Resnik, 2003; Rowley, 2007; Van Neste, 1993; Wilfond, 1995). For instance, some research has been undertaken on public awareness and opinion about genomics (Pin & Gutteling, 2005), on the ethical aspects (Nyrhinen et al, 2004), or the decision-making (Rowley, 2007). However, none of these descriptions are all inclusive or aimed at secondary education. Such a description is one of the sought-after outcomes of the study reported here. What can be derived from the literature is that the decision-making process within genetic testing, the authentic practice we were looking for, can be divided into the following four stages (Bolt, Verweij, & Van Delden, 2005; Decruyenaere, 2003; Grient Dreux, Kooijman, & Korenromp, 2008; Nyrhinen et al., 2004).

Stage 1: Preparation phase, gathering information;

Stage 2: Weighing information and decision-making 1;

Stage 3: The laboratory, analytical phase; and

Stage 4: The post-analytical phase – weighing information and decision-

making 2, interpretation and processing the results (consequences), and support.

In this article, we will concentrate on knowledge concerning stages 1 and 2 because most problems emerge in these pre-analytical phases (Nyrhinen et al., 2004). As the results of the study will show, the first two stages are more relevant for education in this context. Furthermore, these problems are most informative to students not only because they are well aware they might think differently when they are adults and real clients, especially in stage 4 (Van der Zande, Brekelmans, Vermunt, & Waarlo, 2009b), but also because in stage 4 clients go through the same kinds of processes as in phase 1 and 2, only now they are focused on accepting test outcomes.

Analytic Framework for Determining Required Content Knowledge

This article aims to determine the required teacher content knowledge for teaching biology in the genetic testing context. What specific content knowledge is required on relevant concepts and the situational framing of these concepts in the processes of decision-making? The relevance of specific content knowledge for context-based education or teaching controversial socio-scientific issues has been stressed by several authors (Klop & Severiens, 2007; Levinson & Turner, 2001; Levinson, 2006; Sadler, 2009; Zeidler, Sadler, Simmons, & Howes, 2005). However, a tailored description of the content knowledge used in authentic practices, e.g. in the health context of genetic testing, is to the best of our knowledge not available. If we accept the assumption stated above that in a social practice relevant knowledge is helpful or necessary for the successful participation in that practice, we have to explore this authentic practice to find out what this knowledge is. Consequently, if we want to find out what is new in this content knowledge compared with current content knowledge in secondary education, we have to compare this authentic practice-based knowledge claim with the current content knowledge already being taught by experienced biology teachers. Our research question can be formulated as follows:

What content knowledge do biology teachers need to teach genetics in the personal health context of genetic testing?

1. What is the content knowledge experienced teachers use when they teach genetics in the personal health context of genetic testing?
2. What is the content knowledge that can be derived from participants in the authentic practice of genetic testing?

Based on the earlier accounts of situated learning and the current developments in the field of genetic testing, required knowledge can be seen as related to different layers of the authentic practice as pictured in Figure 2.1. As stated above, within the situated learning approach learning takes place in relation to a situation; a specific client considering a specific test (grey-dotted box in Figure 2.1). This specific situation must be selected so that it represents the nature of the overarching medical practice of genetic testing (outer box in Figure 2.1). In the test situation, the concepts relevant for a proper understanding of genetic testing are under discussion (inner box Figure 2.1).

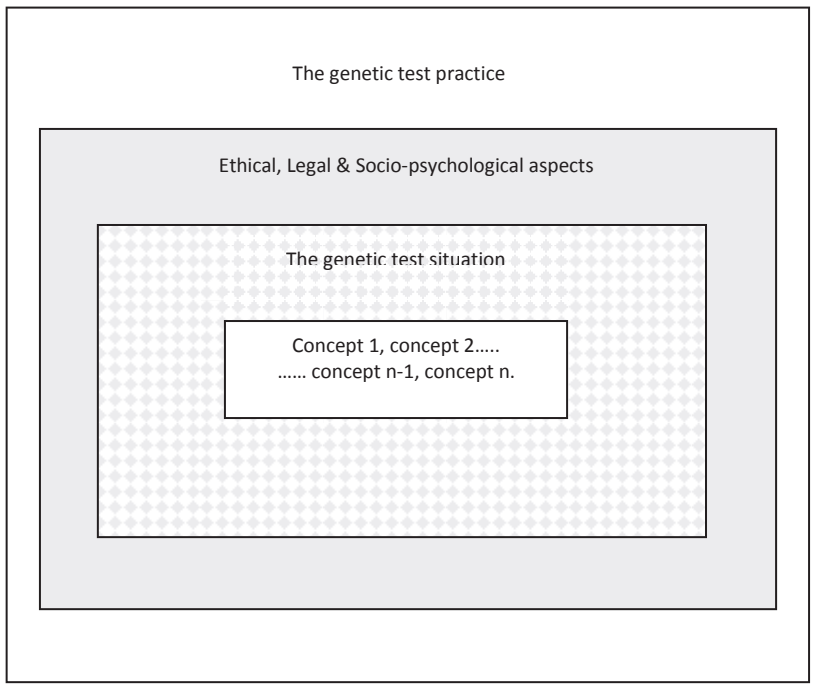

Figure 2.1. Different layers involved in the genetic test practice.

Since the Human Genome Project, several researchers have suggested rethinking the biology curriculum, stating that it needs to also address the ELSA that are inherent to the decision-making processes in genetic testing practice (Baars et al., 2005; Boerwinkel et al., 2008; Harvey et al., 2007; McInerney, 1995; 2002) (grey box in Figure 2.1). If teachers aim to empower students for their future role as health-care clients in genetic test situations, their required content knowledge must take account of these four layers of knowledge of the authentic practice.

For the current biological content knowledge, used in today's biology classes, we explored educational practice by eliciting and describing the content knowledge of experienced teachers. Expertise is supposed to emerge only after long experience. Expert teachers have taught at least 10,000 contact hours (Ropo, 2004). In The Netherlands, that equals at least nine or 10 years of professional practice.

In this study the knowledge and experiences of medical professionals and clients involved in genetic counselling were sought to inform us about the knowledge used in authentic clinical genetic practice. They could suggest what might be worthwhile for students to become prepared citizens, and this content knowledge can be compared with what is already taught in classrooms.

Method

Participants

For the exploration of the current state of domain knowledge in teaching expertise, nine experienced biology teachers were interviewed (Bt1–Bt9). This non-random typical case sample (Onwuegbuzie & Leech, 2007) was selected from a list provided by biology teacher educators of the four biggest teacher education institutes in The Netherlands. These teacher educators were asked to provide us with names of teachers who were known for their expertise in teaching biology in context or were known for discussing socio-scientific issues with their students. The actual selection was based on convenience (Ibid, 2007, p. 114); we received 15 names from the teacher educators and nine were available. The teachers were from eight different schools, with an average teaching experience of 20.7 years. Three out of the nine were female. Two worked at vocational schools, two in pre-university classes, and five at schools with vocational and pre-university education. Five worked at schools with a religious denomination (three catholic, two protestant) and four worked at public schools.

To investigate the expertise that can be elicited from the clinical genetic practice, a stratified sample was used; 12 stakeholders were interviewed individually: four clients (C1–C4), four medical professionals (P1–P4: two physicians; one clinical geneticist, and one genetic counsellor), and four medical ethicists (Me1–Me4). The names of the medical ethicists and professionals were provided to us by the head of a science communication institute in the field of genomics. The ethicists represented four different academic medical centres. The medical professionals came from different cities and provided us with the names of their clients. Each of the three groups consisted of two females and two males. These

three groups were not intended for comparative analysis, but to ensure data from different perspectives on genetic testing.

Instrumentation

Three instruments for data gathering were used. First, the teachers were interviewed in their own school buildings using a semi-structured face-to-face interview of 60 to 75 minutes. In the interviews, they were questioned about the content they taught in their genetic lessons. They were asked to compare the taught concepts with the formal Dutch curriculum.

Concerning context-based knowledge of prenatal and pre-symptomatic genetic testing they were asked whether they had actually taught genetics in the context of genetic testing, what other concepts or knowledge became relevant in the classroom because of this context, and whether they discussed the ethical or other aspects of the test situation with their students in their lessons.

Second, the referents from the authentic genetic testing practice were interviewed using a semi-structured face-to-face interview. The referents were interviewed for 60 minutes in their offices or homes (the clients). They were questioned about what clients must know or be able to do when they were supposed to participate successfully in a genetic testing situation, i.e. what biomedical concepts they considered relevant and what kind of knowledge they considered important within the process of genetic testing. The interviews were recorded and imported as audio files into the software Atlas-ti (Murh, 2006).

Third, because the ELSA mentioned in the interviews with the referents turned out to be exemplary rather than all inclusive, the ELSA suggested by the referents were complemented and ordered by suggestions found in the literature on the ELSA of genetic testing using the search engines Google Scholar and Omega with search criteria such as (prenatal) genetic testing, diagnostic genetic testing, moral aspects, ELSA, health-care, and care ethics in different combinations.

Data Analyses

To answer the main research question, three analytic steps were undertaken. A first step entailed determining the current content knowledge of the experienced biology teachers. This was done by (a) looking at the extent to which the teachers taught biology concepts according to the formal Dutch curriculum, (b) listing possible additional concepts relevant to genetic testing, and (c) determining their familiarity with ELSA.

Second, the required content knowledge of teachers was determined by analysing the interviews of the 12 referents from the authentic practice on genetic

testing. Finally, the ELSA suggested by the respondents were complemented by suggestions found in the literature on genetic counselling.

To show how those concepts mentioned by the referents fitted into a formal curriculum, the latest curriculum from the Dutch Biology Curriculum Innovation Board (CVBO) was considered the formal curriculum in this study (Boersma et al., 2007). The mentioned concepts were arranged into the concept matrix used by the CVBO to illustrate the coherence among biological concepts (Table 2.2). In this matrix, each concept was functionally placed within the organising framework of systems biology. Some concepts mentioned by the referents were related to human activities in the context of genetic testing, and were not yet part of the official CVBO concept matrix. These are presented separately as an added row to the matrix. The placing of new concepts into this matrix was discussed with two other researchers in biology education, one of them the chair of the CVBO, until consensus was reached.

During the coding of the interviews we worked iteratively between the interview data and ELSA found in the literature. In the additional literature search, a saturation strategy was used. Reading stopped, after reading 35 books and articles, when the last two articles provided no single new moral consideration or dilemma and informational redundancy was reached (Onwuegbuzie & Leech, 2007). These articles and books are listed separately in the references. For coding we used a grounded theory approach (Glaser & Strauss, 1999).

The suggestions from the referents and the literature were coded in an open way (Boeije, 2010), the interviews were fragmented, and the fragments were then compared among one other before being categorised and recategorised iteratively by the researcher with the findings from the literature and labelled with a code. This resulted, for instance, in the extensions of 'social' into 'psychosocial' in the ELSA codes.

The inter-rater reliability of the three main codes (concepts, ELSA, and characteristics) were checked by another genomics researcher by comparison with the scoring of 18 interview fragments within these three categories: n = number of categories (Cicchetti, 1976) and $2n^2 = 18$ (Cohen's kappa = 0.87). Some of these fragments were rather lengthy, when the referents started e.g. with discussing a characteristic of the genetic test practice, then illustrated it with an ELSA, and using different biomedical concepts in both parts of the fragment. More than one code could be linked to these fragments.

Within the main code 'characteristics', the four codes (uncertainty, probability, complexity, and morality) were checked for inter-rater reliability by comparing the scoring of $2n^2 = 32$ interview fragments within these four subcategories (Cohen's

kappa = 0.74). Finally, the Cohen's kappa of the three ELSA codes was determined (0.71).

To illustrate the coding categories used in the analyses some examples are listed in Table 2.1 with the corresponding utterances from the referents. In the end, the findings were summarised in two of the four stages of the decision-making process mentioned above:

Stage 1: Preparation phase, gathering information; and

Stage 2: Weighing information and decision-making.

Table 2.1. Coding: Exemplary codes with the corresponding utterances from the referents.

Examples of codes	Exemplary utterances using 23 of the original 267 quotations.	**Referent**
• **Main Codes** Sub Codes level 1 ○ Sub codes, level 2 Sub codes, level 3	**Concepts** CC: Q1 & Q2 *'I use a standard method … where the Mendelian genetics is completely covered, with Punnett squares and family trees and all that … and we link it to the molecular genetics in the higher classes … they construct the double helix of DNA with paper symbols of the different bases and via all the different steps such as messenger RNA they build proteins '*	T1
• **C = Concepts** CC = Concepts Curricular CNC =Concepts None Curricular	*'Some clients lack knowledge or understanding. They ask, for example, "what are those chromosomes?" or "DNA what is that, you can't even see it?" Often they can't believe that this "invisible" DNA determines so much'*	P1
• **ELSA** E = Ethical ○ E-V = Values & moral principles E-V-A = Autonomy E-V-B = Beneficence E-V-I = Informed consent E-V-J = Justice E-V-NM = Non maleficence E-V-P = Privacy E-V-Pr = Protectability E-V-PV = Prima facie values ○ PW = Protecting the weak E-V-S = Solidarity ○ E-D = Dilemma E-D-A/Q = Autonomy - Guilt E-D-T/NT Treatment or not E-D-B/NM care – avoid harm E-D-T: Time dilemma L = Legal ○ L-La = Law L-LA-NK = Right not to know ○ L-Lo = Loans ○ L-I = Insurances	CNC: Q3 & Q4 *'.. I also discus cytoplasmatic factors, I start with epigenetic factors, it is fascinating to tell about ….'*	T2
	'…I think students have to understand the usual concepts such as dominant - recessive, but also the polygenetic setting …. and the whole genome screening, I think they will be confronted with it within 10 years and then they must understand high and low risk genes … if they only understand the black or white Mendelian genetics, they cannot understand the complexity of most genetic diseases'	P2
	ELSA E-V-Pr: Q5 *'Concerning technical possibilities like genetic testing, you have to think about the criterion of desirability and the criterion of carefulness. We must reflect on the question whether it is desirable or not to have genetic testing at all. What does it tell us about illness and pregnancy? Are these still natural processes? But you must not think that you can stop these developments. So, it is important to discuss the circumstances under which these tests may be done'*	Me1
	E-D-T/NT: Q6 *'Imagine you find out that you have a genetic disorder, what can you do? If you cannot prevent or cure it at all, a very important consideration for a doctor is: "do I want to expose my patient to a medical examination when it will bring nothing, just the information that something terrible is bound to happen and you cannot do anything to prevent it?" For the patient the question is whether he or she wants to participate in a process when nothing can be done about it?'*	Me2
	E-D-B/NM: Q7 *'For most expectant mothers it's a big problem, dilemma, if she knows her baby has a genetic disorder. "May I bring this upon my child, what is my responsibility as future parent? Don't we have the responsibility to save them from this misery?" They have to balance this with the felt responsibility of care for their future child.*	Me3

S = Socio-psychological ○ S-F = consequences for family ○ S-ADR = Anticipating Decision Regret • **Ch = Characteristics** Ch-U = Uncertainty Ch-C = Complexity CH-P = Probability Ch-M = Morality • **= Other (Remaining codes)** O-D = Disability rights O-EA = Expressive aspect	*The idea that many women end their pregnancy for trivial reasons is a fable; the vast majority of them experience this as an emotionally difficult dilemma'* E-D-T: Q8 *'Suppose you decide to abort your child, you can never undo that. You will live the rest of your life with the knowledge that you have aborted a child on genetic grounds. Suppose you do not abort it. Then you have a comparable situation; you have to live with the fact that a child is born that will probably require help and care the rest of its life. After a test, in a timeframe of two weeks you'll have to decide something that impacts the rest of your life. I think that is far too radical. I think that in your adolescence, you have to be trained to deal with this kind of dilemmas. These vital questions cannot be postponed to the moment you are confronted with them'* E-D-A/Q: Q9 *'With the introduction of patient autonomy they also became responsible for their decisions, although they cannot know all the consequences… imagine they choose a certain treatment and they become even more sick, than it they are also guilty themselves, so autonomy, becomes responsibility and can become guilt'* S-F: Q10 & Q11 *'When I finally realised that before they could allow me to do a test, they wanted to involve my brother in the process, I didn't persist, I could not bother him with my problems'* *'Sometimes, when a client realises that involvement of family members is necessary, they shy away, e.g. because they don't know these distant relatives or think that they can't burden them with these problems'* S-ADR: Q12 & Q13 *'… it is the phenomenon that people probably accept e.g. a prenatal test more easy to avoid that they have to say in the future… if we only …'* *'Research indicates that people accept prenatal diagnosis because of what we call anticipating decision regret. They don't want to run the risk of blaming themselves afterwards for not having done everything that's possible to avoid the future misery of their children'* **Characteristics** CH – C/U: Q14 *'I think that everybody has to understand that, when one nucleotide in your DNA changes, that does not always indicate that you will become ill, but that it adds a little to the risk you are running. And that such a change only leads to trouble when for instance you also get a virus infection. Students have to understand the genome variation and must be able to accept the complexity, the uncertainty and the relative certainty'* CH-U: Q15 *'Students should be confronted with the limitations. They must be aware that you cannot explain everything with genetics. Biology lessons in a societal context should make them think about what you can do with knowledge, and what you want to do with knowledge. Personally, as well as socially. You can't always get*	Me4 Me4 C1 P1 Me4 Me1 P2 P1

	what you want. What are the possibilities? We are bound to laws. We are bound to the possibility to trace a genetic predisposition. If it is a low risk gene and the medical test is expensive, then such a test will not be offered to the client. Some clients find this difficult to accept, they want everything written on paper. They end up by visiting websites where all kinds of tests are being offered. I think education can help people to become informed about what you can learn from these tests. What is certain, what can be proved for sure, and what is information that won't help you at all?'	
	CH-P: Q16	
	'It is a chance, but for each human being it is 'yes' or 'no', and that's what they want to know'	P3
	CH-M: Q17 & Q18	
	'Although we have these four principles, e.g. autonomy and justice, I think it is very important to relativise that. It is also very important that we learn how to reflect on a situation in a personal way, that you realise that a situation is always much more complex than it seems at first glance, that you realise how you intuitively would like to act in a situation and that you are willing to reflect on this intuition, this preconceived opinion … it is important to teach our students that uncertainty is a great value, because this 'not knowing' gives you the opportunity and the time to grasp the complexity of these dilemma's'	Me4
	'How to deal with all this information, how to deal with all the advice you get from the people around you, how to reflect on your first intuitive reactions, I think that is the most important goal of education'	P3
	CH-C: Q19, Q20 & Q21	
	'Although my wife is working in the healthcare and I am a biologist, at the moment we were confronted with the fact that our child had Down syndrome, this knowledge had no use. At that moment we were confronted by different emotions and moral questions. Biomedical knowledge didn't help us at all'	C2
	'I felt all kinds of emotions, I was frightened. There was chaos in my head: what do I have to do now? I thought: "help, I know nothing about this". And all the people I esteem highly, gave me different advice, it was very confusing'	C4
	'They must understand the difference between disposition for a disease and getting a disease. Or the difference between having the disposition and being a carrier'	P3
	O-D/EA: Q22 & Q23	
	'Are we going to protect the weak and the vulnerable? Whose responsibility is that, the client's, the doctor's or of society as a whole? And how is this responsibility related to the principle of the autonomous patient?'	Me2
	'When you think about the status or respectability of a foetus, you have to deal with the disability rights criticism. Disabled people, or those closely related, find themselves discriminated by these kinds of questions'	Me3

Results

Educational Practice

Answering our research question about the content knowledge they used when teaching genetics in the personal health context, all experienced biology teachers reported that they taught the concepts mentioned in the Dutch examination syllabus (Table 2.2).

> I used to concentrate on the classical heredity questions with **Punnett squares** etc. (Bold added by authors). And of course they had to understand everything about **DNA replication**, and I used a strategy of travelling through the different **organisation levels**, extended with a practical, a cut, paste and paint assignment where they really had to make a model of **DNA transcription**. But now, although I still incorporate these issues, I'm engaged in a CVBO-like context around a cystic fibrosis patient, so I focus also on the symptoms of this disease and they have to use a concept from cytology like **membranes** etc. (Bt1).

> With the national curriculum in mind, we try to link the classic genetics with concepts like **dominant**, **recessive**, **homozygote,** and **heterozygote** to **DNA**, but unfortunately our method treats them separately (Bt2; see Quotation 1, in Table 2.1).

Only one teacher mentioned the importance of an additional concept not included in the formal curriculum: '**epigenetic factors**' (cf. Q3 in Table 2.1). The fact that the teachers taught in accordance with the formal curriculum was explained by their major concern to have their students pass the exams. One of the teachers (Bt2) even mentioned the national curriculum seven times as a reference point during the interview.

Some ELSA of genetic testing were distinguished by the teachers. Because they had also gained life experience, they all were familiar with some ELSA of genetic testing. These experienced teachers were able to recognise these aspects when they were confronted with them during their lessons.

> In discussing positive test outcomes … I use the film "It's in the genes" of the Dutch Alliance of Genetic Interests Groups. At the end, one of the three brothers who were tested appears not to have the genetic predisposition for thyroid cancer, and I always hold the film for a moment there to point out to

them that this boy feels emotionally disconnected from the rest of the affected family members (Bt1).

These feelings were labelled in the literature as feelings of isolation and guilt (e.g. Decruyenaere, 2003; Wilfond, 1995). However, the interviews revealed that the familiarity with ELSA differed from teacher to teacher, and most teachers (seven out of nine) explicitly mentioned the importance of becoming more aware of different ELSA for their future teaching because they considered them an inherent part of the context-based content.

The Authentic Practice of Genetic Testing

First, from the assumption that clients were familiar with the medical framework of their test situation, they mentioned a number of biomedical concepts teachers should know to teach context- based genetics. Next, some ELSA of genetic testing were labelled important and, consequently, should be part of the required teacher knowledge. However, the majority of the referents indicated that for preparing students for genetic testing teachers should be aware of the four characteristics of genetic practice: the uncertainty (nine out of 12 referents), probability (10 out of 12), complexity (10 out of 12), and morality (12 out of 12) of testing (outer box of Figure 2.1). However, to understand these characteristics and accept the consequences of, say, the complexity of genetics for your life, a knowledge of biological concepts seemed to be necessary (inner box of Figure 2.1).

To illustrate how all these concepts, ELSA and characteristics are interwoven in real life, this section ends with the story of Anne, one of the client-referents. Her story is an illustrative case study, based on a dense composition of quotations from her interview. Anne is a mother of two sons, one with a muscle disability, who looks back on her acquaintance with the world of genetic testing during the pregnancy of her third child (Box 2.1). We will discuss how the findings are reflected in this story.

Medical Framework

The referents in the authentic practice made it clear from the beginning that when clients have to decide on a genetic test, they first have to know what kind of heritable diseases they are looking for (including causes, symptoms, life expectations, possible treatments (cf. Q6 in Table 2.1), and side effects), and which tests are available (pre-implementation, prenatal, pre-symptomatic). This medical information is inherent to genetic test practice (grey-dotted box in Figure 2.1). However, to understand this medical information clients must also have additional knowledge. The interviews with the participants in clinical genetic practices resulted

in three sets of data, all informing the context-based knowledge base for teaching in this authentic practice.

Biological Concepts

The referents underlined the importance of sound conceptual knowledge. First, most concepts mentioned in standard curricula were relevant in their eyes (Q2, Table 2.1). Some clients indicated that not understanding these concepts was a problem for them.

> I did not know enough about genetics, and I do not understand **probability** at all. What I wanted to know and understand was how those tests worked and what they were looking for. I do not understand how this disorder is linked to **genes** or something, and although I am highly educated, I have no affinity with genetics and probability (C1).

The professional referents also mentioned extracurricular concepts (Q4, Table 2.1):

> Ok, you have Mendel, the **high risk genes**, and concepts like **dominant** or **X-chromosomal**, but they also need to understand the **low-risk genes**, the **polygenetic** setting where gene a + gene b + gene c + **environment** can also lead to a disorder (P1).

> I think that everybody has to understand that, when **one nucleotide** in your **DNA** changes, that does not always indicate that you will become ill, but that it adds a little to the **risk** you are running. And that such a change only leads to trouble when for instance you also get a virus infection. Students have to understand the **genome variation** and must be able to accept the complexity, the uncertainty, and the relative certainty (P4).

New concepts mentioned by the referents of the authentic practice that were not yet part of the CVBO concept matrix were added in bold in the matrix (Table 2.2). This approach of teaching science in context, which implies that the context indicates what concepts are relevant to teach, can increase the total number of concepts being taught.

Table 2.2. List of biological concepts for genetics education in the health context of genetic testing, in the extended CVBO matrix (Boersma et al., 2007).

Levels of biological organisation	**System concepts**				
	Biological unit	**Self regulation and self organisation**	**Interaction**	**Reproduction**	**Evolution**
Molecular	Adenine (A), Allele, Amino acids, Base, Cytosine (C), DNA, Gene, Guanine (G), Nucleoide, Protein, RNA , Thymine (T), Uracil (U)	Base pair Base sequence Double helix	Dominant, Recessive **High/low risk gene,** **Single nucleotide polymorphism (Snip)**		**Genetic polymorphism** Mutation
Cellular	Autosome, Chromosome Genome, Sex chromosome X & Y chromosome	Genetic code Mitosis Cancer		Diploid, Haploid Heterozygote, Homozygote Meiosis	
Organ system		Cancer			
Organism		Cancer	**Multifactorial disorder** **Polygenic disorder**		Chance
Population				Mendelian , Inheritance Pedigree	**Genomic variation**
Ecosystem					
Biosphere					
Context concepts (Domain specific techniques and activities)			**Sequencing, genetic testing, micro-array, whole genome screening, risk assessment**		

(**Bold** are the concepts mentioned by the referents from the authentic genetic testing practice, which are not (yet) included in the Dutch biology examination syllabus)

ELSA

Part of the teacher content knowledge of this medical health context are the ELSA of genetic testing. According to the referents of the authentic practice, these ELSA were not student content *per se* but should be part of a teacher's knowledge to recognise emerging ELSA during class discussions and provide them with language to clarify unclear student remarks, emotions, or intuitions. In the four stages of medical decision-making concerning genetic testing, the following aspects mentioned by the referents can be taken into account.

Stage 1: Preparation phase, gathering information. The first decision a client makes is whether she wants to have a test. There are different arguments for wanting to know or not wanting to know the test outcome:

- Ethical: religious arguments or arguments of responsibility and care, e.g. can you avoid harm and sorrow? (Q7, Table 2.1);
- Legal: is it legal; is the 'right not to know' applicable? (Wilfond, 1995); and
- Psychosocial aspects (Q8, Q9, Q12, Q13, Table 2.1, and Box 2.1): reassurance, feelings of (un)certainty, relief, guilt, isolation, anticipating decision regret, (in)dependency, responsibility, taboo, discrimination, stigmatisation, complexity, and timing (e.g. Nyrhinen, Hietala, Puukka, & Leino-Kilpi, 2007).
- After clients have decided that they want to know their genetic predisposition or that of their baby, the process of *gathering information* starts, and a lot of questions and knowledge can be relevant.
- Ethical: mostly the four principles of biomedical ethics are at stake – patient autonomy, beneficence, non-maleficence, and justice – completed with the principles of informed consent, privacy, care, and solidarity. Is there a conflict of interest? Which values are important for the client and what do they mean for her?
- Legal: what are the consequences for work, loans, and insurance?
- Psychosocial: who is involved? (Q10, Q11, Table 2.1) What about the carrying capacity of the family (Box 2.1)? Can the client cope (emotionally) with a change of perspective, as is illustrated by the following quote from an expectant mother?

> The most striking aspect of the decision-making process was that I did not know Sophia. I had to make decisions on behalf of a person whose identity was undeclared, unknown, and unknowable (Rosner, 2004, p.20).

Stage 2: Weighing information and decision-making 1. After gathering information, stage 2 starts with the weighing process. Before deciding to undergo a test, the client has to examine, for instance, whether they understand the complex information, what it means to them, and whether they and their social environment can deal with it emotionally (Box 2.1). How are the values at stake balanced? Are the identified interests met and is help needed or not. After communicating the test outcome (stage 3, the *laboratory, analytical phase*), either positive or negative, a client must formulate a personal meaning (stage 4, *interpretation and processing the results, consequences*). Sometimes the difficult question of abortion is acute in a very short timeframe (Box 2.1), but in all cases emotions are involved and follow-up questions of responsibility and social consequences arise. Who else should be notified (Q10, Q11, Table 2.1): children, other family members, parents, or siblings? And finally, some questions are still unanswered: when, how serious, and how fast will the disease develop?

Most problems can be found in stage 1, and concern the issue of informed consent. If students assume the position of a client, the question is whether or not they can understand everything. Can they assess the pros and cons, the risks, their own ethical position, and the medico-legal, emotional, and psychosocial consequences (Nyrhinen et al., 2004)?

Characteristics

Four characteristics relevant to the authentic genetic practice came to the fore, presented here by exemplary quotations.

Uncertainty. Entering the consulting room of a doctor or genetic counsellor, people often expect to find straightforward answers and clear cut solutions. However, one cannot shape life according to one's own desires and directions (Box 2.1).

> Most people have inadequate knowledge of what is possible nowadays. They have unrealistic expectations and do not understand the nature/nurture aspects (Me1).

Moderation of these high expectations by future clients is one of the educational goals mentioned by the referents (Q15, Table 2.1). To understand the uncertainty of genetics, concepts such as ‘genomic variation’, ‘high and low risk genes’, and ‘single nucleotide polymorphisms’ are important.

Probability. The referents agreed on the importance of a proper understanding of probability.

> Risks are evaluated situationally. Risks of close events, e.g. of getting ill, are overestimated, and more far away risks, e.g. risks you run in traffic, are underestimated. Even the language to present risks to people influences their perception (Me1).

Not only did the professionals stress this point. The clients also mentioned that this was one of the most difficult aspects for them to grasp, and as a consequence, knowing the chance did not help at all (Box 2.1). Concepts such as 'chance' and 'risk assessment' help understand genetic probability.

Complexity. The referents stressed the importance of understanding the complexity of heredity.

> In the beginning most clients don't see the difference between confirmation and excluding possibilities. Confirmation is sometimes possible, ruling out mostly not (P1).

> It is not a one–to-one relation between gene and disease. Students must understand the complexity of the numerous genes involved in a disease (P2).

Often things are even more complex, and then clients do not go through these stages in an orderly way, and report other characteristics that influence their decision.

- The process is cyclic; clients go through some of the stages more than once. It is possible that, after learning some of the consequences, you no longer want to have a test, although you started out wanting it (Q10, Table 2.1);
- The complexity of the process can be perceived as confusing and can cause all kinds of emotions (Q20, Table 2.1);
- The process is under time pressure; preparation for this time pressure is one of the arguments the referents had for teaching genetics in this context (Box 2.1, Q8, Table 2.1);
- Choices are not only difficult, sometimes they have to be made in a chaotic and detached context. In this perspective, referents said that it is important that students learn how to personally reflect, even more than learning genetics and ethics (Q17, Q18, Table 2.1). What does it mean to be that ill? For your child or for you?; and
- According to the referents, emotional and rational considerations are important in education. One client confirmed the importance of these

> considerations by going even one step further by stating that rational considerations didn't help at all (Q19, Table 2.1).

To understand the complexity of genetics, concepts such as 'multifactorial disorder', 'polygenic disorder', and 'genetic polymorphism' are also important.

Morality. According to the professionals, to be capable of making responsible decisions concerning genetic testing, one should also know something about ethics.

> Also certain values, principles, and moral experiences are relevant for this kind of considerations; respect for autonomy, the principle of human dignity, prima facie duties like non-injury. If you only reflect on intuitions or your own experiences, the narratives, it will not be enough (Me2).

Knowledge alone is not enough; what does this information mean? (Q17, Q18, Table 2.1). The referents suggested that it could be informative to students to step out of the personal context and take a societal perspective. Then, a number of overarching issues can be raised including desirability, respectability, and the protection of the weak and those without voice (Q22, Q23, Table 2.1).
Or, what ethicist label 'expressive aspect' of an argument, and was voiced by Albert (2003):

> If society condones searching out and eliminating people like me, what does this say about how I am valued by others and how I should value myself? (Albert in Levinson & Reiss, 2003, p. 115).

And finally, are there (no) limits in what we can do or want to manipulate? Is this a personal responsibility or do we have enough societal guidance and legal regulations? In other words, do our ethics meet our medical and technical possibilities? According to the referents, these are important issues to address in education.

The Story of Anne

When teachers want to situate student learning in authentic practices such as genetic testing, they must be able to fathom the complex cases so typical of these practices. The experience of Anne, one of our client-referents, is an example of such a case and illustrates several of our findings. First, it is the specific authentic practice that prescribes the content knowledge and shapes the ELSA relevant for successful participation in the authentic practice: opting for a test with its possible far-reaching consequences. Anne's lack of biomedical knowledge, e.g. the biomedical background of the triple test, and her struggle with the concept of chance illustrates the first. The latter is shown by her emotional confusion, how she anticipated her decision regret, the role of others, her own background, and how she surveyed her carrying capacity. Next, her story illustrates the four common characteristics inherent to genetic testing practice, i.e. the difficulty she had with probability and the uncertainty of the situation. In fact, her story reflects one big ethical struggle, what to do in this complex situation, and why? Looking back on it now, she can voice it, but she would have been helped at the time had her biology teacher discussed this perspective with her.

Box 2.1. Concepts, ELSA, and characteristics of the genetic test practice illustrated by a client story.

The story of Anne

Looking back on it now, I realize that I did those tests, the Triple test, without proper considerations in advance. All I really wanted was reassurance. And of course that is a strange starting point, because there is a chance that you won't be reassured. I think that most people doing punctures and other such tests expect to be reassured and ready to enjoy their pregnancy afterwards. For me this was a naïve way to view such a test. Especially a test that will only give you a chance, a percentage. Because then in fact you still know nothing. I would never do that test again. If I ever was to feel the need for such a test I would do a puncture or some other test that would give me more certainty. And I would have thought about what I would do with the possible results in advance, so I would be able to anticipate on them. After John, who could not even walk though he was three, my mistake was that I thought I could not handle another child with a handicap. I thought I could not endure another infant who could not do anything on his own. So I decided to get myself some reassurance. And although the echo looked ok, I was worried, so I did a test that was not risky for the baby. You are so relieved that something can be done, so you do it, because you don't want to feel like you didn't do everything possible for your child. When my husband got the phone call and the doctor told him that I had a risk of one out of 280 or something, my husbanded responded with: "well that sounds good". But it was not good at all! It was an increased risk, and I should visit the doctor. He told me that my risk was four times higher than normal, and suddenly it sounded completely different. One out of 280 or four times higher than normal. But in the mean time I was pregnant for 13 or 14 weeks. The triple test indicated it wise to puncture my placenta. That tests' outcome could be expected within one or two weeks and then I had exactly one week left to decide whether I wanted an abortion or not. How could I decide in two weeks time over the life or death of my child? I was just in time and could "still do something about it" as the doctor put it. But my body already showed my pregnancy, and I felt life inside me, little movements. So I looked down at my belly and thought; doing something about it? No way, it's my baby. I felt so unhappy, I didn't want that puncture, in fact I only wanted to tuck it all away. If they had told me I had a chance of 50 percent,

maybe. But even then I didn't want to make that kind of decision, I didn't want to decide for an abortion, because I was afraid I would regret it in the end. On the other hand, I know it could mean a lot of special care. And I am not religious in the way that I believed this to be the burden I had to carry. I did not think I could manage it without depriving my other two kids, my family. The doctor strongly advised me to do the puncture and was looking very worrisome. So I came home crying and told my husband I had a chance of one out of 280. And he responded: 'what kind of a chance is that anyhow? If you step out the front door, you might have the same chance to get hit by a car.' Later we saw on the internet that a puncture had the same chance of miscarriage, so what kind of choice was this? I was so confused, so unprepared. When you have a healthy child with Down syndrome, it can still live a happy life. However, if it has to undergo all kinds of operations, and it would suffer a lot, what kind of life would that be? And until today, it is still not clear to me what a chance of one out of 280 actually means. 'Chance' wasn't just flowing in my bloodstream, was it? There must have been something in my blood that was not good, but they never explained it to me. Either there was something in my blood or something wasn't in my blood, but there is no 'chance' in it. As lay person I did not get it. Fortunately I went to my midwife and she soothed me. We should have seen something on the echo. Also my mother convinced me that our baby would be just fine and that I should trust my own body and feelings. And you know, there are always risks, you have to accept that. From that moment on, I pushed it away until the birth of Joan. And although I pushed it away successfully, the relief was immense when everything turned out to be right when she was born. I never went back to that doctor again, I was so angry at him, at the situation, at myself, for being so naïve. The doctor never told me what an acceptable chance was, or when it would be wise to do a puncture or not. He simply advised me just to do the test first and then we would see what's next. Now I know that's not wise. You should think about what you would want to do with every possible outcome. People should know whether they want to know it, why they want to know it, and what they would do if they knew it. In the end I chose that I didn't want to know, in good faith and hoping for the best.

Conclusion and Discussion

What content knowledge do biology teachers need to teach genetics in the personal health context of genetic testing? Current educational practice shed some light on the content knowledge we were looking for. This encompassed sound conceptual knowledge, included in the formal curriculum and necessary to help students pass their exams; concepts such as dominant, recessive, homozygote, heterozygote, DNA replication, and transcription. The referents of the authentic practice brought up several other biological concepts, such as high risk genes, low risk genes, multifactorial disorders, and polygenic disorders (Table 2.2). According to them, these concepts are necessary for understanding the characteristics of uncertainty, complexity, probability, and morality. These characteristics were considered relevant for successful decision-making in genetic testing.

Finally, the authentic practice, complemented by the relevant literature, provided an overview of the ELSA of genetic testing, which can be presented to teachers in four stages. These ELSA included ethical issues of informed consent and solidarity, dilemmas such as that between patient autonomy and guilt, legal issues concerning insurance, and social implications for relatives or future children (Table 2.1). Some of these ELSA were familiar to the experienced teachers, but that differed depending on a teacher's life experience. Most thought it relevant to become more aware of these ELSA for their future teaching.

To the best of our knowledge this is the first time the authentic practice of genetic testing has been explored for the possible content knowledge of context-based biology teaching. We started from the basic assumption of situated learning that the authentic practice is prescriptive and frames what is relevant to learn (Lave & Wenger, 1991). The literature (e.g. Boersma et al., 2007; Nyrhinen et al., 2004) gave us reason to believe that information about relevant knowledge and ELSA could be provided by the referents of the authentic practice. The results of this study confirmed this expectation.

This study, as some extracurricular developments, aim to introduce more contemporary concepts and genomics research techniques in school biology (Dougherty, 2009; Van Mil, Boerwinkel, Buizer-Voskamp, Speksnijder, & Waarlo, 2010). However, most of the concepts mentioned do not form a part of the formal curriculum, and also exceed some earlier recommendations that were limited to the more classical Mendelian concepts (Richards et al., 1995). This might be an important side effect. If each context that will be explored to facilitate authentic learning results in extracurricular concepts, the issue of an overloaded biology curriculum must be addressed.

The recommendation of the referents to include the specific ELSA of genetic testing in biology education and their descriptions is helpful for describing the knowledge base for teachers who want to prepare students for the complexity of the testing situation. These ELSA could also help the debate on education for citizenship concerning this social practice (Aikenhead, 2006; Levinson & Turner, 2001; Ratcliffe & Grace, 2003).

The referents put an unforeseen emphasis on the characteristics of uncertainty, complexity, probability, and morality. This idea can be informative for biology teachers who want to apply the authentic learning approach because these characteristics are best understood via extracurricular concepts. For understanding uncertainty in genetics, for instance, the concepts of 'genomic variation', 'high and low risk genes', and 'single nucleotide polymorphisms' are needed. Moreover, concepts such as 'chance' and 'risk assessment' help explain genetic probability. The emphasis on the characteristics of morality and complexity underlined the fact that genetic testing is a socio-scientific issue. Clients in a genetic test situation are confronted with a controversial and ill structured problem (Levinson, 2006; Sadler, 2009). Test outcomes are not always as unambiguous as they want them to be, and clients have to weigh scientific and medical information with complex social and ethical consequences, while rational considerations fall together with emotional confusion.

The emphasis on the characteristic of uncertainty joins in with the discussion about the NOS and affirms its place in science education (Cobern, 2000; Lederman, 1999; Meichtry, 1999; Osborne et al., 2003; Ryder, 2001). Ryder (2001) states that the knowledge of the role of uncertainty in science is one of the main areas of relevant science knowledge for functional scientific literacy. Next, insight in the making of science can also influence students' own learning of science (e.g. Hogan, 2000). The author's description of the possible interaction between the distal and proximal knowledge of NOS is of interest within our focus on student learning. According to Hogan, it could be that stimulated reflection in the two areas recursively supports the development of both. The distal knowledge of NOS, or the 'knowledge about the enterprise of professional science, including the epistemological commitments that undergird the formation and judgment of scientists' knowledge claims' (Hogan, 2000, p. 62), could influence the proximal knowledge of NOS, or the 'metacognitive knowledge about and perspectives on personal experiences in scientific sense-making (i.e., learning), and personal epistemological commitments about scientific knowledge and knowing, especially in school contexts' (Ibid, 2000, p. 62), and vice versa.

This study focused on what teachers should know to prepare their students for the making of personal meaning of scientific knowledge rather than on broader socio-cultural aspects. We did not discuss aspects such as the economic, sociological, and political role of science in our modern world, the sociology of science, or the way science is practised and constructed by society (Brickhouse, 2001; Cunningham & Helms, 1998; Lemke, 2001). In our view, these perspectives should be discussed with the teachers who want to develop the knowledge basis described here, because personal meaning making is not simply a matter of accepting facts and logical relationships. It helps to develop an identity by reflecting on one's system of beliefs and values, and is also based on the understanding that science is a part of larger communities and their cultures (Lemke, 2001).

The fact that some clients experienced no support from rational considerations is in line with the findings of earlier research. For instance, some research has indicated that scientific information was either not understood or found irrelevant in dilemmatic situations (V. Dawson, 2003; Haidt, 2001; Layton, Jenkins, MacGill, & Davey, 1993). This makes teaching in context an even greater challenge, one that surpasses the content perspective of teaching. It raises the question how people reason in dilemmatic situations, and whether reflection on that reasoning during their educational years can improve it.

Not only are the concepts in the formal curriculum relevant for teaching in context but so are additional concepts. This shows the importance of updating school curricula according to changes in the field (Table 2.2). Since our results indicate that teaching based on authentic practices could lead to a rethinking of curricula, initiatives should be taken to update science curricula in light of recent techno-scientific developments, such as new knowledge and technologies in genomics, and their implications for citizens. The first steps on this road have already been made (e.g. Boerwinkel et al., 2008; Dougherty, 2009).

For improving teacher knowledge, the four layers of knowledge of the authentic practice should be taken into account (Figure 2.1) in teacher education programmes and the training of biology teachers. (Student) teachers need to acquire knowledge of the ELSA and the four-stage-process of testing helps them in doing so. Next, they require more knowledge of how concepts and ELSA can be conceived in the context of specific genetic test situations. Finally, they require knowledge of the four basic characteristics of genetic practice that make it so challenging.

This article has described the content knowledge, part of the necessary knowledge for teaching genetics in context. This raises questions about the other categories of teacher knowledge, in particular the PCK of teaching genetics in this

genetic testing practice. Having described the concept knowledge for teaching genetics in the context of genetic testing, the question arises how this knowledge can be taught (Shulman, 1987). What teaching and learning activities are appropriate? This is an important question for future research.

In particular, we raised the question how people reason in dilemmatic situations, and whether reflection on that reasoning during their educational years can improve it. Owing to the moral aspect of the dilemmatic genetic test situations this kind of reasoning can be referred to as moral reasoning (Haidt, 2001), and our question indicates that it can be useful to develop teaching and learning activities for moral reasoning in science education. Although some research has already been dedicated to this question (P. Van der Zande et al., 2009b), more research is needed before teachers at different levels in secondary education can be accommodated with satisfying learning activities for (reflection on) moral reasoning.

Appendix

Respondents of the Educational Practice and the Clinical Genetic Practice
Teachers Bt1 to Bt9, clients C1 to C4, physicians (and genetic counsellors) P1 to P4, and medical ethicists Me1 to Me4.

Box 2.2. Books and articles (for the saturation strategy concerning the ELSA of medical decision-making).

1. (Bates, 2003)
2. (Beauchamp & Childress, 2001)
3. (Bolt et al., 2005)
4. (Borkenhagen et al., 2007)
5. (Challen et al., 2006)
6. (Cherry & Cherry, 2003)
7. (Collins et al., 2003)
8. (De Visser, 2007)
9. (De Wert, 1999)
10. (Decruyenaere, 2003)
11. (Dols-Caanen, Konings, Gómez Garcia, & Schrander-Stumpel, 2008)
12. (Finck, Meister, Stöbel-Richter, Borkenhagen, & Brähler, 2006)
13. (Frets, 1990)
14. (Grient Dreux et al., 2008)
15. (Grob, 2006)
16. (Guttmacher et al., 2007)
17. (Harvey et al., 2007)
18. (Hietala et al., 1995)
19. (Nyrhinen et al., 2004)
20. (Nyrhinen et al., 2007)
21. (Pin & Gutteling, 2005)
22. (Resnik, 2003)
23. (Rosner, 2004)
24. (Rowley, 2007)
25. (Rudnick, 2007)
26. (Stratton & Rahman, 2008)
27. (Twomey, 2006)
28. (Vähäkangas, 2001)
29. (Van Baarsen, 2003)
30. (Van Kleffens, Van Baarsen, & Van Leeuwen, 2004)
31. (Van Neste, 1993)
32. (Wilfond, 1995)
33. (Wüstner & Heinze, 2007)
34. (Yesley, 2008)
35. (Zallen, 1997)

Chapter 3

Expertise for Teaching Biology Situated in the Context of Genetic Testing*

Abstract

Contemporary genomics research will impact the daily practice of biology teachers who want to teach up-to-date genetics in secondary education. This article reports on a research project aimed at enhancing biology teachers' expertise for teaching genetics situated in the context of genetic testing. The increasing body of scientific knowledge concerning genetic testing and the related consequences for decision-making indicate the societal relevance of an educational approach based on situated learning. What expertise do biology teachers need for teaching genetics in the personal health context of genetic testing? This article describes the required expertise by exploring the educational practice. Nine experienced teachers were interviewed about the pedagogical content, moral and interpersonal expertise areas concerning how to teach genetics in the personal health context of genetic testing, and the lessons of five of them were observed. The findings showed that the required teacher expertise encompasses specific teaching and learning activities, interpersonal expertise and a preference for teacher roles and teaching approaches for the moral aspects of teaching in this context. A need for further development of teaching and learning activities for (reflection on) moral reasoning came to the fore. Suggestions regarding how to apply this expertise into context-based genetics education are discussed.

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Introduction

In science teaching, there is a growing emphasis on teaching scientific content in relation to socially relevant life situations. This approach has been referred to as situated learning (SL) (Boersma et al., 2007; Gilbert, 2006; Sadler, 2009; Van Aalsvoort, 2004; Van der Zande et al., in press). An educational approach based on situated learning in science education is meant to provide relevance to what is learned (Greeno, 1998; Putnam & Borko, 2000), and in doing so to promote student motivation. Situated learning affects educational practice in at least two ways. First, in this approach, the authentic practice becomes prescriptive and frames what is relevant to learn, thereby defining the concepts and knowledgeable skills in a meaningful way (Herrington & Herrington, 2006). Second, in the situated learning approach, students' learning takes place in relation to a situation that is deduced from the authentic practice. Authentic practices inform both the selection of content to be taught and the situational framing of this content, because the authentic context supports the specification of a concept's meaning and brings about the coherence of concepts within a larger whole (Herrington & Herrington, 2006; Van Aalsvoort, 2004; Van Oers, 1998). In this study, the authentic practice of genetic testing was selected as a context for teaching genetics in secondary biology education. Recently, there has been a rapidly increasing body of knowledge in the field of genomics with important consequences for citizens. This makes genetic testing a suitable context for teaching genetics, because our students may be prospective clients in genetic testing practices.

Genetic testing is a socio-scientific issue. Controversial issues such as genetic testing that have conceptual as well as procedural connections to the sciences, and are viewed as socially significant, are labelled socio-scientific issues (Sadler, 2004). Despite the increasing interest in an educational approach in science education based on situated learning theory, Day and Bryce (2010) state that science teachers are generally unfamiliar or uncomfortable teaching socio-scientific issues. Teachers not only find it difficult to organise classroom discussions (Levinson & Turner, 2001; Osborne, Erduran, & Simon, 2004) and small group discussions on socio-scientific issues (Bennett et al., 2010), they also need support on how to strengthen student argumentation concerning this kind of issue (V. M. Dawson & Venville, 2010).

This study aimed to determine what expertise biology teachers need to teach genetics according to a situated learning approach. The study is part of a larger research project aimed at expertise development of biology teachers for context-based genetics teaching (Van der Zande et al., 2009, in press). Science teachers, who want to practise a situated learning approach in teaching genetics, need

specific expertise; they need to be aware of the current state of the art in the authentic clinical practice of genetic testing and be familiar with successful ways to situate their genetics teaching in situations derived from that practice. Although the relevance of context-based expertise is stressed by several authors (Klop & Severiens, 2007; Levinson, 2006; Levinson & Turner, 2001; Zeidler, Sadler, Simmons, & Howes, 2005), a tailored description of the expertise to teach genetics in this context is, to the best of our knowledge, not available. In an earlier study, we explored the authentic clinical practice of genetic testing to investigate the knowledge base necessary for teaching genetics in the personal health context of genetic testing (Van der Zande et al., 2009, in press). In this study, we explored the practice and ideas of experienced biology teachers to find out what expertise these teachers show when they teach genetics in the personal health context of genetic testing.

In the following sections, we describe which contemporary changes in genetics and genetics education require specific expertise of teachers.

Teaching Socio-scientific Issues in Authentic Practices

Science is making rapid progress, in particular in the field of life sciences such as genomics. The expanding body of knowledge has important consequences for citizens. Increasingly, they should be able to make reasonable decisions on controversial biomedical issues, weighing complex medical information together with ethical or legal considerations (Gearon, 2003) in social environments in which several perspectives are possible (Veugelers & Vedder, 2003). Education should prepare students for this kind of decision-making in their future role as citizens (Ratcliffe & Grace, 2003).

In general, socio-scientific issues have an important place in education for citizenship (Levinson, 2006). Kolstø (2001) states that through teaching socio-scientific issues, content-transcending topics associated with the limitations of science can be emphasised and the critical attitude of students can be stimulated. These claims for teaching socio-scientific issues, such as the moral implications and limits to scientific possibilities, must be taken into account when exploring the authentic testing practice for the teacher expertise needed in a situated learning approach.

Genetic testing is a socio-scientific issue in the sense that it concerns an issue that has a) conceptual as well as procedural connections to science and b) is viewed as socially significant by the community participants themselves (Sadler, 2009). Genetic testing is a complex practice that has ethical, legal and social aspects (ELSA), for the professional participants as well as the clients involved. Thus, not

only are the concepts used in this practice of interest for biology teachers who want to teach in this context, but so are the ethical, social and legal consequences of the decision making process of the client engaged in genetic testing situations.

Teacher Expertise

Teacher expertise can be generally defined as the ability of teachers to teach successfully (cf., Cianciolo et al., 2006; Sternberg & Horvath, 1995). If teachers have expertise, it means that they are able to adapt to task demands and to reorganise and refine their representations of knowledge and procedures for efficient application to everyday classroom practice (Ericsson et al., 2006). Expertise is considered to be domain-specific, and this also applies in the professional domain of teaching. Teaching is a complex profession, in the sense that teachers often have to fulfil many functions at the same time, for example creating a safe and motivating learning environment, instructing students and organising learning activities (Doyle, 1986).

Teacher expertise is often described in terms of Shulman's teacher knowledge that comprises of seven categories; for example a) content knowledge, b) pedagogical content knowledge and c) curriculum knowledge (e.g., Shulman, 1987). Central to this categorisation is concept *knowledge*. In our conception of expertise, we also include teacher beliefs, attitudes, skills and behaviour, because they all contribute to the ability of teachers to teach successfully. For this expertise, we explored the educational practice of experienced teachers. Several authors suggest that expertise arises from sustained experience (cf., Dreyfus & Dreyfus, 2005; Schmidt & Boshuizen, 1993; Tynjälä, 1999), in this case with teaching.

In line with Doyle's (1986) statements that teaching is multifaceted different areas of teacher expertise can be discerned. One of these areas is subject matter expertise. From a situated learning perspective, it is important to determine subject matter expertise not only by looking at current school subjects, but also by including recent insights from the authentic practice, in this case the clinical practice of genetic testing. In this article, subject matter expertise encompasses relevant curricular concepts as well as relevant extra-curricular concepts derived from the authentic practices. Another area of teacher expertise is pedagogical content expertise, which is about representing subject matter in such a way that it takes into account the learning difficulties and student conceptions concerning that specific subject matter. A third area of teacher expertise is interpersonal expertise, which is about the ability to build good relationships with students (Wubbels, Brekelmans, Den Brok, & Van Tartwijk, 2006). Finally, a fourth area, particularly relevant when it comes to teaching socio-scientific issues, is moral expertise,

referring to the ability to clarify the normative component of socio-scientific issues and to discuss and reflect on the norms and values at stake. In the following, we will describe these four expertise areas in relation to genetics teaching in general before we explore educational practices for the relevant extension of this expertise, in particular concerning teaching genetics in the context of genetic testing.

The need for subject matter expertise in genetics education

Expertise concerning the subject matter entails knowledge of relevant parts of the curriculum, and the ability to address this knowledge in class, for example addressing genetic concepts and heuristics such as Punnett squares and genealogical family trees. Recently, it has been argued that the biology curriculum should shift from focussing on single gene disorders to polygenetic disorders (Dougherty, 2009), and there is a growing awareness of the need to align the content of genetic teaching practice with developments in the authentic practices (Boerwinkel et al., 2008). The current focus on monogenetic heredity, common in classical Mendelian genetics, is thought to hinder the necessary insight into the crucial role of variation and individuality in modern genetics (McInerney, 2002), can lead to a deterministic view on genetics (Jiménez-Aleixandre, 2010), and does not prepare students for effective participation as medical consumers (Dougherty, 2009). According to Kolstø (2001), the content-transcending topics associated with the limitations of medical science in genetic testing and the ELSA of genetic testing also belongs to the knowledge base for teaching in the context of genetic testing. The authentic practice of genetic testing can be informative for this context-bounded knowledge that often surpasses the contemporary biology curriculum. In an earlier stage of this research project, we explored the authentic practice of genetic testing and elaborated the recommendations concerning the subject matter expertise (Van der Zande et al., in press). These recommendations are summarised below (see Table 3.1).

Next to the recommendation of sound understanding of genetics as described in high school curricula, the referents of the authentic practice brought up several extracurricular biological concepts, such as high-risk genes, low-risk genes, multifactorial disorders and polygenic disorders. These concepts are necessary for understanding genetic testing situations as uncertain, complex and moral, and based on probability. It is the awareness of these latter characteristics that is argued to contribute to successful decision making in genetic testing. Finally, the authentic practice provided an overview of the ELSA of genetic testing.

Table 3.1
Subject Matter Expertise for Teaching Genetics in the Context of Genetic Testing

Area of expertise	Aspects of expertise area
Subject matter expertise	Curricular genetics concepts
	Extracurricular genetics concepts
	Ethical, legal and social aspects of genetic testing
	Characteristics of genetic testing practice
	Medical information genetic tests
	Knowledge of students moral reasoning

These ELSA included ethical issues of informed consent and solidarity, dilemmas such as that between patient autonomy and guilt (meaning that control implicates responsibility with all its consequences), legal issues concerning insurance and social implications for relatives or future children. For a detailed description of the subject matter expertise for teaching biology situated in the context of genetic testing, see Van der Zande et al. (in press).

The need for pedagogical content expertise in genetics education

Pedagogical content expertise concerns the way in which the learning process of the students about a particular subject matter can be facilitated by the teachers, e.g. by selecting appropriate teaching and learning activities. Knippels et al. (2005) identified ten categories of problems in learning and teaching genetics. The abstract nature and complexity of genetics were labelled as the main problems. In their review study, Knippels et al. (2005) explained that students experience genetics as abstract because they have difficulties in linking genetic principles to real biological phenomena, due to a lack of connection between inheritance and sexual reproduction in general, and meiosis in particular (ibid, p. 109). Genetics is complex because it covers all levels of biological organisation (cf., Duncan, Rogat, & Yarden, 2009). To deal with the complexity, Knippels designed and tested the so called yo-yo teaching strategy:

> The yo-yo strategy copes with the complexity by explicitly distinguishing the levels of biological organisation, and by descending and ascending these levels, starting from the concrete organismic level. Explicating the levels makes the transect nature of genetics transparent to students, and provides an insight into what hereditary phenomena, processes, and structures occur on the different levels of biological organisation (Knippels, 2002, p. 181).

Knippels' suggestion is in line with other findings in the literature. Lewis and Kattmann (2004), for example state that a process-oriented teaching approach, starting from the context of a visible phenomenon, illustrated by Lewis and Kattmann by the illness sickle cell anaemia, can enable students to become aware of the relationship between the basic processes of genetics and the biochemistry or physiology of the whole organism.

Although teaching genetics in the context of genetic testing is rather new in biology education, it can be assumed that experienced teachers will have ideas about how to elaborate this situated learning approach. The practice and ideas of experienced teachers can be informative for the pedagogical content expertise that can be applied in this specific context of genetic testing.

The need for interpersonal expertise in genetics education

Interpersonal expertise contains the ability of the teacher to create and maintain good relationships between their students and themselves. Do the students experience that the teacher is interested in them, knows them as individuals and understands their problems? Do they trust him or her, and does the teacher have enough authority and provide them with motivating and structured learning environments? The student perception of the teacher-class relationship can be mapped with the Model for Interpersonal Teacher Behaviour (Wubbels et al, 2006). With this model, based on Leary's model of interpersonal behaviour (Leary, 1957), the student's perception of the interpersonal behaviour of their teacher can be described by means of eight types of teacher behaviour; leadership, helpful/friendly, understanding, giving students freedom and responsibility, uncertain, dissatisfied, admonishing and strict (see Figure 3.1). The two dimensions underlying these eight types are labelled *Influence* (Dominance – Submission) and *Proximity* (Opposition – Cooperation). Research on teachers' profiles showed eight different combinations (eight different interpersonal profiles) of these eight types of behaviour: Directive, Authoritative, Tolerant/Authoritative, Tolerant, Uncertain/Tolerant, Uncertain/Aggressive, Drudging and Repressive (Wubbels et al, 2006). We expect one of these eight profiles, the Tolerant/Authoritative profile, to be found amongst experienced teachers who invite students to reflect on their moral reasoning concerning genetic related controversial issues (see Table 3.2). Tolerant and authoritative teachers maintain a structure that supports student responsibility and freedom, and use a variety of methods to which students respond well. This profile corresponds with the criteria Haidt (2001) formulated for moral reflection. Translated to an educational setting, these criteria entail that students should feel at ease with their teachers before they engage in reflection on

their moral reasoning and learn from that reflection. Besides determining their teacher profile, the practices and ideas of experienced teachers can be informative for the interpersonal expertise that is needed in the context of genetic testing.

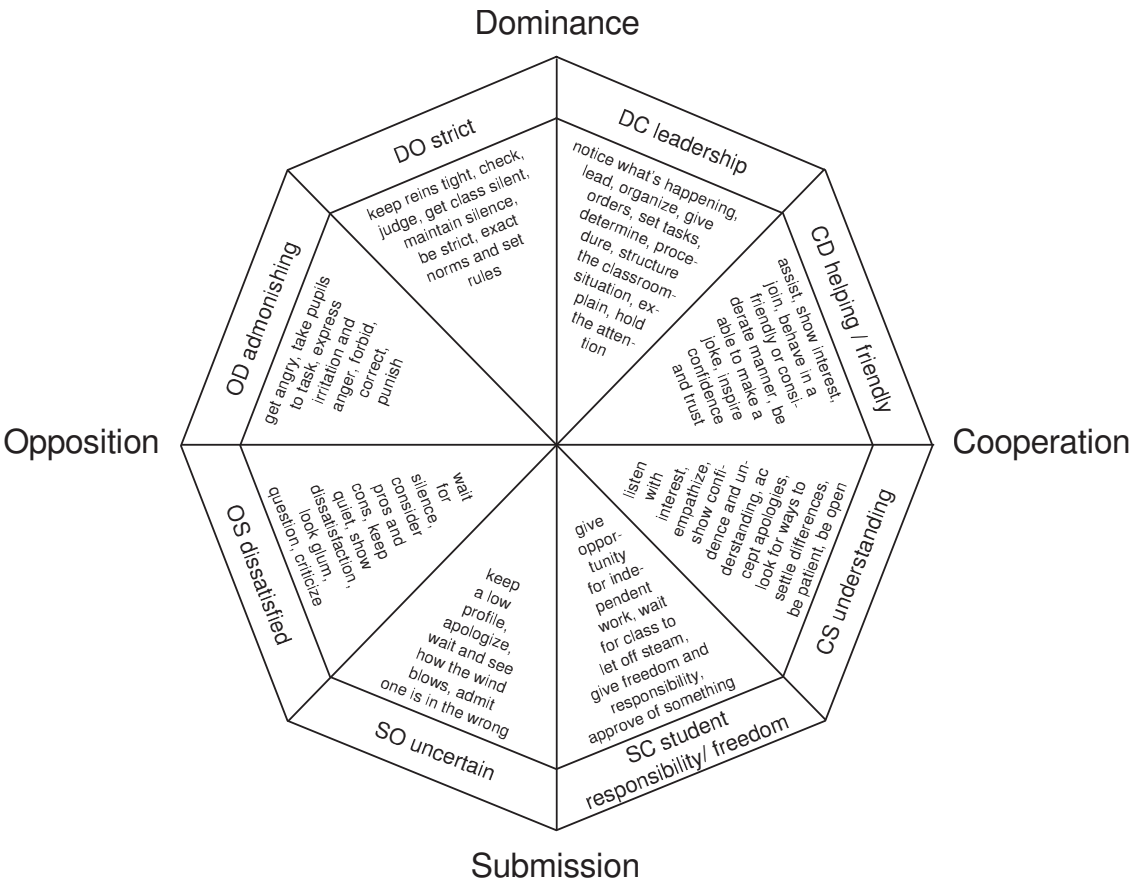
Table 3.2
Classroom environment typical for the Tolerant/Authoritative teacher profile (Wubbels, Brekelmans, Den Brok, & Van Tartwijk, 2006, p. 12).

	Classroom environment
Tolerant and Authoritative	Tolerant and Authoritative teachers maintain a structure that supports student responsibility and freedom. They use a variety of methods, to which students respond well. They frequently organise their lessons around small group work. While the class environment resembles the climate in the Authoritative class [i.e. well structured, pleasant and task-oriented, with clear rules and procedures], Tolerant/Authoritative teachers develop closer relationships with students. They enjoy the class and are highly involved in most lessons. Both students and teachers can be seen laughing, and there is very little need to enforce the rules. These teachers ignore minor disruptions, choosing instead to concentrate on the lesson. Students work to reach their own and the teachers' instructional goals with little or no complaints.

The need for moral expertise in genetics education

When, as stated above, controversial issues bring ethical questions into the classroom, they highlight a teacher's ability to clarify the normative component of socio-scientific issues and to discuss and reflect on norms and values at stake. Teachers' moral expertise concerns the way teachers deal with values in education, not only restricted to behavioural manners in the classroom, but also connected to the subject matter. Frazer and Kornhauser (1986) pointed out that although science was mainly concerned with explaining phenomena in the past, nowadays attention should be paid to questions of ethics and social responsibility in science education since science is a crucial part of man's effort to change the world.

Figure 3.1
The Model of Interpersonal Teacher Behaviour (Wubbels, Brekelmans, Den Brok, & Van Tartwijk, 2006).



A first part of moral expertise is a teacher's ability to apply different approaches in moral education when appropriate. Ritzen (2004) described four different approaches that can be applied when the situation requires it. One of the four is value transfer; the teacher teaches his own set of values. These values can be rooted in an external source like the Bible or the Koran, or, for example, norms and values on classroom behaviour in school regulations. A second one is value

clarification, an approach where the values of the students themselves are the focus point of discussion. It is a process of awareness raising in which students are challenged to investigate their own values. One way to do so is to confront students with other values and norms and to invite them to compare and weigh these different values. According to Ritzen, even this approach is not completely value-free. Values like critical thinking, freedom, tolerance and autonomy are appreciated in a positive way. Value development, the third approach, starts from the premises that children develop their moral thinking over the years (Kohlberg, 1973), and that teachers can support this development.

Table 3.3
Roles available to the teacher in (moral) class discussions (Harwood, 1998).

Role	Description
1. Participant	Is free to express ideas, opinions and feelings just like any other member of the group.
2. Devil's Advocate	Tries to stimulate participation by deliberately taking oppositional stances.
3. Impartial/Neutral Facilitator	Chairs the discussion by organising and facilitating students' contribution and by maintaining rules and limits. Does not express personal viewpoint. Does not give positive or negative feedback after students' contributions.
4. Instructor	Explains and clarifies relevant information, concepts and ideas. Asks task questions to assess understanding. Gives positive or negative feedback after students' contributions.
5. Committed Instructor	Uses the instructor role, as above, in a sustained way, to propagate own viewpoint on controversial issues.
6. Interviewer	Questions individuals to elicit their ideas, feelings and opinions.
7. Observer	Observes the students during their discussion, but does not intervene.
8. Absent Leader	Withdraws from the group after initial organisation of work.
9. Other?	……

The last approach is called value communication, that is, when teachers try to contribute to the capabilities and skills students need to participate successfully in this kind of communication. In the classroom, these approaches can easily mingle, such that you can not communicate your values if you have not clarified them, but

emphases in different approaches can be distinguished (Ritzen, 2004). A second aspect of moral expertise, next to applying different approaches, is teachers' ability to perform different roles in moral education. Several roles can be described (see Table 3.3): participant, devil's advocate, neutral facilitator, (committed) instructor, interviewer, observer and absent leader (Harwood, 1998; Waarlo, 1999). The practices and ideas of experienced teachers can indicate which of the roles are relevant for teaching in the context of genetic testing.

Research Questions

The aim of our study was to find out what expertise biology teachers show related to the four specific expertise areas described above; respectively, the subject matter, pedagogical content, interpersonal and moral expertise areas. In order to reach this aim, we explored two types of practices. In the first part of this project, we explored genetic testing practices in order to find out what subject matter expertise is needed. This subject matter expertise is outlined above and reported in more detail by Van der Zande et al. (in press). In the current study, we wanted to find out what expertise is needed in the three other expertise areas, and we explored the practices and ideas of biology teachers. Experienced teachers were expected to provide us with suggestions for needed expertise and also to indicate what expertise still needs to be developed. We wanted to find out both their ideas on their own and required expertise and consider what they did in their classes. By what they tell and show, supplemented by what they indicate as still difficult or yet to be developed, we intended to derive the needed expertise.

> Our research question was:
> What expertise do experienced biology teachers show in the pedagogical content, the interpersonal and moral expertise areas concerning how to teach genetics in the personal health context of genetic testing?

Method

Participants

For the exploration of current teacher expertise, nine experienced biology teachers were interviewed (Bt.1–Bt.9), This non-random typical case sample (Onwuegbuzie & Leech, 2007) was selected from a list provided by biology teacher educators of the four biggest teacher education institutes in The Netherlands. These teacher educators were asked to provide us with the names of teachers who were known for their expertise in teaching biology in context or were known for discussing

socio-scientific issues with their students. The actual selection was based on convenience (Ibid, 2007, p. 114); we received 15 names from the teacher educators and nine were available.

Expertise is thought to emerge only after long experience. Expert teachers have taught at least 10,000 contact hours (Ropo, 2004). In the Dutch situation, that equals at least nine or ten years of professional practice. The teachers, from eight different schools, had an average teaching experience of 20.7 years and each of them had more then 10 years. Three out of nine were female. Two worked at vocational schools, two in pre-university classes and five at schools with vocational and pre-university education. Five worked at schools with a religious denomination and four at public schools.

Data gathering

The teachers were interviewed using a semi-structured interview. In face-to-face interviews of 60 to 75 minutes, they were questioned about their expertise concerning genetics education and their experience with teaching in the context of genetic testing. For their behaviour in the classroom and tacit expertise, the lessons of five teachers were videotaped and stimulated recall interviews (Sim, 2005) were organised immediately after the observed lessons. These observations were used to illustrate their utterances and to describe the possible consistency between their utterances and their behaviour. All the interviews were recorded and imported as audio files into the software Atlas-ti (Murh, 2006).

To determine the teachers' profile of the experienced teachers, the five teachers and their students filled in the Questionnaire on Teacher Interaction (QTI). The QTI is based on the Model for Interpersonal Teacher Behaviour (Wubbels, Brekelmans, Den Brok, & Van Tartwijk, 2006) (see Figure 3.1). The QTI is a standardised and well evaluated test. In this test the linear combination of the eight scores that represent the eight sectors of the model of Interpersonal Behaviour is used to summarise these scores by means of the underlying two dimensions, Influence and Proximity. The homogeneity of each of the eight scores expressed as the internal consistencies (Cronbach's α) for student ratings at the class level is generally above .80. The agreement between the scores of students in a single class met the general requirements for agreement between observer scores. The internal consistencies (Cronbach's α) of students' scores in one class, when considered as repeated measures, were above .90 (Brekelmans, Wubbels, & Créton, 1990).

We consider congruence between teacher and student perspectives as an indication of teacher's awareness of student perspectives and therefore as an aspect of teacher expertise. The assumption was that the profiles of this teacher

sample would indicate the sought-for profiles for all biology teachers who want to teach genetics in this situated learning approach.

Data analysis

For each teacher interview, statements referring to expertise were categorised in the different expertise areas in the form of a single case matrix (Miles & Huberman, 1994). Interrater reliability was checked by comparison with the scoring of 50 interview fragments within these four categories by a second researcher (Cohen's Kappa = .80).

For moral expertise, we used given classifications, so we formulated detailed codes concerning the self-reported characterisation of the chosen role they played in a class discussion or debate (Harwood, 1998), and their utterances concerning their pedagogical approach in moral reasoning with students (Ritzen, 2004). These codes were analysed in a cross-case matrix analysis (Miles & Huberman, 1994). The idea behind this was that not all roles and approaches are relevant or effective for teaching genetics in context, and the results of the teacher sample indicated what roles and approaches are. Since, when describing their approach for moral education, the teachers did not use the concepts used in the literature, we had to interpret their utterances. To check the interrater reliability of the four pedagogical approach codes, a second researcher was asked to code 35 interview fragments (Cohen's Kappa = .74). The prescribed minimum fragments needed for checking the interrater reliability in this case is 32. Cicchetti (1976); minimum $\geq 2n^2$, n = number of categories.

The QTI's filled in by the teachers were compared with the QTI's filled in by their students. The dimension scores for the five teachers were interpreted based on their position in a graph representing the two dimensions of the model for interpersonal teacher behaviour (Figure 3.1).

Results

Pedagogical Content Expertise

To meet the complexity of genetic education, the experienced teachers recommended variation in the use of teaching and learning activities. During genetics lessons, these nine experienced teachers used an average of 11 different teaching and learning activities (varying between eight and 17). Table 3.4 shows the teaching and learning activities for teaching genetics mentioned by the experienced teachers. As can be seen in this Table, the teachers used narratives such as stories or multi-media, discussions varying from teacher-centred (chalk and talk) to entirely

student-centred (think, pair, share and problem-based small groups), whole class activities as well as group work and individual assignments, a variety of practical lessons and assignments for presentation (poster), evaluation (writing assignments) or reflection (yes/no interlude).

The following quotation from one of the experienced teachers illustrates the kind of 'mixed-methods' approach these experienced teachers use when they teach genetics in the context of genetic testing:

> Last year we started with the context of cystic fibrosis and worked with the yo-yo method of Knippels from the organism level via translation and transcription back to the molecular level of DNA. I used a lot of animations from the web, but also a television program. Next, I used several practical lessons and do-assignments, for example they had to build the molecules with Lego© blocks, and they had to design the whole process via the *Doing DNA Method*[1] (quote from teacher Bt3).

The use of different teaching and learning activities was strongly linked to their ideas on student learning. All of them labelled variation in teaching and learning activities as an important way to stimulate learning, next to dialogue (seven out of nine). Teacher Bt2 mentioned that in dialogue, students not only stimulate each other, but by questioning each other, they also function as *mind sharpeners* (Bt3), and in the dialogue they bring in their different perspectives, so important in these controversial issues (Bt6).

Zooming in on the situated learning approach, six out of the nine experienced teachers reported some form of problem-based learning. They explained their preference for this approach through referring to their (more or less) constructivist educational vision. Students were stimulated to construct their own conceptual understanding of a given problem, and a variable degree of student regulation of the learning processes could be distinguished.

[1] See (Van Duin, 2003)

Table 3.4.
Teaching and learning activities for genetics education mentioned by the experienced teachers (n = 9).

Teaching and learning Activities	
1. Stories	8. Concept list, concept map
a. Dilemma stories	9. Mind mapping
b. Newspaper reports	10. Computer simulations (on internet)
c. Student stories (story telling)	11. Practical
d. Case studies	a. Microscopy (e.g. root tips)
e. Patients sites on the internet	b. Drosophila crossings
2. Guest speakers	c. Doing DNA (a cut, paste and paint assignment) [a]
3. Whole class discussions	d. Extracting DNA
a. Chalk and Talk	e. DNA mobile lab [b]
b. Teacher guided discussion	f. Chromosome practical [c]
c. Role-play	g. Using LEGO© building blocks or beads for explaining DNA and sequencing.
d. Debate	h. Visualising mitosis and meiosis (e.g. with shoes, clothes-pegs)
e. Socratic discussion	12. Training in crossing exercises
f. Panel discussion	13. Making a family pedigree
g. Think, pair, share	14. Yes/no interlude
h. Statement-discussion	15. Writing assignments (e.g. essays)
4. Group work	16. Excursions
a. Small group discussions	17. Internships
b. Gender related small groups	18. PowerPoint presentations
c. Problem based small group assignments	19. Poster presentations
5. Multi-media	20. Opinion writing assignments
a. Video	21. Design of an information folder
b. Movies	
c. TV-programs, documentaries	
6. Small scale models	
7. Reading the biology schoolbook	

[a] See Van Duin (2003), [b] See Van Mil (2010), [c] See Knippels (2002)

In their problem-based approach, they used role-play and working in small groups. For instance, one of the respondent teachers (Bt4) transformed his class from 24 students into 12 grown-up couples who intended to have children. They all learned that there were different genetic disorders in their family. They had to puzzle out the heredity of 'their' disorder, and to report to their peer students about it, including whether or not they would request a genetic test or not.

One experienced teacher (Bt5) did not mention problem-based learning during the interview, but classroom-observation showed that he used all kinds of problem-based questions to engage his students in mastering genetic concepts. Within the frame of their problem-based approaches, the teachers used a variety of teaching and learning activities such as case studies, concept mapping and student presentations.

Next to these problem-based activities, they all used narrative methods (films, documentaries or personal stories) to start their lessons, so as to achieve empathetic involvement they described in the stimulated recall interviews. In doing so, they invited students to change perspectives with patients and provoked the moral emotion of empathy. They considered empathy as a motivational factor as the following quotations illustrate.

> When students are '*touched*', they get involved and are more motivated to cooperate, to learn things (Bt5).

> Empathy enables students to change perspectives. Those who can't change perspectives often hold indisputable black-white opinions (Bt6).

The next observation illustrates these interview findings. The teacher who transformed his class from 24 students into 12 grown-up couples (Bt4) introduced the lessons by a documentary on a boy with Duchenne muscular dystrophy, and used a short self-made story to start the assignment. While playing 'Have I told you lately that I loved you?' by Van Morison in the background, he explained to his students that:

> On this average Monday morning, at 8.50 hr., in classroom 11 of our school, miraculous cosmic radiation, special weather conditions and sounds from outside met each other at the right time in the right place, and created together a very special energy field. Suddenly, certain students appeared to have developed intense warm feelings for each other, and the subsequent couples were made; Yuri and Robin, Sufian and Melida,…

As explained above, after forming these couples, they were supposed to imagine that they planned to have children. Then, all couples learned that there were different genetic disorders in their family. The fragment shows how the teacher first tried to interest his students in the issue of genetic testing through their empathy for the boy with Duchenne. Next, he tried to transfer this interest in a need to know

by inviting them, in a narrative way, to imagine themselves in a situation that could be recognisable for them in a few years time, and in which they might need proper knowledge of genetics.

Concerning moral reasoning, the teachers reported class discussions and role-play based on rational argumentation. Although personal reflection was reported to be important, teaching and learning activities for reflection on moral reasoning were not yet a common part of their expertise. Only two teachers mentioned activities selected explicitly for enabling reflection on different kinds of considerations, like *'opinion-writing in gender-related small groups'*, and *'yes/no, agree/disagree or 0/10 interlude'*. During the latter, students physically positioned themselves on a line and justified their positioning in which considerations based on reason and feelings were both accepted. The teachers explained the activity as follows:

> (…) it is very physical in space, almost literally, where do you want to stand, where do you stand for? (…) Entirely on zero or ten? Or somewhere in between? Where exactly? And can you explain it? They feel it, literally in their bodies when they change positions due to the argumentations of their peers (Bt5).

This teacher stressed the physical awareness students have when they change their position due to a change in argumentation. Because they move their body, they are very aware that they change their mind. It is this awareness that might help the students to remember that it is possible and acceptable to change your opinion due to dialogue in which you listen to and consider the argumentation of your peers.

Interpersonal expertise

All teachers mentioned good interpersonal relations as an important precondition for this kind of education. Open communication, shared goals, mutual understanding and acceptance were all mentioned repeatedly by the nine teachers. In addition, they mentioned safety (nine out of nine) or a safe atmosphere (four out of nine). On being asked how they tried to achieve that, they mentioned, for instance, comfort and avoidance of confusion and disorder, well-structured lessons (eight times), clear rules of conduct (seven times) and making interventions when students say or do something that does not fit within the rules. The teachers summarised this role as '*being a good pedagogue*' (eight times) or '*a sharp coach'* (once). A pleasant classroom, for example walls decorated with materials made by

the students, was also mentioned. Creating a safe atmosphere is not only a matter of planned action, but being a sensitive teacher is also part of it, as the following classroom observation illustrates.

> A student of one of the teachers had agreed with the teacher that she would tell her classmates about her genetic disease, Marfan syndrome. However, when the moment was there, she shied away; with cast down eyes she tried not to meet the teachers gaze. He continued talking about other things, walked to her, looked at her, she looked back, and he continued with the lesson, as if nothing had happened. He never asked her to tell her story, she relaxed visibly, and the other students would never have noticed a thing, except that her friend moved to sit next to her and put an arm around her to comfort her. When the lesson was over, she expressed her gratitude to her teacher. She herself was taken off guard by her emotional blockade and felt supported by his reaction.

The teachers' self reports about this expertise area were in line with the students perceptions of the interpersonal behaviour of the teachers. According to the QTIs, one of the five observed experienced teachers belonged to the Authoritative profile (Bt2) and the other four to the Authoritative/Tolerant profile. They had the highest scores in the sections 'leadership, helping friendly and understanding', and the lowest scores in the section 'dissatisfied' (see Figure 3.1). The high score for leadership is in line with the teachers' emphasis on providing structure and rules in classrooms.

Moral expertise

Because controversial issues such as genetic testing bring ethical questions into the classroom, the way teachers fulfil their role as moral educators is of interest. On being asked about their responsibilities as educators, the teachers indicated that they realised that they were role models for their students. During discussions and role-play, most experienced teachers took the stance of value development and value communication (eight out of nine). The teacher in the next fragment describes why he appreciates some approaches more than others.

> I: What do you mean by opinion forming?
> Bt3 (laughing): Well, most of them already have an opinion. Sometimes it needs nuancing and substantiating.
> I: And how do you do that?

> Bt3: I try to organise it in such way that they help each other. My first argument is that I don't feel competent enough to supervise all these discussions (…) but more important is that I think it is better, stronger when they discus these issues among themselves. If I would influence them too much it would become value transfer. When they themselves bring in the different perspectives, arguments and nuances (…) then it can become value communication.

The teacher indicated that he supported value development in the sense of nuancing and substantiating. In his case, this development was stimulated through value communication, because he trusted student dialogue to be effective in helping them to develop their values. At the same time, he tried not to be too influential because he did not adhere to value transfer in this educational setting.

Teachers working in schools with a religious denomination (five out of nine) sometimes took the position of value transfer, in case they thought their students were wrong from a biblical point of view (two out of five). The following is an example of this:

> Bt7: Look, our school is from the reformist protestant denomination, so all of us are brought up with the values of the Bible (…) and when they have a discussion where one says this and the other says that … I think that I need to steer them to look at what the Bible has to say. Is that applicable here? You cannot say that it does not count when it comes into your personal life (…) that it does not suit you well now (…) and I think it is very valuable when they question each other on such issues and start to think about them…

These teachers made clear that, for them, being a religious person is not a value-free position, and they sometimes thought it wise to confront their students with the values promoted in their religious referential frame, in this case the Bible.

In the interviews, three of the teachers explained that they chose the role of 'absent leader' (sometimes 'neutral facilitator') during discussions and role-play, and six of them were mostly the 'committed instructor'. For the five teachers we observed in the classroom, these statements were in line with what we witnessed.

Expertise to be improved

The experienced teachers appointed one area of expertise where they would like to develop their expertise. They labelled reflection on students' moral reasoning relevant when teaching socio-scientific issues and all of them paid attention to the way students argue during debate or dialogue. However, seven out of the nine

teachers indicated that they did not feel skilled enough to support their students during reflection on their moral reasoning. They had no teaching or learning activities to their disposal; at least, they were not aware of such teaching or learning activities.

General concerns

Finally, some general concerns indicated by the experienced teachers will be reported. A situated learning approach, such as teaching genetics in the context of genetic testing, can demand reshuffling the content in the curriculum as expressed by one teacher:

> Normally, we discuss the subject of cancer when we are teaching meiosis and mitosis, and not within genetics (Bt1).

Besides, one teacher explains that teaching socio-scientific issues can lead to a struggle with the time table:

> You know, the problem is that we have to work with the national curriculum, the exams. We have to teach all these subjects, and although some topics are in my opinion more important for the students than others, the time factor is decisive. I would like to spend much more time on these kinds of controversial issues, but you have to keep on going (Bt2).

These general concerns indicate that, in order to achieve more situated learning in biology education, the needed expertise must be described, but consequences on the curriculum level (for example structure and timetable) should also be considered.

Discussion and conclusions

Our central question was: what expertise do experienced biology teachers show in the pedagogical content, interpersonal and moral expertise areas concerning how to teach genetics in the personal health context of genetic testing?

The aim of this study was to find out what expertise biology teachers need to teach genetics in the genetic testing context. In the first part of this research project, we described the needed subject matter expertise (Van der Zande et al., 2009; in press). The explorations of the educational practice of experienced biology teachers reported in this paper indicated the necessary expertise in the areas of

pedagogical content, interpersonal, and moral expertise. Table 3.5 gives an overview of these suggestions.

In the pedagogical content expertise area, the teachers all used a variety of teaching and learning activities, for example narratives to evoke empathy, activities aimed at perspective taking and role-play. The experienced teachers showed a preference for problem-based education in order to stimulate active knowledge construction by students. This problem-based approach is in line with the constructivist learning theory that is viewed as suitable for this kind of context-based education (Boersma et al., 2007).

Table 3.5
Expertise for Teaching Genetics in the Context of Genetic Testing

Area of expertise	Aspects of expertise area
Subject matter expertise	Curricular genetics concepts Extracurricular genetics concepts Ethical, legal and social aspects of genetic testing Characteristics of genetic testing practice Medical information genetic tests Knowledge of students' moral reasoning
Pedagogical content expertise	The use of narratives The use of problem-based approaches The use of teaching and learning activities for (reflection on) moral reasoning
Interpersonal expertise	Creating a safe atmosphere Good relations with students
Moral expertise	Applying different roles in a classroom discussion Applying different approaches for moral education

A main feature of expertise can be found in interpersonal expertise. The teachers made it clear that for teaching socio-scientific issues such as genetic testing, a safe atmosphere is important. They indicated the importance of being able to create this safety, and having the capability to establish and maintain good interpersonal relationships with students. Congruent with this, the experienced teachers mainly had the Tolerant/Authoritative profile according to their students and themselves. Teachers with these profiles have, according to their students, relatively high levels of Influence and Proximity and are referred to as showing the relevant interpersonal expertise.

Regarding moral expertise, preference for the stance of value development and value communication came to the fore, as did the role of 'absent leader' or 'committed instructor' during class discussion and role-play. What additional expertise for teaching genetics in the personal health context of genetic testing needs to be developed according to the experienced biology teachers? By declaring how they approached their teaching in context, they pointed out expertise that could be developed by less experienced teachers. Although the teachers recognised the need for teaching and learning activities for (reflection on) moral reasoning, they indicated that this part of their expertise could be improved. This is in line with the recommendations of Dawson and Venville (2010) who stated that teachers need support on how to strengthen student argumentation concerning socio-scientific issues.

By showing similar expertise in the four areas, the experienced teachers implicitly showed that other characteristics might not suit good teaching practice in the health context of genetic testing. Exclusive use of the approach of value transfer (Ritzen, 2004), and the roles of participant, devil's advocate and interviewer in moral class discussions (Harwood, 1998) were not mentioned. It is our assumption that they did not perform these roles because it could imply a dominant teacher role, contrasting with their preference for activating teaching methods. The interpersonal teacher profiles Directive, Uncertain/Tolerant, Uncertain/Aggressive, Drudging and Repressive were not present among the experienced teachers. The prevalence of the Tolerant/Authoritative profile amongst experienced teachers in this context above others was in line with our expectations, as this profile corresponds with criteria formulated by Haidt (2001) for moral reflection.

Although activities aimed at improving moral reasoning of the students are part of the required expertise, we learned from the teachers that new teaching and learning activities for reflection on moral reasoning would be welcomed. This call for new activities can fuse with recent psychological and neurobiological findings. There are a growing number of indications that we make our moral decisions based on intuition and emotion. We use our arguments only to justify our position, after this position is taken intuitively (Damasio, 1994; Dijksterhuis, 2007; Sunstein, 2005). Our common rational approach to moral education needs to be broadened. There are researchers who have indicated that intuitive and emotive reasoning play an important role in informal reasoning by students (Sadler & Zeidler, 2005). Especially, the notion that we have to incorporate intuition and emotion in our moral reflection is a rather new one in the educational world where rationalistic reasoning is more practised and reported in the literature (Bögeholz, Höble, Langlet, Sander, & Schlüter, 2004; V. Dawson, 2003; Ratcliffe & Grace, 2003). The

development of new teaching and learning activities which aim at improving the moral reasoning of students is most welcome (Van der Zande et al., 2009b). This should be followed by the development of teacher expertise concerning these activities.

Two suggestions and follow-up questions spring from these findings. First, we recommend further development (of expertise) of teaching and learning activities for teaching socio-scientific issues such as genetic testing and particularly the development of teaching and learning activities for (reflection on) moral reasoning in science education. What is moral reasoning and how can you reflect on it? Early explorations in this direction are already made in the research project reported here (Van der Zande et al., 2009b).

Next, the question can be raised as to how biology teachers can acquire the expertise to teach genetics in context. What developmental trajectory can contribute to biology teachers' learning to teach a socio-scientific issue such as genetic testing? This study provides several essential ideas and building blocks for the expertise development of biology teachers in such a developmental trajectory.

Chapter 4

Moral Reasoning in Genetics Education*

Ah yet, when all is thought and said,
the heart still overrules the head

Arthur Hugh Clough

Abstract

Recent neuropsychological research suggests that intuition and emotion play a role in our reasoning when we are confronted with moral dilemmas. The idea to incorporate intuition and emotion in moral reflection is rather new in the educational world, where rationalistic reasoning is preferred. To develop a teaching and learning strategy to address this moral reflection, a research project aimed at empowering biology teachers for moral education in context-based genetics was started. The first focus was on how intuitive and emotive considerations are dealt with in present moral education. Fifteen pre-university students were interviewed on their way of reasoning by confronting them with real-life situations. Next, nine experienced biology teachers were interviewed about their approach to moral education, and about their views on student reasoning. These findings were confronted with suggestions found in literature on moral reasoning. All students used intuitive, emotive, and rationalistic considerations during the interviews. Teachers reported that they observed students using intuition and emotion in their reasoning. However, conceptual distinction between emotive and intuitive reasoning proved to be difficult for students and teachers. Neither the educational literature nor the interviews yielded an articulated pedagogical approach in which these considerations played a role in moral reflection.

* Van der Zande, P., Brekelmans, M., Vermunt, J. D., & Waarlo, A. J. (2009). Moral reasoning in genetics education. Journal of Biological Education, 44(1), 31-36.

Introduction

Today, three developments are challenging science teachers. The first development is scientific. Now more than ever there is a rapidly increasing body of biomedical knowledge with important consequences for citizens. Recently, scientists have sequenced the human genome and this knowledge has a huge impact on biomedical science. Scientists try to benefit from this knowledge, e.g. in tackling health problems like cancer by developing gene-based pre-symptomatic testing (Collins et al., 2003). Due to these new insights, patients are faced with an increasing number of decisions, each with its own ethical, legal, and social implications. In their vision for the future of genomics research, they explicitly state that "high-school students will be the users of genomic information (……) high-school educators need information and materials about genomics, to use in their classrooms" (Collins et al., 2003, page 841).

Secondly, there is a tendency in science education to make education more relevant by teaching science in context. Relevance can be a motivational learning factor for students (Boersma et al., 2007). Also, it can help to prepare for future citizenship (Aikenhead, 2006; Levinson, 2006; Ratcliffe & Grace, 2003). Education within the context of genetic testing in health care can empower students for future complicated decisions with moral implications.

The third development is a combined result of psychological and neuro-biological findings. There is a growing number of indications that we make our moral decisions based on intuition and emotion. We use our arguments only to justify our position, after this position is taken intuitively (Damasio, 1994; Dijksterhuis, 2007; Sunstein, 2005). Thus, our usual rational approach to moral education is getting out of date. Although there are researchers who have indicated that intuitive and emotive reasoning plays an important role in informal reasoning by students (Sadler & Zeidler, 2005), especially the notion that we have to incorporate intuition and emotion in our moral reflection is a rather new one in the educational world where rationalistic reasoning is more valued and practised (Bögeholz et al., 2004; V. Dawson, 2003; Ratcliffe & Grace, 2003). If we want to prepare our students for future decision making, science education can do so by translating these psychological and neurobiological insights into the classroom practice. Our research project aims at supporting biology teachers in developing the accessory expertise. Therefore, we wanted to find out what kind of moral reasoning students use, prior to any experiences with moral education in biology lessons, and what the actual knowledge of experienced teachers about student moral reasoning is.

Moral reasoning

Prenatal diagnostics or presymptomatic genetic testing in healthcare are relevant contexts for genetics education. In real life, these are controversial issues and people are confronted with difficult choices. The biomedical knowledge is not always decisive, test outcomes are not as unambiguous as you want them to be, and other people (i.e., family members) are also involved in the process. People often make their choices on personal (moral) grounds, not based on scientific knowledge at all. As future citizens, students may have to deal with this scientific uncertainty, and are better off if they know what genetic knowledge means to them personally, how to value biomedical information. Thus, students will benefit from education that prepares them to deal with these kinds of choices in moral dilemmas (Ratcliffe & Grace, 2003). To achieve that goal, teachers can teach students how to reflect on their moral reasoning, and that kind of reflection is rather new in the science classroom.

In this article we build on the definition of moral reasoning Haidt uses: "a conscious mental activity that consists of transforming given information about people or situations in order to reach a moral judgement", and moral judgements are "evaluations (good versus bad) of the actions or character of a person that are made with respect to a set of virtues held by a culture or subculture to be obligatory" (Haidt, 2001p. 6). In his Social Intuitionist Model (SIM) Haidt states that moral judgement is caused by intuitions, and can be improved through social and reasoned persuasion. If we want to improve the moral reasoning of our students, we can create opportunities for moral reflection in a social setting.

First, we have to identify the different kind of considerations that can be used in moral reasoning. Sadler and Zeidler (2005) described three kinds of reasoning;

1. Rationalistic reasoning with reason-based considerations
2. Emotive reasoning with care-based considerations
3. Intuitive reasoning with considerations based on immediate reactions.

In rationalistic reasoning, prominent in education, two types of arguments can be distinguished; (a) hypothetical, under assumption, but still logically reasoned, and (b) empirical, proven facts.

In emotive informal reasoning as mentioned by Sadler and Zeidler, the care-based considerations like empathy, are considerations directed at others. We think it is worthwhile to extend emotive reasoning with the basic emotions like anger, joy, sorrow, fear and surprise (Evans, 2001). These basic emotions are self-directed, and often also crucial in moral reasoning. These emotions, preceded by thoughts that are worth exploring and explicating, can be seen as value-indicators (Nussbaum, 2001). In general, intuition is described as the 'immediate knowing'. It

involves “all psychological processes of which we are not conscious although they do influence our behaviour (or our thinking, or our emotions)” (Dijksterhuis, 2007, page 40). Haidt (2001, page 6) specified intuition into moral intuition “the sudden appearance in consciousness of a moral judgment, including an affective valence (good-bad, like-dislike) without any conscious awareness of having gone through steps of search, weighting evidence or inferring a conclusion”. Besides this immediate knowing, rationalist ethical intuitionism defines another use of intuition, referring to prima facie duties. In this deontological ethical theory, prima facie duties are obligations that, on first examination, are intuitively known and self-evident; self-evident in the sense that it is evident without any need of proof, or of evidence beyond itself (Audi, 2004). In the 1930’s, Ross proposed a list of prima facie duties like duties of fidelity, justice, gratitude, beneficence, and non-injury. Ross claimed that these duties are not self-evident since the beginning of our life, but they become so due to experience and “when we have reached sufficient mental maturity and have given sufficient attention to the proposition” (Ross in Audi, 2004, page 41). In high school, reflection on the expression of prima facie duties by students can be worthwhile, because often the mental maturity and the sufficient attention can be questioned. In our research, we will also include this deontological use of intuition in intuitive reasoning.

Relevance of emotions and intuition for moral reasoning

Brain-research indicates the importance of emotions in moral reasoning. People with damage restricted to the ventro-medial area of the pre-frontal cortex are not capable of experiencing emotions. They are not capable of making rational decisions that are socially acceptable (Damasio, 1994; Phelps, 2004). People with brain damage in the amygdala also show crippled emotional responsiveness to one's behavioural choices. They fail to make social acceptable moral decisions (Damasio, 1994). Not only do we need our emotions to balance possible actions against each other, our emotions are also strong founders of our intuitions (Nussbaum, 2001). The fact is that intuitions are built on experiences in the past, and on the emotional reactions felt during previous actions. In addition, feedback from significant others like parents, and the private reflections on these actions also contribute. Because reflection and feedback can contain logical reasoning and factual information, intuition has an emotional and a rational input.

By definition, intuition is unconscious. Only after our unconscious mind has come to a conclusion, we, acting as an advocate, think of the arguments to substantiate our ‘opinion’. Although rational arguments are used to justify our choices, we rarely change our opinion due to these arguments (Dijksterhuis, 2007;

Haidt, 2001). This 'post hoc' explanation is what teachers frequently require from their students in the classroom. But if the students are not invited to evaluate their intuitions or to reflect on the origin of their emotions, it seems plausible that they will not improve their moral reasoning.

Moreover, although our thinking and acting might often be based on intuition and emotion, this does not mean intuition always leads to morally correct behaviour. Some intuitions and emotions are based on prejudices and 'gut-level'-feelings, and should be subject to rational scrutiny (Hunt, 2006). This rational scrutiny, this reflection on the intuitions and emotions that lead to their actions can increase their cognitions. Most situations allow more than one interpretation. The question is whether their interpretation is the only possible one. Do the emotions, that established an intuition in the past, still mirror your present values? When emotions are indicators of values, appropriating other values can change emotional valuation of a situation. Thus, reflection can result in new cognitions, adjusting future intuitive actions (Haidt, 2001).

Use of emotions and intuition in moral reflection

For moral reflection Haidt introduces his SIM: 'The central claim of the social intuitionist model is that moral judgment is caused by quick moral intuitions, and is followed (when needed) by slow, ex-post facto moral reasoning' (Haidt, 2001, page 5). Due to reflection on this ex-post facto reasoning people may be capable to change their intuitions, either through private reflection, for instance initiated through a role play, or through social persuasion, when they get feedback from people they respect.

> Because people are highly attuned to the emergence of group norms, the model proposes that the mere fact that friends, allies, and acquaintances have made a moral judgment exerts a direct influence on others, even if no reasoned persuasion is used. Such social forces may elicit only outward conformity, but in many cases people's privately held judgments are directly shaped by the judgments of others (ibid, page 7).

This influence mentioned in Haidt's model, can be profited from in classroom. In education students can reflect on their moral reasoning with the help of fellow students and teachers they like and trust.

Research questions

In mapping the required teacher's expertise, we first focus on a crucial element of that expertise, i.e. moral reasoning, and its promotion.

Review of relevant literature may help to identify general characteristics of moral reasoning. Student reasoning was already investigated among college students (Sadler & Zeidler, 2005) and high school students after lessons about DNA-testing (Dawson, 2003). However, we were more interested in the ways students reasoned prior to any experience with moral reflection in science education. We considered this as pre-knowledge for teachers, and thus part of the sought-after expertise. Next, we wanted to find out how teachers perceived their students' reasoning and how their perceptions affected their teaching.

The research questions have been specified as follows:

1. What kind of reasoning do students use in discussing controversial genetic issues prior to any education on this subject?
    a. What kind of considerations do students use when confronted with controversial genetic issues?
    b. Are students aware of the considerations they use?
2. What is the knowledge of experienced teachers about student moral reasoning?
    a. What kind of considerations do they discern in the moral reasoning of their students?
    b. What kind of considerations do they take into account in their teaching of controversial genetic issues?
    c. How do they take these considerations into account in their teaching of controversial genetic issues?

The answers to these questions should provide design criteria for genetic education in the context.

Method

Study 1: Student reasoning

Participants

To investigate students' reasoning, 15 high school students, 14-15 years of age, were interviewed individually. Criteria to select an interviewee were (a) representatives of the range in Dutch educational levels, vocational and pre university, and (b) a good mix of boys (7) and girls (8). All students had followed introduction lessons in Mendelian genetics during junior secondary education.

Instrumentation

The students were asked to classify their preferential considerations. The question was straightforward: What kind of considerations do you use, when you have to

make an important decision? Discussing cases, later on in the interviews, the students were occasionally asked: How did you arrive at this point of view or at this decision? They were invited to express whether they relied on reason, emotion or intuition. Next to this self reported pattern, their way of reasoning was probed by confronting them with real-life situations. They were asked what they would do and why. The dilemmatic situations were presented to them in two cases. One case was about a young mother who doubted whether or not she should accept her doctor's offer for prenatal diagnosis. The other case dealt with a young adult who wondered if he or she should undergo a pre symptomatic genetic test. The test appeared to be relevant because of an affected family member.

Data analysis

The interviews were recorded and imported as audio files into the software Atlas-ti (Murh, 2006). Student considerations were extracted from their answers and classified after the three types of considerations reported by Sadler and Zeidler (2005). Rationalistic considerations included arguments concerning the severity of disease conditions, the possibilities of modern medical treatment, the calculus of probabilities, etc. Reasoning was considered intuitive when a student immediately knew how to act, to approve something or not, and when a student referred to a prima facie duty. As mentioned before, by emotive reasoning, we added the basic emotions to Sadler and Zeidler's care based emotions. Interrater reliability of the coding of the three types of considerations was checked by comparison with the coding of 20 interview fragments by a research colleague (Cohens Kappa = 0,89).

Study 2: Teachers expertise

Participants

For the exploration of teaching expertise eight experienced biology teachers, from seven different schools, with an average teaching experience of 19.3 years, were interviewed. Three out of eight were female, five male. Two worked at vocational schools, two in pre-university classes, and four at schools with vocational and pre-university education. Five worked at schools with a religious denomination, three at public schools.

Instrumentation

The teachers were interviewed using a semi-structured interview. In face-to-face interviews they were questioned about their perceptions of student reasoning, whether and how they addressed moral reasoning in their lessons and how they promoted moral reasoning in their classes.

Data analysis

The interviews were recorded and fully transcribed. The interviews were imported as word files into Atlas-ti (Murh, 2006). The statements were analyzed in a single case matrix (Miles & Huberman, 1994). Teachers' labelling of students' considerations were classified after the three considerations reported by Sadler and Zeidler (2005). The interviews of the teachers were analysed on self reported knowledge and application of the main concepts of our theoretical framework on moral reasoning, whether they paid attention to the different kinds of considerations or not, and the (unintentional) use of elements of Haidt's SIM. From their utterances we tried to induce a description of their teaching profile, the conditions they reported necessary for moral education, and the activities undertaken concerning moral reflection with their students.

Results

Study 1: Student reasoning

Self-reported considerations

None of the students reported the use of all three types of considerations in their reasoning. On being asked, 53 % of the students reported that they acted on the basis of emotive considerations, or 'their feelings' as they put it. 20 % thought they mainly used rationalistic considerations, or 'their head', and 26 % said that they used both kinds of reasoning. None of them said that intuition was the main source.

Actual consideration.

In line with the findings of Sadler and Zeidler (2005), all 15 students showed the three types of considerations in their reasoning, especially when their argumentation was of longer length, no matter what their self-reported reasoning had been. We will exemplify this with a quote from a student who mentioned only emotive reasoning in her self-reportage.

When discussing the dilemmatic cases during the interview however, she also used the considerations of the other types. The quote deals with preventive mastectomy.

> Interviewer: "What do you think about it?"
> Student: "Well, actually I think it is a bit nonsense."
> Interviewer: "Because?"
> Student: "Because you don't know actually whether you'll get it or not. For women it is important, after breast surgery you don't feel at ease, not feminine anymore…. So I think it is a little bit…it is nonsense to operate upfront…the fear

> for it, for the uncertainty is a bit exaggerated because perhaps you will never get it. And when you get it, you can always try to operate then. To do it upfront, I think is a bit exaggerated."

The student used-care based considerations (the women don't feel feminine anymore) and basic emotions (they fear for it). But she also used rationalistic reasoning by using logic (when you get it, you can always operate then).

> Interviewer: "So you have heard about children with Down syndrome. Some people say that they are welcome, they let them be born. Others say 'well, first I want to think about that thoroughly'. What do you think?"
> Student: "I would let it be born, it is my child."
> Interviewer: "……yes…"
> Student: "Not only do I know something about Down children, but it is my child! I will not let it be taken away, it is my child."

Here she used a rational and an intuitive consideration. Because she knew something about Down children she would let it be born. For her this is empirical knowledge. This was labelled rationalistic reasoning. But the other strong motive was: 'I will not let it be taken away, it is my child', a consideration she did not explain further, for her it did not need any further explanation. This was labelled intuitive reasoning because of the underlying prima facie value of non-injury.

Study 2: Teacher expertise; the experienced teachers

Teachers' view on student reasoning

The eight experienced teachers mentioned two different ways of student reasoning: rationalistic and emotional considerations, based on 'feelings or intuition'. Conceptually, none of the teachers made a differentiation between emotive and intuitive reasoning.

Reasoning in the classroom

Although the teachers all recognized two different types of reasoning, only one reported that she did take these differences into account. She explicitly accepted the implications of emotive considerations.

> Teacher 5: "Your feelings tell you very clearly whether you are doing wrong or right. But you can always use some rational reflection."

However, in the conceptual framework we use, this moral guideline for appropriate behaviour based on 'feelings', would be labelled intuitive.
During classroom discussions and debate, all teachers reported to reflect on the quality of rationalistic reasoning. Three of them mentioned a role of emotions.

Teacher 4: "Emotions can block rational reflection about a possible decision."

Although teachers were aware of the different kinds of reasoning, this knowledge did not resonate in their choice of learning activities concerning moral reflection. At the best they started the lessons with narrative activities (video, case studies) to elicit care-based emotions like empathy, so as to get their students motivated.

The practice of promoting moral reasoning
The teachers could roughly be divided into two groups. Four out of eight teachers started from the idea that moral development of students was a personal constructive process, best stimulated in a social context. Student motivation was a central concept in their thinking.

Teacher 1: "A good context is simply something that gets my students involved…… I'm convinced that when it is relevant, it will lead to motivation, to more attentive students, and to better learning."

On average, these teachers used 16 different learning activities in their genetic lessons, varying from practical and movie, to role play and debate. They reported that they used narrative activities like stories, films or personal experiences of their students to evoke empathy.

Teacher 1: "Empathy leads to involvement and motivation."
Teacher 4: "Empathy enables students to change perspectives."

They were supporters of activating teaching methods, and used elements of cooperative learning. These teachers stressed the importance of the interpersonal perspective. They repeatedly (3 to 8 times) mentioned a safe atmosphere in the classroom, and good relations with their students as essential preconditions for teaching moral. Although the teachers included discussions about moral dilemmas in their biology lessons, they did not refer to the importance of liked and respected group members in moral reflection. Neither did they explicitly take emotive or

intuitive reasoning into account. Even unintentionally, they did not use any elements of Haidt's SIM.

The other four teachers talked about the transfer of values. They stressed more often which values were worthwhile. Student inspiration was a central concept in their thinking.

> Teacher 5 and 6: "Sometimes when I think it is necessary I take the Bible and say: let's see what the Bible tells us to do."

These teachers used an average of 7 different learning activities during their genetic lessons. Reading and working with the school book had a prominent place in their lessons next to storytelling and class discussion. One of these teachers explicitly mentioned emphatic involvement as a key factor, the others intuitively made use of this effect:

> Teachers 5, 6 and 7: "Personal experiences are often a starting point in lessons."

A safe atmosphere in the classroom and good relations with their students were also mentioned by these teachers, when asked for essential conditions for teaching controversial or moral issues. However, compared to the interviews with their colleagues mentioned above, these conditions played a minor role. They referred to them only once or twice.

These teachers did not report planned moral reflection, but spontaneous class discussions with moral dimensions. Neither did they use any elements of Haidt's SIM.

Conclusion and discussion

What kinds of reasoning do students use in controversial genetic issues prior to formal genetics education, and what is the knowledge of experienced teachers about moral reasoning of their students? Can we answer these questions now?
From the interviews we learned that all students used emotive and intuitive reasoning next to rationalistic reasoning, although they were not aware they did. Neither the students, nor the teachers, conceptually made a clear distinction between emotive and intuitive reasoning. The teachers did not translate their knowledge of student reasoning explicitly into their pedagogical approach. Teachers

did use care-based emotions like empathy for motivational goals. Empathy was also used within perspective taking.

The teachers differed in the way they promoted moral reasoning. Some represented a more constructivist approach, others a more classical approach, i.e., playing a more central role in the learning processes. Differences between these two approaches were the number of learning activities applied, and how directive they were in identifying which values were important. All teachers agreed on the importance of a safe atmosphere in the classroom and good relations with their students for teaching moral issues.

The occurrence of the three types of considerations in student reasoning is in line with findings of other researchers (e.g. Dawson, 2003; Sadler and Zeidler, 2005). Our study differed from those studies by the fact that we brought up arguments in support of extending the classification of Sadler and Zeidler. We added basic emotions to emotive reasoning and prima facie duties to intuitive reasoning. Because we found both kinds of considerations in the student reasoning, we consider these results as an affirmation for this refinement of their classification. Sometimes we were unable to unravel emotive and intuitive reasoning due to the use of common language by the students. This interfered with our results; the part of emotive and intuitive considerations would otherwise be greater in their reasoning.

Although experienced teachers do not explicitly reflect with their students on emotive or intuitive considerations in moral issues, this study indicates that there are reasons to do so, if we want to improve student reasoning through science teaching. Recent findings in neurobiology and psychology presented in this article provided arguments for a more prominent role for intuitive and emotive considerations in moral reflection. However, the fact that neither the students, nor the teachers, conceptually made a clear distinction between emotive and intuitive reasoning, made us aware that there are still some questions about the appropriateness of a strict distinction between these two types of reasoning for reflection on moral reasoning in the classroom.

Haidt's Social Intuitionist Model appears to be an interesting possibility for improving moral reasoning. This promising model is one of the rare suggestions found in the literature discussed in this article.

Educational implications

The new insights in moral reasoning indicate that it is important to develop teaching and learning activities in which we take, next to rationalistic reasoning,

intuitive and emotive reasoning into account, that we accept the (partly) emotional basis of intuitions and shape the feedback by respected peers and teachers.

Learning activities that can prompt students to inspect their subjective conceptions of a given situation or dilemma, and to consider alternatives. Activities that invite them to look for the values behind their emotions, to reflect on other possible values and perspectives, and that ask them to subject their intuitions to rational scrutiny, e.g. based on relevant biological or medical information. In short, moral reflection so as to teach the students how to improve their moral reasoning, and by doing so, empowering them for dealing with future moral dilemmas, for example, those concerning genetic testing. To the best of our knowledge, this kind of reflection on moral reasoning is not being practised in secondary education.

There are still some questions about the appropriateness of a strict distinction between emotive and intuitive reasoning for reflection on moral reasoning in the classroom. These classifications proved to be helpful in a research setting and might sharpen the ears of teachers who want to supervise moral reasoning. But nevertheless, they might be too complicated for student use.

We will continue our research with a focus on the design, implementation and evaluation of learning activities based on the ideas behind Haidt's 'Social Intuitionist Model', and based on the premise that students already have an (intuitive) opinion before controversial moral dilemmas are being discussed. After listing relevant biological concepts and dilemma's in genetic testing practices, a team of biology teachers will translate these insights into their educational practice. Those teachers will be monitored in order to describe the expertise they develop during that learning process and the kind of activities that contribute to their learning outcomes. Attention will be paid to the interpersonal perspective and the pedagogical climate, so hopefully their students grow to consider the teachers confidential enough to let the teachers persuade them to reflect on their moral reasoning and learn from that process.

Chapter 5

A Teacher Community for Learning to Teach Socio-Scientific Issues*

Abstract

This study explored the use of a teacher community to develop teachers' expertise for an educational approach based on situated learning theory. Eight biology teachers participated in order to develop expertise for teaching genetics in the context of genetic testing in four areas: subject matter; pedagogical content; moral and interpersonal expertise. Genetic testing is a controversial socio-scientific issue. Teaching such issues involves the professional identity of the teachers. Individual developments are reported using constructed narratives, overall patterns by aggregating individual data. The findings show that the community was useful for expertise development and that this development connects to identity development in terms of self-understanding.

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Introduction

In secondary science education, there is an increasing focus on situated learning in which scientific content is taught in the context of social situations (Bennett & Lubben, 2006; Sadler, 2009; Van Aalsvoort, 2004). For example, the current Dutch curriculum reform of secondary biology education encourages teaching concepts in authentic practices, referred to as contexts (Boersma et al., 2007). Educational approaches based on situated learning theory.aim to ensure that what is learned is relevant (Greeno, 1998; Putnam & Borko, 2000; Sadler, 2009). An example can be found in secondary biology education, where the topic of genetics can be taught in relation to everyday situations concerning genetic testing. Genetic testing is a socio-scientific issue, in the sense that it concerns an issue that: a) has conceptual as well as procedural connections to science, and b) is viewed as socially significant, preferably by the community participants themselves (Sadler, 2009, p.11). Walker and Zeidler (2007) stated that through learning about socio-scientific issues, students can be empowered to reflect not only on the physical and social world around them but also on the (moral) principles behind science-based issues, the decisions made concerning them, and what those decisions mean in terms of their views of a virtuous life.

Despite the increasing interest in situated learning approaches in science education, science teachers are generally unfamiliar or uncomfortable with teaching socio-scientific issues (S. P. Day & Bryce, 2010). Teachers not only find it difficult to organise classroom discussions (Levinson & Turner, 2001; Osborne et al., 2004) and small group discussions on socio-scientific issues (Bennett et al., 2010), but they also need support regarding how to strengthen their students' argumentation concerning these kinds of issues (V. M. Dawson & Venville, 2010).

Our aim in this paper is to better understand how science teachers can be supported when they want to shift towards teaching a socio-scientific issue using a situated learning approach. Some authors have suggested that teacher communities can be fruitful settings in which teachers can learn about educational innovations (cf., Hammerness et al., 2005). We want to find out how this applies to biology teachers who aim to learn to teach genetics in the context of genetic testing. In the following section, we will describe in more detail what expertise is required for a situated learning approach towards teaching genetics, and the ways in which teaching socio-scientific issues might affect one's self-understanding. Then, we will describe the value of teacher communities for teacher learning.

Expertise required for teaching genetics as a socio-scientific issue

As Van der Zande et al. (2009a; 2009b; in press) have shown, there are four areas of expertise that are particularly relevant to learning to teach genetics: 1) subject matter expertise; 2) pedagogical content expertise; 3) interpersonal expertise; and 4) moral expertise. In a previous study, we determined the required expertise for these four areas by interviewing experienced biology teachers with expertise in teaching socio-scientific issues, a well as clients of genetic testing practices, medical professionals and medical ethicists. Table 5.1 provides an overview of the required expertise according to the results of this previous study.

Table 5.1
Expertise required for teaching genetics in the context of genetic testing

Area of expertise	Aspects of this area of expertise
Subject matter expertise	Curricular genetics concepts Extracurricular genetics concepts ELSA[a] of genetic testing Characteristics of genetic testing practices Medical information on genetic tests Knowledge of students' moral reasoning
Pedagogical content expertise	Use of narratives Use of a problem-based approach Use of teacher and learning activities for (reflection on) moral reasoning
Moral expertise	Applying different roles in classroom discussions Applying different approaches for moral education
Interpersonal expertise	Creating a safe atmosphere Good relations with students

[a] ELSA = ethical, legal and social aspects

It has been argued that different bodies of expertise relate to different parts of a teacher's identity. Beijaard, Verloop and Vermunt (2000) found that teachers see their professional identity as consisting of a combination of the distinct aspects of expertise, but also that their perceptions changed throughout their career and professional development. This change in teachers' perceptions of their professional identity might indicate that if biology teachers acquire specific additional expertise, this may influence how they understand who they are as teachers.

Recently, Kelchtermans (2009, p. 263) described five components of teachers' self-understanding as:

1. *Self-image*: how teachers describe themselves (based on self-perception and what others, for example their students and colleagues, mirror back to them). This is the descriptive component;
2. *Self-esteem*: the teacher's appreciation of their actual job performance. This is the evaluative component;
3. *Job-motivation*: what drives the teacher, their motives for becoming and staying a teacher. This is the conative component;
4. *Task-perception*: what the teacher thinks he or she must do in order to be a good teacher. This is the normative component;
5. *Future perspective*: how the teacher sees himself or herself in the years to come and how he or she feels about this. This is the dynamic component.

In addition to studying biology teachers' learning in terms of the four areas of expertise and required expertise (as summarised in Table 5.1), we aim to look at possible changes in teachers' self-understanding.

Teacher communities as a learning environment

In educational research, there is an increasing interest in professional communities as a natural and self-regulating way for professionals to organise their learning. According to Wenger (2000), communities of professionals are considered to be valuable because "they produce a shared repertoire of communal resources-languages, routines, sensibilities, artefacts, tools, stories, styles etc. (…) they offer an opportunity to negotiate competence through an experience of direct participation (p. 229)

In the field of research concerning teachers, many scholars have stressed the value of teacher communities in terms of the professional development of individual teachers as well as for improving teaching and schooling practices (cf. Grossman, Wineburg, & Woolworth, 2001; Hammerness et al., 2005; Little, 2002; Piazza, McNeill, & Hittinger, 2009). Several studies have confirmed the benefits of collaboration between teachers for their professional development (e.g. Meirink, Meijer, Verloop, & Bergen, 2009; Shank, 2006).

Due to the positive findings regarding professional communities, both the organisational and educational fields have started to look for ways to initiate and facilitate professional communities as a way of supporting learning (Hildreth & Kimble, 2004). Akkerman, De Laat and Petter (2008) showed that the deliberate initiation of professional communities is more successful when community members define their personal and shared interests and determine what they want

to achieve as a community. In this study, a shared interest was provided by the current Dutch curriculum reform in the area of secondary biology teaching, which is aimed at teaching concepts in contexts defined as authentic practices (Boersma et al., 2007).

Following the idea that teacher communities are valuable learning environments, the first author initiated a community of biology teachers who were interested in applying a situated learning approach to the topic of genetics. Due to the fact that dialogue between teachers on the controversial issue of genetic testing in the community was expected to challenge the teachers' beliefs, the ways in which the teachers would manage their professional self-understanding was of interest, as well as the development of their expertise. The central question in this paper is: in what way can a teacher community contribute to biology teachers' learning to teach a socio-scientific issue, such as genetic testing?

Method

Initiation and organisation of a teacher community of biology teachers

In order to create an environment in which teachers could learn how to teach context-based genetics, a group of eight biology teachers was initiated by the first author. The aim of this group was to gradually build up a teacher community, that is, a group in which people are engaged in a joint enterprise with a shared repertoire of communal resources, such as routines, sensibilities, artefacts and vocabulary (Lave & Wenger, 1991; E. Wenger, 1999). The joint enterprise of the teachers in this teacher community was to develop, plan, discuss, practise and evaluate teaching and learning activities with regard to genetic testing. The teachers gathered outside their schools, but experimented in their classes with what they developed. They had seven evening meetings of two hours each in a time period of 14 months. Although the first author provided input on genetic testing, an open approach was used and the participating teachers could put their stamp upon the activities and the fine-tuning of the expertise to be learned. Although the participating teachers shared their profession and were therefore likely to share a common vocabulary, they worked at very different schools. This diversity in the social and cultural backgrounds of the teachers was expected to lead to rich dialogues about teaching and the controversial aspects of genetic testing. During the teacher community meetings, activities were planned in relation to the specific areas of expertise.

Subject matter expertise

The information on the relevant subject matter was based on recommendations from experienced teachers and participants in real-life genetic testing practices in the first part of the project (Van der Zande et al, 2009a). In the teacher community, discussions were held about new (extracurricular) concepts, background information regarding the 10 most common genetic disorders, and the ethical, legal and social aspects (ELSA) of genetic testing. The discussions on the ELSA of genetic testing and disorders were illustrated by the teachers' own experiences of genetic testing, pregnancy, child mortality, etc.

Pedagogical content expertise

In the teacher community, the participants developed, practised and evaluated teaching and learning activities, such as (reflection on) moral reasoning. Rough teaching and learning activity outlines were produced by the first author based on the recommendations of experienced teachers in the first part of the project (Van der Zande et al, 2009a). Next, the participants developed, and received peer feedback on, their own materials (a design for a problem-based approach, student instructions for teaching and learning activities), and reported back to the teacher community on how they experienced their lessons. Building blocks for this approach, such as suggestions for narrative starts of the lessons, came from the first author.

Moral expertise

The participants discussed the roles of a teacher and approaches to moral education. These discussions were based on the contextual differences between the teachers' practices i.e. differences in their educational goals, denominational differences between the schools, differences in the pedagogical climate and personal freedom to act as teachers within the different school contexts

Interpersonal expertise

In the teacher community, discussions were held on safe atmosphere regarding how to manage students' emotional reactions to the topic (genetic disorders), and how to deal with the teacher's own emotions.

In order to study interpersonal expertise, Wubbels et al. (Créton, Wubbels, & Hooymayers, 1989; Wubbels et al., 2006) adopted the Leary circumplex model (Leary, 1957) for use in the classroom context, by labelling the two dimensions underlying the model as control and affiliation. Affiliation is conceived as warmth and care, and control as the authority or interpersonal influence a teacher conveys

in class. Research based on the dimensions of control and affiliation has shown that students who perceive more teacher control and affiliation show greater cognitive achievement, engagement and more positive subject-related attitudes than students who perceive their teachers as having lower levels of these dimensions (Brekelmans, Sleegers, & Fraser, 2000; Wubbels et al., 2006). Thus, teachers with relatively high levels of control and affiliation (according to their students) are referred to as showing higher levels of interpersonal expertise. In the current study, the Questionnaire on Teacher Interaction (QTI), filled in by students, was used to map teachers' interpersonal expertise. Students were treated as multiple informants of their teacher's level of expertise (Den Brok, Brekelmans, & Wubbels, 2006; Lüdtke, Robitzsch, Trautwein, & Kunter, 2009). The interpersonal expertise levels of teachers with uncertain/tolerant, uncertain/aggressive, drudging and repressive profiles were considered to be too low (Wubbels et al., 2006) for them to be selected as participants in the teacher community.

The first author took on the role of researcher/expert. By being involved in the description of the required expertise in the first part of the research project, he could provide the teacher community members with the information they needed in order to develop their expertise. In addition, having been a biology teacher for more than 20 years, and a biology teacher educator for 10 years, he was also able to bring in his educational experience.

Finally, a temporary communal website was created, onto which background materials such as literature and information on genetic tests and the ELSA etc. were uploaded, and where the teachers could share the lesson plans and teaching and learning activities they developed.

Participants

Eight teachers participated in the teacher community on a voluntary basis and convenience (Onwuegbuzie & Leech, 2007). Nine teachers expressed an interest in participation after attending a workshop on teaching genetics provided by the first author at a conference for teachers, and 12 teachers responded to an e-mail sent by the same author. Ten out of the 21 respondents actually joined the community, but two gave up prematurely for personal reasons. The eight teachers worked in seven different schools, with an average experience as biology teachers of 4.2 years, and an average age of 35 years old. Half of the teachers were female. One taught only in pre-university classes, and seven at schools which provided both vocational and pre-university education. Two worked at schools belonging to a religious denomination (one catholic, one reformist protestant), and six worked at public schools.

Data gathering

In order to investigate the learning processes of the participants in the teacher community, different instruments were used to capture: 1) the initial situation; 2) the process of development of the individuals and the community; and 3) the outcomes. First, in order to capture the initial situation, the teachers were interviewed for 60 to 75 minutes at the beginning of their participation. The interviews were semi-structured and face-to-face, usually taking place in the teachers' schools. They were questioned about the content they taught in their genetics lessons, and about the extent to which they were familiar with the situated learning approach and teaching genetics in the context of genetic testing. They were also invited to express their pedagogical beliefs regarding student learning and "good education", and their thoughts on the kind of teacher they thought they were and wanted to be. In addition to interviews, during the first meeting the teachers were asked to write down their personal motives and expectations for participating in the project.

Second, in order to capture the process, the teachers were asked to describe a learning experience which they considered to be important at least four times during the project. During the first meeting, the meaning of these notes was discussed, and examples of possible learning activities were mentioned (Bakkenes, Vermunt, & Wubbels, 2010). Bakkenes et al. (2010) elaborated on the learning activities which teachers reported during their learning processes. These activities consist of six main categories, namely *experimenting, considering one's own practice, getting ideas from others, experiencing friction, struggling not to revert to one's old ways* and *avoiding learning*. We extended this categorisation with the categories *linking theory to practice* and *practising* (for a detailed description see Appendix 1). We were also interested in these two activities because of the intended nature of the teacher community, as an environment in which background information on subject matter could be distributed and teaching and learning activities could be practised.

The aim was that the participants should feel free to report any worthwhile learning experiences, and they were not obliged to write about something they had experienced in the context of the teacher community. These learning experiences were collected via e-mail. The teachers who completed the project wrote 31 digital notes in total, describing 53 learning activities. During the process, contextual information was also gathered including: a) materials used in the meetings (agendas, literature, etc.); b) audio recordings of the meetings; c) classroom observations; d) lesson plans and teaching materials developed by the teachers; e) e-mails; and finally f) personal communications.

Third, when the teacher community came to an end, concluding interviews were conducted with all of the biology teachers on an individual basis. These interviews were mostly situated in their homes, and started more openly with the question of what they considered to be the main outcome of the project. The rest of the concluding interviews addressed the same topics as the initial interviews. Both the starting and the concluding interviews were recorded and imported as audio files into the software Atlas-ti (Murh, 2006). After the concluding interviews, the respondents were asked to fill in a tick list that covered all of the elements of the knowledge base required by teachers, as mentioned above (see Table 5.1). In this way, they reported whether or not the project had contributed to the enhancement of their knowledge, and whether their knowledge was now sufficient or still insufficient.

Data analysis

The data analysis consisted of two steps. The first step consisted of the construction of narratives for each individual biology teacher, describing their situation at the start of the project, the process and the outcomes of their participation in the teacher community. People use stories to organise their experiences and give meaning to their lives, and narratives are a way to organise episodes and (accounts of) actions in time (Hermans & Hermans-Jansen, 1995). In this article, narratives are constructed descriptions of the learning processes of individual teachers. Table 5.2 presents the way in which we structured the narratives and indicates what data sources were used.

The reason for constructing narratives is that they allow us to take into account the temporal (for example, relevant personal and work experience), personal and social (for example, the actions and interactions) and contextual aspects (for example, the school context) of a process (Craig, 2007). A member check was conducted in order to determine the validity of their narratives. For the member check, the narratives were presented to the teachers with the question of whether the researcher had captured their experiences in the teacher community correctly. All of the respondents recognised themselves in the narratives constructed by the researchers and found that their most important experiences were included. They recommended only small adjustments in the wording and the description of their contexts (family background, work experience, etc.).

Table 5.2
Structure of constructed narrative

Elements of story	Summary of	Distilled from
Sketch of teacher as a person	Type of person	Researcher observation
	Educational and professional background	Start interview, personal communication and researcher observation
	Relation with researcher	Researcher description
	School context	Initial interviews
Starting situation of teacher	Self-reported motives for participation	Individual notes made during the first meeting
	Self reported (lack of) expertise in the four areas[a]	Initial interviews
Learning process of teacher	Self-reported learning experiences in relation to the type of learning activities	Learning experiences sent by e-mail to researcher
Learning outcomes	Self-reported development in the four expertise areas	Tick list of development of expertise after concluding interview
	Self-reported major outcomes in terms of growth in expertise and change in self-understanding	Concluding interviews

[a] see Table 5.1

The second step in the analysis entailed aggregating individual data about the learning processes and learning outcomes, in order to allow us to say something about the overall patterns. For the learning processes, we aggregated the learning activities reported in the digital notes on learning experiences during the collaborative process. The learning activities were identified by coding all of the digital notes using the categorisation set out by Bakkenes et al. (2010), extended with the categories linking theory to practice and practising. In order to check the interrater reliability of the coding of the learning activities, a second researcher was asked to code all of the digital notes (Cohen's kappa = .79).

For the overall learning outcomes, we aggregated the self-reported expertise in the four areas at the start and end of the trajectory. In addition, we labelled the types of expertise that were valued most. We also counted the changes in the five components of self-understanding as distinguished by Kelchtermans (2009). In order to understand the learning outcomes, we considered how changes in self-understanding related to the most valued areas of expertise.

The researcher and teachers were not "blank slates" for each other. We therefore considered it wise to conduct a summative audit procedure in order to check the reliability and validity of the analyses that resulted in the narratives (S. Akkerman, Admiraal, Brekelmans, & Oost, 2008; Guba, 1981). An auditor is an independent evaluator who judges the quality of the research:

> The main underlying question for the auditor is whether these results and conclusions [of the final product, this article] are grounded in the process of data gathering and data analysis in a way that the auditee made linkages that are visible (visibility), substantiated (comprehensibility), and logically and scientifically acceptable (acceptability) (Akkerman et al., 2008, p. 269).

In order to enable the auditor to conduct quality analyses, the auditee wrote a process document describing the ways in which all of the findings were grounded in the data gathered. For instance, each statement in the narratives was underpinned by elements from one or more data sources. The auditor wrote a report on his findings in which he concluded that, in general, the narratives were illustrative and grounded in the data in a traceable way. The auditor proposed two additional remarks, and questioned the linkages between two statements in the narratives with the data. After looking at the data once more, we accepted his critique and the auditor agreed with the rewritten elements of the stories which we proposed.

Results

In the following section, we will present three of the eight narratives. The three narratives were selected because they represent the different sorts of changes in expertise and self-understanding which were found. Second, we will present the aggregated findings regarding the learning processes and learning outcomes of all of the teachers.

Narratives of biology teachers

The three selected narratives depict the development of Eli, Jack and Dietrich during the teacher community period.

Eli's story

Eli, the mother of three busy boys, is an experienced teacher of 53 years old, with a round, joyful face framed by long, curly hair. Her experience is mostly in teaching science and mathematics, and not so much in biology. As a science teacher, she has not only worked in different schools in the Netherlands, but also in different African countries. Although she has a great deal of experience of teaching, she used to be very modest about her competences. She has only five years of work experience as a biology teacher, and in the first interview she explained how she still felt unconfident when it came to teaching biology.

Eli and I have a long history together,[2] because we know each other from university, some 35 years ago. Over these years, I have come to know her as an active woman with a sober lifestyle, fond of laughing and always busy making things comfortable and nice for her family, friends or students. She grew up in a lively family of 12 children. Her father was a professor in organic chemistry, and she once told me that his intellectual status may have been one of the reasons why she was unwilling to portray herself as being at a similar intellectual level in public, and why she became the modest woman she is.

In recent years, Eli has been working in a well-known Dutch high school, which is famous for its pioneering work and involvement in educational reforms. It is a liberal school with a strong emphasis on tutoring, and she herself is one of the study advisors for students.

She wrote down several motives for volunteering to participate in our project during the first teacher community meeting. First, because she had not been teaching biology in pre-university classes for long, she felt uncertain with regard to her knowledge of molecular genetics and teaching and learning activities concerning that knowledge. In saying this, she articulated a focus on the areas of subject matter and pedagogical content expertise. Another motive was that she wanted to learn more about the current reforms in Dutch biology teaching that are aimed at situated learning, which is again related to pedagogical content. The other motives she wrote down were "becoming inspired" and "becoming a nice and amusing biology teacher". Though these motives could indicate a focus on the area of interpersonal expertise, her explanations on paper suggest that she wanted to become a reliable source of biological information and an inspiring teacher due to a huge variety of appropriate teaching and learning activities. This illustrated her leading motive for participating in the teacher community; she felt uncertain as a biology teacher, and in order to increase her confidence she hoped to learn about

[2] I in the narratives = the first author.

appropriate subject matter with regard to genetics and increase her pedagogical content expertise. At the beginning of the project, she thought she knew enough about the dilemmas that can occur in genetic testing due to her personal experience of the world of genetic testing, and she had enough professional experience and life experience to feel comfortable in her interpersonal and moral roles.

Eli was one of the most dedicated members of the teacher community. She never missed a meeting, and in order to master the new concepts, she read all of the background material shared amongst the members of the teacher community She was one of the few teacher community members who also searched for additional information in newspapers and on the Internet. She wanted to be well informed so as to feel at ease when entering the classroom. During teacher community meetings, she was active in the sense that she posed questions, made notes, volunteered in role plays, etc. Despite her active participation, she maintained a modest attitude. She preferred listening to others presenting their ideas or accounts of successful classroom experiences, and she was certainly not the first to profile herself as a good teacher.

Eli showed herself to be insecure about her biology teaching. In her digital notes, she expressed a need to practise and to get ideas from others (in the form of receiving positive feedback) before applying a new theory or teaching and learning activities in her own classroom. She reported a few important learning activities, one of which was the following:

> After practising this teaching and learning activity [move-reasoning[3]] in the teacher community, I dared to do it with my school colleagues during team training. They were very enthusiastic and they gave me a lot of positive feedback (yes, really, only positive!!). These experiences supported me enough to trust myself, and now I think I can apply it in my classroom.

In her digital notes, she indicated five times that she needed the teacher community as a stimulus for starting and being able to teach this complex subject matter and apply these new teaching and learning activities. The feedback she received from her students was also important for gradually increasing her

[3] Move-reasoning is a teaching and learning activity developed in the teacher community, in which students move through the classroom symbolising their position in favour or against a statement, and the kind of reasoning they used: rationalistic, emotive or intuitive (Van der Zande et al., 2009b).

confidence. In the teacher community, all of the teachers decided to give a QTI to their students in order to find out how their students valued the interpersonal behaviour of the teachers. In the QTI, the students labelled her as authorative. For Eli, this appeared to be a very important event: although she was uncertain about the subject matter and teaching, she learned through a sound research instrument that her students perceived her as an authoritative teacher. She reported in her digital notes:

> I thought it was a big gift when I read it, I thought it was fantastic, Wow. I even used it during my job evaluation conversation with my manager, and he reacted very positively as well.

When asked to reflect on the whole project in the concluding interview, she gave the following summary:

> (…) and that is what I notice now, I don't feel uncertain any more. I feel much stronger as a teacher and also as a team member. Now I do not doubt how to approach a lesson so much anymore, or what to do. I used to feel very insecure in this field, and I am convinced that this whole process of the past year has contributed to it, absolutely, yes, very much so.

In the concluding interview, Eli reported sufficient growth in the areas of expertise she had previously felt uncertain about. For instance, she reported a sufficient level of conceptual expertise, and expertise concerning pedagogical content. Like Ben, the other teacher community member with experience in the field of genetic testing, she thought that her knowledge of ethical dilemmas was insufficient at the end of the project, whereas she had previously judged it to be sufficient.

Apparently, her confrontation with the dilemmas described in the reading materials handed out during the project and discussed during teacher community sessions had changed her frame of reference, and made her realise that her own experiences with genetic testing were only a part of all there was to experience.
However, in her opinion, the most important thing was that because of the increase in her expertise in the subject matter and pedagogical content, she had become convinced of her abilities as a biology teacher.

Table 5.3
The self-reported development of Eli's expertise

Area of expertise	MV	Aspects of area of expertise	Start	End
Subject matter expertise	x	Curricular genetics concepts	NS	S
		Extracurricular genetics concepts	NS	S
		ELSA	S	I
		Characteristics of genetic testing practices	NS	S
		Medical information on genetic testing	NS	S
		Knowledge of students' moral reasoning	NS	S
Pedagogical content expertise	x	Use of narratives	NS	S
		Use of a problem based approach	NS	S
		Use of teaching and learning activities for (reflection on) moral reasoning	NS	S
Moral expertise		Applying different roles in classroom discussions	NS	S
		Applying different approaches for moral education	NS	S
Interpersonal expertise		Creating a safe atmosphere	S	S
		Good relations with students	S	S

MV = most valued; (N)S = (not) sufficient; I = improved, but not sufficient.

At the end of the project, she was convinced that she knew enough, that she knew how to organise lessons on this topic, and she felt well prepared and self-confident. Working in a teacher community, practising methods in a safe environment and getting feedback from colleagues at school and her students helped her to develop her expertise in all the areas that could be improved (see Table 5.3). However, she valued most the development of her expertise in the areas of *subject matter* and *pedagogical content*, resulting in a change in her professional identity through an increase in her *self-esteem* and an improved *job motivation*. When we started, she was looking for ways to find her place in biology education, and at the end it looked as if she had found her place.

Jack's story

Jack, the son of a family doctor, who was 24 during the project, was the Benjamin of the group with the least experience. This was only his second year as a professional teacher. He is an open, straightforward person, where what you see is

what you get. His own schooling had always been “great fun”. In his eyes, this is exactly what life and school ought to be.

I have known him since his years as bachelor student. We clashed once when he was a student in an introductory course on teaching that I was giving, because he was reading newspapers during presentations made by his fellow students. For several reasons, I thought that he was not ready to become a teacher. Ignoring my advice, he entered the teacher education programme a few years later, and it was then that I learned to appreciate this honest young man with his passion for children and biology.

At the time when this project was conducted, Jack was working in a public Dalton school, where the students were guided to become responsible for their own learning. Goal setting, choosing learning activities and planning their own learning processes were, at least partly, their own responsibility. Jack flourished in this setting, and he loved the dialogue with his students. However, Jack was sometimes concerned about whether the learning content outcomes would suffer from this liberal approach to teaching. After he had been working there for a year, I visited his school, and both his students and the school managers told me that he was a real asset to the school. Therefore I was pleased when he volunteered for the project.

Jack described his motive for participating in the project as a desire to learn how to deal with the situated learning approach. He had heard about it, but labelled his knowledge as insufficient. During the initial interview, he indicated a strong preoccupation with the crossover between the moral and interpersonal areas of teaching.

> At this moment, I want to grow as a pedagogue. I have noticed that I’m not good at it; I think I’m too young for it (…) being only 24, I still have to develop myself, I’m still finding out who I am (…) When students make remarks, I have an urge to confront them with my personal opinion (…) I was brought up in a very direct way; if something is wrong, you just say so to the other person, and sometimes this can be interpreted as being blunt (…) you must not approach students in that way, especially if you do not know them or their backgrounds very well (…).

When asked at the start of the project to qualify his expertise, Jack reported having a sufficient knowledge of Mendelian genetics in the subject matter area, while his knowledge of molecular genetics could have been improved. Being a doctor’s son, he also reported sufficient medical knowledge and knowledge of the ELSA of

genetic testing. In the interpersonal area, he reported having sufficient expertise. However his interactions with students in his role as a pedagogue, therefore his moral expertise, could have been improved according to himself.

During the teacher community meetings, he was an active listener, and according to his digital notes, he learned as much from the other teacher community members as from experimenting in his own classes. From the first meeting onwards, he was somewhat amazed when he heard how seriously the others were anticipating and planning the interpersonal aspects of their lessons, as well as the importance they attached to other aspects of teaching biology in addition to the subject matter. In a digital note, he wrote how this had led him to think about himself:

> Why is it that some other teachers find it so difficult to discuss ethical issues in class? This question shows a lot about me. I think it is a challenge to do it well, but I'm not afraid of strange reactions at all (…) I see it as a challenge. But it does make me think: is my open way of communicating with students always right? (…) These meetings make me think about this. The effect is not that I'm more prudent now; I'm still convinced of my own approach. I will not change in this aspect, but I'm convinced that due to this confrontation with other teachers, I will go on reflecting on my teaching, and the result might be that I change my ideas.

After experimenting with a new teaching and learning activity called "move-reasoning", his thoughts changed slightly:

> I gained the skill of coaching such an activity concerning an ethical question. As you know, I am rather inclined to take the lead and spit my own opinion out. I did not do that this time, although it was with great difficulty. This convinced me that I'm capable of guiding classes in these discussions in the future. It also showed me that, thanks to this approach, students really get involved with the content of the issue. They are still discussing it with each other, and even with their parents.

Jack repeatedly said that he often just did what came to his mind, almost intuitively, and that he also saw this as a weak spot in his attitude, calling it bluntness, especially when moral issues were at stake. Although his main goal in education was creating a safe and pleasant atmosphere, his students often did not appreciate him just saying and doing what came to his mind. In the initial interview, he said:

> The truth, not to beat about the bush (…) I'll have to restrain myself; sometimes it is not necessary to tell the truth (…) I talk faster than I think, and often that is my problem. Because sometimes I say something, which perhaps is the truth but which is not essential, and sometimes it only hurts people. This has been part of me all my life, and it prevents me from discussing some issues in class.

In all his digital notes, this balance between spontaneous and well-considered communication was referred to as a topic, and even in the concluding interview he sighed that he was aware that he still had a lot to learn, especially in his contact with students:

> I still have confrontations with students, and then I'm sure that I caused it by blabbing something tactlessly. It is still the story of my life.

In order to achieve good moral discussions, he wanted to create a safe atmosphere, and in order to accomplish this, he had to work on his 'spontaneous' behaviour. Therefore, his main focus was on interpersonal expertise.

At the end of the project, he reported having improved his knowledge of the situated learning approach. His QTI showed that his students considered him to be a tolerant-authorative teacher, in line with his own conviction that his expertise in the interpersonal area had improved. This was a remarkable statement from Jack, because in the beginning he reported having sufficient expertise in the interpersonal area, and in the end he reported growth, but, according to him, there was still room for improvement. Like Eli with regard to her knowledge of dilemmas, a change in a teacher's frame of reference can be the cause of a shift in their self-evaluation.

When asked to reflect freely on the main personal outcomes of this project, Jack once again mentioned his difficulties with his interpersonal expertise, and in particular his direct methods of communication. He mentioned that he had become interested in looking at his work in a more conscious way. He had even become a member of an interschool research project, investigating the quality of education in the community. He had enjoyed the research-based way of thinking in the project.

Working in a teacher community, interacting with the other members and experimenting in his own class helped Jack to develop his expertise in all areas (see Table 5.4), though he acknowledged that most aspects could still be improved. During the concluding interview, he focussed mainly on his improvement in the interpersonal *area*. Jack's story reveals a change in *task-perception* on one hand,

and a change in *self-image* on the other. During the course of the project, Jack became more and more aware of the fact that he did not like the image he had as a blunt teacher. The project helped him to get one step further on his own road, and by working on his self-image he was slowly changing his professional identity, from one of spontaneous action and reaction to one of deliberate practice.

Table 5.4
The self-reported development of Jack's expertise

Area of expertise	MV	Aspects of area of expertise	Start	End
Subject matter expertise		Curricular genetics concepts	NS	I
		Extracurricular genetics concepts	NS	I
		ELSA	S	S
		Characteristics of genetic testing practices	NS	I
		Medical information on genetic testing	S	S
		Knowledge of students' moral reasoning	NS	I
Pedagogical content expertise		Use of narratives	NS	S
		Use of a problem based approach	NS	I
		Use of teaching and learning activities for (reflection on) moral reasoning	NS	I
Moral expertise		Applying different roles in classroom discussions	NS	I
		Applying different approaches for moral education	NS	I
Interpersonal expertise	X	Creating a safe atmosphere	S	I
		Good relations with students	S	I

MV = most valued; (N)S = (not) sufficient; I = improved, but not sufficient

Dietrich's story

Dietrich, 30 years old during the project, is a believing person. He is very studious, and always eager to learn new things, especially when education or biology is concerned. You cannot meet him without him asking at least three or four questions about your views on controversial biological or pedagogical issues. During his study of biology, he had worked in Peru for a year, where his motivation to become a teacher slowly grew stronger. He is an idealist, and wants to contribute something to the world, and in order to do so he wanted to become a good teacher. In line with his religious background, he even uses the word "calling". After his year in Peru, I met him for the first time when he entered my classroom for the

biology teacher education programme, at the age of 25. He was already working at a secondary school in the eastern part of the Netherlands. Years before, he had been a student at the same school in which he was now working as a teacher, which was a strict reformist protestant school.

While he was qualifying for teacher, we had a lot of ethical and pedagogical discussions, and I was always impressed by the honest and open way in which this young man explored different views on, for example, life, teaching, religion and evolution. Being unprejudiced, he always wanted to know what others were thinking, and why they thought the way that they did. I was not surprised when he volunteered to participate in my research project five years later.

His main motive for participating was that he wanted to be inspired by his colleagues, so as to improve gen-ethical discussions in class. This motivation appeared to be inherent to his more general professional interest in the area of moral expertise, illustrated by the fact that, as well as being a teacher, he also studied pedagogics during the project.

Teaching genetics in the context of genetic testing was new for him, and at the beginning of the project, he said that in general his expertise was insufficient. Only his medical knowledge of genetic tests and his capability to establish good relationships with his students he labelled as being sufficient.

Dietrich started out being very motivated with regard to the project. Although he had a strong affinity with the moral aspects of teaching, he was no expert in the appropriate teaching and learning activities for these aspects. He found it very useful to practise teaching and learning activities in the teacher community, translating these new ideas into his own teaching materials, and to get feedback on these materials from the other teacher community members. However, most of his self-reported learning experiences were linked to working with these new materials and teaching and learning activities with his students and his reflections on these experiences. Five out of his six digital notes had a strong emphasis on the question of what (reflection on) moral reasoning is about, and one focused on the value which his students attributed to rational arguments and accurate genetic knowledge in a reasoning process concerning genetic testing.

He was an active member of the teacher community. During the meetings, he often sought out others' motives, volunteered in role plays, was eager to discuss his draft materials and willing to report on his experiences, and he was always ready to listen to feedback from the others. During the fourth teacher community meeting, he volunteered to be interviewed in a teaching and learning activity, while the other teacher community members observed. The teacher community was developing this teaching and learning activity, called "The flip side of being morally right".

During this interview, he was asked what he thought he would do in the event that his wife became pregnant, and there was a chance that the child would have a genetic disorder. The disorder became graver with each new case that was presented to him, and thus he was confronted with dilemmas concerning genetic testing and possible consequences that got worse with each step. In the end, he really did not know what he would do. He indicated after this exercise that, as a religious man with strict principles, not knowing what to do was a remarkable experience. Following his experience in the teacher community of the teaching and learning activity "The flip side of being morally right", Dietrich used it during his lessons on genetic testing. In the debriefing afterwards, he mentioned that he was really impressed by the outcomes. He specifically referred to Matt, a 15-year old boy in one of his classes, who would never consider an abortion, because life was God-given and so an abortion would be murder in any case. In the end, his opinion softened. He still clung to his principles, but he could imagine that others, such as parents who already had some children with a severe disorder, could think differently, and then he would not call an abortion murder. He could imagine that they could consider it as being motivated by love for their child. Dietrich was really pleased with his new insight.

> This teaching experience is really beautiful, it is really about their own lives, and they want to discuss this. It tells me something about their heart and the place God has in there. If you notice that they are discovering what their own values are, then in my eyes you are involved in really valuable education.

During this period, Dietrich was still going back and forth between value transfer and value communication. On the one hand, he preferred value transfer, just like his school did; for example, his school governors asked him, after he had had Socratic discussions with his students, why he had not explained to the students at the end of the session what was the right thing to do, and what the Bible prescribed. A month after his experience with Matt, he wrote:

> I don't think everything is relative and that ethics is just a matter of personal taste or personal liking in the end. The framework and content of a curriculum can contain a direction, and point out what is right or wrong. Whether or not to have a prenatal or a postnatal genetic test is a difficult dilemma with pros and cons, and if you are actually discussing the consequences of possible outcomes, then there is the matter of right and wrong, just and unjust.

On the other hand, he slowly dissociated himself from value transfer, as he reported in the concluding interview:

> These controversial issues are not foregone conclusions, as they consider them to be in the reformist protestant world: in my school, you don't discuss these kinds of issues. But these issues are controversial and I learned how to deal with that in my classroom (…) But I see my class as a group of individuals, each of them with their own story, their own perspectives and background (…) For students these issues raise all kinds of contradictions (…) I have learned to start a multi-controversial dialogue, in which students feel 100% safe and accepted, and can dare to be emotional (…) yes, the whole process, the project was really necessary for that (...) Due to the overall process, I do not think in different positions so strongly anymore. Each person has to make his or her own development. I do not have the answers for them.

In the meantime, his religious beliefs grew stronger:

> (…) for myself, I'm even more convinced of the protectability of unborn life. (…) I cannot be the judge of life. God is life. That is why life deserves all the protection there is. (…) So in the end, I have even stronger principles on the one hand and fewer principles on the other.

After the project, Dietrich changed jobs. Although his level of expertise in the area of teaching genetics in the context of genetic testing had improved satisfactorily, with regard to subject matter as well as the other areas of expertise (see Table 5.5), this was not the major development he reported himself. He came to the conclusion that he no longer fitted within the pedagogical climate of the school he had been a part of for so many years. Slowly, he had detached himself from his school by starting to acknowledge the complexity of moral reasoning and the personal positions of students with regard to controversial issues, and not the school beliefs as such. His school had been a good school for Dietrich the student, but he had begun to experience problems with the strict religious rules which the school imposed on him and his teaching. He had begun to differ with his colleagues regarding their task perception. At the beginning of the project, he was already struggling with his obligations as an educator within his religious setting. The project gave him an opportunity to explore this even more, and this led to his decision to leave his school. He is now working at a university as a teacher educator. In the end, his development in the area of *moral expertise* changed his

job motivation, his *task perception* and his *future perspective*, and consequently also his *professional identity*.

Table 5.5
The self reported development of Dietrich's expertise

Area of expertise	MV	Aspects of area of expertise	Start	End
Subject matter expertise		Curricular genetics concepts	NS	S
		Extracurricular genetics concepts	NS	S
		ELSA	NS	S
		Characteristics of genetic testing practices	NS	S
		Medical information on genetic testing	S	S
		Knowledge of students' moral reasoning	NS	S
Pedagogical content expertise		Use of narratives	NS	S
		Use of a problem based approach	NS	S
		Use of teaching and learning activities for (reflection on) moral reasoning	NS	S
Moral expertise	X	Applying different roles in classroom discussions	NS	S
		Applying different approaches for moral education	NS	S
Interpersonal expertise		Creating a safe atmosphere	NS	S
		Good relations with students	S	S

MV = most valued; (N)S = (not) sufficient; I = improved, but not sufficient

Aggregated findings regarding the learning process and outcomes

Learning activities

The teachers reported 53 learning activities in total (see Table 5.6). The majority of the learning activities reported were related to the categories of *experimenting* (30%) and g*etting ideas from others* (32%). In addition to these two, only the category of *considering own practice* was frequently mentioned (13%). The other categories were mentioned three or four times or were not mentioned at all (*avoiding learning*).

Table 5.6
The learning activities reported by the teachers in their digital notes

Learning activity	Number	%
Experimenting	16	30
Considering own practice	7	13
Getting ideas from others	17	32
Experiencing friction	3	6
Struggling not to revert to old ways	3	6
Avoiding learning	-	0
Linking theory to practice	3	6
Practising	4	7
Total	53	100

Learning outcomes

In this study, we considered learning outcomes both in terms of growth in expertise as well as in terms of changes in self-understanding. Table 5.7 presents the overall development in expertise as reported by the biology teachers at the end of the project. As well as the three teachers whose stories were presented as narratives, the other five teachers will be taken into account: Emma, Tim, Sarah, Elsa and Ben. In general, it can be stated that at the beginning, the teachers were not familiar with the specific expertise necessary for teaching genetics in the context of genetic testing, and that they developed this expertise by participating in the community and experimenting in their own classes. Half of the teachers even improved their knowledge of the concepts currently in the curriculum. In addition, either seven out of the eight or all of the teachers reported improvements in other areas of their expertise, such as extra-curricular genetic concepts, the characteristics of genetic testing, teaching and learning activity for moral reasoning, and aspects of the area of moral expertise (see Table 5.7). Thanks to these teaching and learning activities, they reported increased opportunities to strengthen their students' reasoning concerning socio-scientific issues. Two teacher community members with their personal experiences of genetic testing reported having sufficient knowledge at the start and insufficient knowledge at the end of the project, perhaps due to a change in their frame of reference (see Eli's story). On only two occasions did a teacher report no development, having started at an insufficient level. This was one of the two teachers who did not actually implement the lessons, and so she had no real experience with teaching in this context. The second teacher who did not implement the lessons reported some growth, due to discussions and exercises in the teacher community. Finally, the majority of the teachers did not report improvements in the area of interpersonal expertise.

Table 5.7
The self-reported development of the expertise of eight teachers in the different areas of teacher expertise and the area in which they valued development most highly

Area of expertise	M.V	Aspects of area of expertise	Start	End
Subject matter expertise	1	Curricular genetics concepts	S 4	S 8
		Extracurricular genetics concepts	S 0	S 8
		ELSA*	S 3	S 4, I 4
		Characteristics of genetic testing practice	S 1	S 7, I 1
		Medical information on genetic tests	S 4	S 8
		Knowledge of students' moral reasoning	S 0	S 5, I 2
Pedagogical content expertise	3	Use of narratives	S 3	S 7, I 1
		Use of a problem-based approach	S 2	S 6, I 2
		Use of teaching and learning activities for (reflection on) moral reasoning	S 0	S 4, I 3
Moral expertise	3	Applying different roles in classroom discussions	S 1	S 4, I 4
		Applying different approaches for moral education	S 1	S 4, I 4
Interpersonal expertise	2	Creating a safe atmosphere	S 5	S 7, I 1
		Good relations with students	S 5	S 7, I 1

S(n) = number of teachers with sufficient expertise; I(n) == number of teachers with improved, but not sufficient expertise; MV = most valued; * Two teacher community members reported sufficient knowledge at the start and insufficient knowledge at the end of the project

Tables 5.8 and 5.9 present the changes in the self-understanding of the eight teachers. Table 5.9 shows how these changes relate to the areas of expertise which were valued most highly by each teacher. This valuation was deduced from the areas of expertise which were central in their digital logs and concluding interviews, and is the conclusion of the eight narratives constructed on the basis of these data.

Table 5.9 shows no typical relationship between development in one area of expertise and one aspect of self-understanding, but instead shows mainly individual differences. While one teacher changed mainly in terms of their self-esteem due to the fact that she valued growth in the areas of subject matter and pedagogical content expertise, the other changed more in terms of his self-image due to the

development of his interpersonal expertise. Once again, another teacher changed his task-perception and future perspective, in relation to learning in terms of moral expertise.

Table 5.8
The self-reported changes in the self-understanding of the eight teachers

Component of self–understanding which changed	Number of teachers concerned
Self-esteem	3
Self-image	3
Task-perception	4
Future perspective	1
Job-motivation	4

Table 5.9
Teachers who showed relations between their areas of expertise which developed and the aspects of their self-understanding which changed

Area of expertise	Component of self-understanding				
	Self-esteem	Self-image	Task-perception	Future perspective	Job-motivation
Content	Eli				Eli
Pedagogical Content	Eli Emma	Emma	Tim		Emma Tim
Moral	Sarah		Dietrich Ben	Dietrich	Dietrich
Interpersonal		Jack Elsa	Jack		

Conclusions and discussion

Science teachers find it difficult to make the shift towards situated learning, particularly in the case of socio-scientific issues. A teacher community was created in order to find how such a community can contribute to biology teachers' learning to teach a socio-scientific issue, such as genetic testing. In order to depict the impact of the teacher community on the teachers' learning, we constructed narratives for each teacher as well as collecting individual data on the development of the teachers' expertise and any changes in their self-understanding.

The findings showed that the teacher community facilitated growth in the expertise in three out of the four areas for all of the teachers, and also led in various ways to changes in their self-understanding. The majority of the teachers reported already having enough interpersonal expertise at the beginning of the process. This could be explained by the fact that the teachers had an average length of teaching experience of about five years. In general, it is assumed that most teachers have stable interpersonal relationships with their students by this point (Wubbels et al., 2006). The teachers who reported an improvement in this area were those with less experience.

In the beginning, most of the teachers did not have the specific expertise necessary to teach in this context, such as knowledge of extracurricular genetics concepts or the students' moral reasoning, or the ability to apply teaching and learning activities for (reflection on) moral reasoning (see Table 5.7). This is in line with the statement of Day and Bryce (2010) that science teachers are generally unfamiliar with teaching socio-scientific issues. After the teacher community activities we found that almost all of the teachers (seven or eight out of eight) reported sufficient growth in their expertise in all of the relevant aspects of genetic testing: extra-curricular genetic concepts ELSA; the characteristics of genetic testing; and teaching and learning activities for moral reasoning; and aspects of the area of moral expertise. Not only did participation in the teacher community provide them with ways to organise classroom discussions, they also developed expertise regarding how to strengthen their students' reasoning concerning these kinds of issues.

The analysis of the learning processes revealed that the most valuable learning activities were getting ideas from others (the teacher community members) and experimenting in their own classes. It does not seem surprising that the teachers reported that these learning activities were the most useful, because that was the intention of the teacher community, a combination of learning inside and outside of the school. It is, however, remarkable that learning activities frequently reported in

other settings (Bakkenes et al., 2010) were almost absent in the digital notes, such as struggling not to revert to old ways. One activity was completely absent from the notes: avoiding learning. We argue that an important explanation for this might be the voluntary participation of the teachers in this study, as opposed to a nationwide obligatory curricular innovation whereby all teachers are confronted with an educational reform, such as in the study by Bakkenes et al. (2010).

A noteworthy finding was that the teachers reported major outcomes both in terms of their valuation of growth in a specific area of expertise and in the related changes in their self-understanding. This indicates that, although growth was reported in all areas of expertise, some had more of an impact on the teachers in terms of how they understood themselves. Looking at what initially motivated the teachers to participate, they seemed to already have an interest in a particular area of expertise and in a specific component of their self-understanding more than others. For example, Eli wrote in the first teacher community meeting that she wanted to know more about subject matter relating to genetics and about ways to teach genetics in an appealing way, and wanted to develop her self-esteem. In the end, she changed mainly in terms of her self-esteem due to her growth in the areas of subject matter and pedagogical content expertise. Similarly, we noticed how the learning experiences of teachers during the process were mostly connected to the area(s) of expertise which they mentioned in the beginning. These findings indicate that the fact that the project had such an impact on these areas of expertise and on the teachers' self-understanding depended not only on the teacher community or the socio-scientific issue in question, but also on the teachers themselves; the teachers they already were, and the expertise and components of their professional identity which they were already struggling with at the beginning of the project. The effect of personal struggles on the identity of teachers was also reported by Akkerman and Meijer (2011), and Beijaard et al. (2004) and relates to Day's statement that, amongst other aspects, the "who" of the teacher is decisive with regard to what is being learned (C. Day, 2004).

This study yielded some evidence of relationships between the different components of teacher identity in terms self-understanding and expertise development. The exact nature of these relationships is not clear yet. From the narratives it can be derived that contextual and personal factors are influential. Vermunt and Endedijk (in press) stated that next to those factors, the learning patterns of the teachers are decisive for the learning outcomes. In this study we only looked at the learning activities the teachers reported, and their motivation to participate in the project. Analysing the role of the other components of the learning patterns in teacher learning; teacher beliefs about their own learning, and

their learning motivation in more general sense might be informative for the relationship between the development of expertise and the development of professional identity. More research is needed to further clarify these inter-relations.

What do our findings imply for the value of a teacher community as a learning environment? Considering the learning outcomes of the eight teachers, both in terms of growth in expertise as well as in terms of changes in their self-understanding, our community seems to have been successful. A community with enough time for dialogue between teachers can provide a normative space for teachers to position themselves regarding controversial socio-scientific issues, and when self-governance is possible, they can also develop a pedagogical approach that suits them in their own professional context. The stress on the voluntary participation of members of the community seemed to contribute to its success.

The finding that for instance struggling not to revert to old ways was almost absent from the teachers' notes, and that avoiding learning was completely absent, requires further exploration. The suggestion that the voluntary participation of teachers in this teacher community might be the reason for the absence of the activity may be informative for school governors who have to decide on in-service training programmes.

Despite these positive results, we argue that more could have been achieved through realising that: 1) teachers do not have neutral opinions regarding the different areas of expertise to begin with; and 2) that the growth of their expertise has an impact on their self-understanding. This realisation would have allowed the facilitator and the teacher community members to specify and tailor activities and feedback for each teacher. Similarly to the suggestions of Tigchelaar, Brouwer and Korthagen (2008) for other teacher education settings, we propose that person-oriented forms of intake should be incorporated, pointing out more explicitly what expertise is to be developed.

Finally, we suggest looking at teacher learning in future research first as the development of their expertise and also in terms of changes in their self-understanding. Until now, the literature has mostly focused on either one or the other. This study indicates how closely related the development of expertise and changes in professional identity are.

Appendix 1

A categorisation scheme for learning activities (source: Bakkenes et al., 2010).

The activities consist of six main categories, namely:

1. **Experimenting** is a combination of purposefully trying out something new in practice and some form of reflection about it;
2. **Considering own practice.** This learning activity refers to the teacher reflecting on their own teaching practice and/or on the students' learning or functioning
3. **Getting ideas from others**. This refers to activities in which a teacher consciously takes notice of the views or practices of others and evaluates them;
4. **Experiencing friction.** Friction refers to a discrepancy between what is expected or desired and what actually happens. Experiencing friction consists of noticing this discrepancy and appraising it. Two forms of frictions can be reported: (a) a completely unexpected event (positive or negative) taking place, and (b) the realisation that a teacher's usual approach to teaching no longer works;
5. **Struggling not to revert to old ways.** When teachers try to change their approach to teaching, they sometimes fall back on old patterns, even when they are no longer in the experimental phase;
6. **Avoiding learning.** Some teachers engage in activities that allow them to avoid learning about new teaching methods. They ensure that they do not learn certain things by organising their lessons, materials or experiments in such a way that the results prove that the new approach does not work and so that their existing theory of practice would be confirmed.

We extended this categorisation with the categories of linking theory to practice and practising. We were also interested in these two activities because of the intended nature of the teacher community, in which background information on certain subject matter would be distributed and teaching and learning activities could be practised.

7. **Linking theory to practice**. The participants would receive a lot of background information. Some teachers use this information for the development of their expertise.
8. **Practising**. In the teacher community, the teachers practised teaching and learning activities. Teachers report that practising made a relevant contribution to the development of their expertise.

Chapter 6

General Conclusions and Discussion

If you knew when you began a book what you would say at the end,
do you think that you would have the courage to write it?

Michel Foucault

In this chapter, I will first draw conclusions, discuss the relevance of our findings and formulate suggestions for further research and practical implications. Second, I will reflect on a) the theoretical approach including the main concepts and b) the approach we took in the intervention (the teacher community).

General conclusions

Initially, this study had two main research questions (Van der Zande et al., 2006):

1. What is the needed expertise for teachers who want to teach genetics in the personal health context of genetic testing?
2. How can teachers develop the expertise for teaching genetics in the personal health context of genetic testing?

The first question is elaborated in chapters 2, 3 and 4, the second question in chapter 5. I will summarise the findings and conclusions of the subsequent studies.

In the first study (chapter 2), restricting teacher expertise to the area of subject matter expertise, we focused on the required content knowledge and formulated the following research questions:

1.1. What content knowledge do biology teachers need to teach genetics in the personal health context of genetic testing? Two sub-questions were:

1.1.1. What is the content knowledge experienced teachers use when they teach genetics in the personal health context of genetic testing?

1.1.2. What is the content knowledge that can be derived from participants in the authentic practice of genetic testing?

The findings show that the educational practice and ideas of experienced teachers and the authentic practice of genetic testing provided us with supplementary suggestions for the needed teacher expertise. For educational practice, this encompassed sound conceptual knowledge, included in the formal curriculum and necessary to help students pass their exams: concepts such as dominant, recessive,

homozygote, heterozygote, DNA replication and transcription. The referents of the authentic practice of genetic testing brought up several other biological concepts, such as high risk genes, low risk genes, multifactorial disorders, and polygenic disorders (see Chapter 2, Table 2.2). According to them, these concepts are necessary for understanding the characteristics of the genetic test situation: uncertainty, complexity, probability and morality. Insight into these characteristics was considered relevant for successful decision-making in genetic testing.

One of the conclusions of this study is that teacher expertise should contain knowledge of students' moral reasoning and of teaching and learning activities aimed at reflection on student reasoning. Not only the experienced teachers suggested that new insights concerning students' moral reasoning would be welcomed, also the referents from the authentic practice of genetic testing pointed us to a need to strengthen reasoning in dilemmatic situations. Our informants explained to us that scientific knowledge alone, in this case a proper understanding of the genetics underlying genetic testing, was not enough to know what decision one should make.

Finally, the authentic practice, complemented by the relevant literature, provided an overview of the ethical, legal and social aspects of genetic testing. These included ethical issues of informed consent and solidarity, dilemmas such as that between patient autonomy and guilt (meaning that control implies responsibility with all its consequences), legal issues concerning insurance and social implications for relatives or future children. The knowledge base needed for teaching genetics in the context of genetic testing is summarised in Table 6.1. (For a more detailed description of the aspects of the expertise area mentioned in Table 6.1, see chapter 2.)

Table 6.1
Subject Matter Expertise for Teaching Genetics in the Context of Genetic Testing

Area of expertise	Aspects of expertise area
Subject matter expertise	Curricular genetics concepts
	Extracurricular genetics concepts
	Ethical, legal, and social aspects of genetic testing
	Characteristics of genetic test practice
	Medical information on genetic tests
	Knowledge of students' moral reasoning

The second study aimed at complementing the subject matter expertise described in the first study and the following research question was formulated:

1.2. What expertise do experienced biology teachers show in the pedagogical content, interpersonal and moral expertise areas concerning how to teach genetics in the personal health context of genetic testing?

The findings of this study encompassed the necessary expertise in three different expertise areas (see Table 6.2).

Table 6.2
Three Areas of Expertise for Teaching Genetics in the Context of Genetic Testing

Area of expertise	Aspects of expertise area
Pedagogical content expertise	The use of narratives
	The use of problem-based approaches
	The use of teaching and learning activities for (reflecti on) moral reasoning
Interpersonal expertise	Creating a safe atmosphere
	Good relations with students
Moral expertise	Applying different roles in classroom discussion
	Applying different approaches for moral education

In the *pedagogical content expertise* area, the teachers used a variety of teaching and learning activities, for example narratives to evoke empathy, and activities aimed at perspective taking such as role-play (see Table 3.4, p. 69). The experienced teachers showed a preference for problem-based education in order to stimulate active knowledge construction by students.

The *interpersonal expertise area* turned out to be particularly important, as the teachers emphasised the importance of creating a safe atmosphere. They stressed that a teacher who wants to create a dialogue on a socio-scientific issue such as genetic testing, should be able to create safety and should have the capability to establish and maintain good interpersonal relationships with the students. Congruent with this, the experienced teachers evaluated themselves as Tolerant/Authoritative, which was in line with how they were evaluated by their students. This profile indicates sufficient interpersonal expertise, because tolerant and authoritative teachers maintain a structure that supports student responsibility and freedom, and use a variety of methods to which students respond well.

Regarding *moral expertise*, preference for the stance of value development and value communication came to the fore, as the role of ‘absent leader’ or ‘committed instructor’ during class discussion and role-play (for a detailed description of the

possible teacher profiles, approaches for moral education and teacher roles, see chapter 3). The teachers recognised the need for teaching and learning activities for (reflection on) moral reasoning. They indicated that this part of their expertise could be improved.

In the third study, we addressed the question of how people reason in dilemmatic situations, and if we could enable teachers to support student reflection on moral reasoning. After exploring theoretical notions we specified the following research questions:

1.3.1 What kind of reasoning do students use in discussing controversial genetic issues prior to any education on this subject?

1.3.2. What is the knowledge of experienced teachers about student moral reasoning?

All our student referents used emotive as well as intuitive reasoning next to rationalistic reasoning, although they were not aware that they used all three types of considerations. Neither the students, nor the nine experienced teachers we interviewed, made a clear conceptual distinction between emotive and intuitive reasoning. The teachers did not translate their knowledge of student reasoning explicitly into their pedagogical approach. Teachers did use care-based emotions like empathy for motivational goals, for example when they used narrative starts in their lessons in order to engage the students. In the same sense, they used empathy in teaching and learning activities that invited students to take different perspectives, for example role-play. The experienced teachers indicated that their expertise related to (reflection on) students' moral reasoning could be improved.

In our last study, we initiated a professional teacher community in order to enable and stimulate the participating teachers to develop the required expertise. Besides studying biology teachers' learning in terms of the four expertise areas and required expertise (as summarised in Tables 6.1 and 6.2), we looked at possible changes in teachers' self-understanding because we suspected that learning specific additional expertise might influence their professional identity. The following research question was central in this last part of our research:

2.1. In what way can a teacher community contribute to biology teachers' learning to teach a socio-scientific issue such as genetic testing?

The findings revealed that the teachers developed both in terms of growth in expertise and changes in self-understanding. In general, it can be stated that, in the beginning, the teachers were not familiar with all the expertise necessary for teaching genetics in the personal health context of genetic testing. They developed

this expertise by participating in the community and experimenting in their own classes. The analysis of the learning processes revealed that the most valued learning activities were getting ideas from others (the other members of the teacher community) and experimenting in their own classes. With regard to expertise development, half of the teachers even improved their knowledge of the current curricular concepts. In addition, either seven out of eight or all teachers reported an improvement in other expertise areas: extra curricular genetic concepts, characteristics of genetic testing, teaching and learning activities for moral reasoning and aspects in the moral expertise area. Thanks to these teaching and learning activities, they reported increased possibilities to strengthen student reasoning concerning socio-scientific issues. The changes in self-understanding of the eight teachers related to the areas of expertise most valued by each teacher. There was no typical relation between the development in one area of expertise and one part of self-understanding. The teacher developments showed individual differences. Where one teacher changed mainly in self-esteem due to valued growth in the areas of subject matter and pedagogical content expertise, another changed more in self-image due to expertise development in the interpersonal area. Again, another teacher changed his task-perception and future perspectives based on the moral expertise he learned.

The above reported findings are an answer to our main questions. The described expertise in the four areas (as summarised in Tables 6.1 and 6.2) portrays the needed expertise for teachers who want to teach genetics in the personal health context of genetic testing. These findings contribute to a better understanding of how meaningful contexts inform students' learning of biology. Next, our study showed that an intervention by means of a teacher community and teacher learning situated in their own educational practice can be a successful way to support teacher development of that needed expertise.

Discussion

In this section, I will discuss the findings in relation to what can be seen as three layers that are addressed in this thesis: situated student learning, teacher expertise and (situated) teacher learning. Subsequently, I will discuss how our way of analysing student moral reasoning differed from the analysis where we started from, presented by Sadler and Zeidler (2005).

Situated student learning

By discussing our findings concerning situated learning, I will simultaneously reflect on one of the aims of this thesis, namely contributing to an empirical basis for a situated learning approach in secondary biology education. We started from the basic assumption of situated learning that the authentic practice is prescriptive and frames what is relevant to learn (Lave & Wenger, 1991). The literature (e.g. Boersma et al., 2007; Nyrhinen et al., 2004) gave us reason to believe that information about relevant knowledge could be provided by the referents of the authentic practices; in our case, the participants of genetic testing practice and educational practice. The results of this study supported our expectations. The needed expertise was deduced from the authentic practices and was inspirational and informative for the teachers in the teacher community. After the intervention, the teachers reported positively on their experience with teaching genetics in the context of genetic testing, based on motivated student participation due to the experienced relevancy of the content taught (see for example the quotes of Jack in his story on page 107).

Teacher expertise

Connected to teacher expertise, I want to discuss findings related to the areas of interpersonal expertise and moral expertise. Concerning interpersonal expertise, one of our findings corresponded to a theoretical premise found in literature. The emphasis experienced teachers put on a safe atmosphere and good interpersonal relationships with students, and the fact that the experienced teachers and most teachers who participated in the teacher community showed a Tolerant - Authoritative profile, correspond with the criteria Haidt (2001) formulated for moral refection. Translated to an educational setting, these criteria come down to the notion that students should feel at ease with their teachers before they engage in reflection on their moral reasoning and learn from that reflection.

In the area of moral expertise, I want to discuss two findings. First, all referent teachers, the experienced teachers as well as the teachers in the teacher community, informed us of the need for teaching and learning activities for (reflection on) moral reasoning. This need for activities expressed in the educational practice is in line with the recommendations of Dawson and Venville (2010) who stated that teachers need support on how to strengthen student argumentation concerning socio-scientific issues. Another finding in the authentic practice, the fact that some clients experienced no support from rational considerations, confirms the findings of earlier research (Dawson, 2003; Haidt, 2001; Layton et al., 1993). In dilemmatic situations, people often fall back on emotional or intuitive reasoning.

Teachers should at best be aware of this phenomenon. Also, students who are invited to reason in dilemmatic situations show this behaviour. This is not to say that they do not understand the scientific content, for example the genetics, learned in (foregoing) educational settings.

Teacher learning and the teacher community

After our intervention, we found that most of the participating teachers reported sufficient growth in their expertise concerning teaching and learning activities for (reflection on) moral reasoning and teaching socio-scientific issues. Responding to the statement of Day and Bryce (2010) that science teachers are generally unfamiliar with teaching socio-scientific issues, we suggest that a teacher community can be an effective environment for learning to teach socio-scientific issues. Not only did participation in the teacher community provide them with ways to organise classroom discussions, which in general teachers find difficult (cf., Levinson & Turner, 2001; Osborne et al., 2004), they also developed expertise regarding how to strengthen their students' reasoning concerning these kinds of socio-scientific issues, for which in general teachers need support (cf., Dawson & Venville, 2010).

With regard to how the teachers learned this new expertise, we gave notice of their most reported learning activities[1]. However, some learning activities frequently reported in other settings (Bakkenes et al., 2010) were almost absent in our findings, for example learning activities such as struggling not to revert to old ways. One activity was completely absent: avoiding learning. We argue that an important explanation for this might be the voluntary participation of the teachers in this study, as opposed to a nationwide obligatory curricular innovation whereby all teachers are confronted with an educational reform, such as in the study by Bakkenes et al. (2010).

Another finding worth mentioning is that by looking at what initially motivated the teachers to participate, they seemed to already have more interest in a particular area of expertise and in a specific component of their self-understanding than the others. We noticed how the learning experiences of teachers during the process were mostly connected to the area(s) of expertise which they mentioned in the beginning. These findings indicate that the fact that the project had such an impact on these areas of expertise and on the teachers' self-understanding depended not only on the teacher community or the socio-scientific issues in question, but also on the teachers themselves; the teachers they already were, and

[1] For a description of these learning activities, see appendix 1 chapter 5 (p. 122)

the expertise and components of their professional identity which they were already struggling with at the beginning of the project. The effect of personal struggles on the identity of teachers was also reported by Akkerman and Meijer (2011) and Beijaard et al. (2004) and relates to Day's statement that, amongst other aspects, the 'who' of the teacher is decisive with regard to what is being learned (Day, 2004).

As reported above, the findings showed that our teacher community facilitated growth in expertise and also led in varying ways to changes in self-understanding. These findings contrast with other studies where difficulties in establishing successful professional learning communities are reported (cf. Akkerman et al., 2008). We suggest that the way our community was organised and the role of the facilitator contributed to these outcomes. We initiated a teacher community for teachers to learn recommended expertise in relation to their own practice. The teachers were seen as partners in this expertise development research, because we wanted an intervention that corresponded with the concerns of the teachers involved, as such that it could result in *ownership* of those teachers (Vermunt, 2006). Originally, the teacher community was meant as a context for expertise development and was not the object of study. After the issue of identity development emerged, the intervention proved to be very influential and contextual information was collected, next to the interviews and the digital logs (see chapter 5, p. 100). Our research shows that organising teacher learning by means of a teacher community is a promising intervention. In this research, the teachers reported a growth in expertise as well as a change in self-understanding in a period of only 14 months. On the basis of the contextual information gathered during the period in which the teacher community functioned, we can only sketch in rough lines the characteristics of this intervention which might have contributed to this success. Nevertheless, based on our experiences and the reports of the teachers, we will make several recommendations that can contribute to further research on the productive qualities of professional teacher communities.

A formative intervention is preferred above an intervention that is designed in a more prescriptive and predefined way. In a formative intervention, there is more room for self-governance of the learning trajectory (for example, the topics to discuss, the steps to undertake, the design of meetings). Perhaps the researcher loses control over the intervention, but the agency of the participants will support the effectiveness of the intervention and may produce outcomes that can be used in other settings (cf., Engeström, 2008). When self-governance in a community is maintained, the participating teachers can develop in a way that suits their own professional context and needs. We advocate an approach towards the teacher as

agent, that is, an active participant in and owner of his or her own learning process and outcomes. Voluntary participation of participants in the community seemed to contribute to the success of such a community (cf., Bakkenes et al., 2010). In the case where expertise development is aimed at teaching socio-scientific issues, there must be adequate opportunity for teacher dialogue, because it can provide a normative space for teachers to position themselves regarding controversial socio-scientific issues.

The realisation that a) teachers do not have neutral opinions regarding the different areas of expertise to begin with and b) that the growth of their expertise has an impact on their self-understanding can allow the facilitator and the teacher community members to specify and tailor activities and feedback for each teacher. Similarly to the suggestions of Tigchelaar, Brouwer and Korthagen (2008) for other teacher education settings, we propose that person-oriented forms of intake should be incorporated, pointing out more explicitly what expertise is to be developed.

Finally, the role of the facilitator is important. We know this from the concluding interviews and evaluative discussions with the participating teachers. Although we did not report these findings in the empirical chapters, we consider them relevant enough for future facilitators who want to foster teacher learning by means of a teacher community. According to the participating teachers, the facilitator should be capable of doing a number of things. First of all, he or she should give teachers self-governance. For instance, through the creation of enough time for teacher dialogue, and in doing so provide a normative space for teachers to position themselves regarding controversial socio-scientific issues. In order to do so, a facilitator must be able to create a safe atmosphere for that teacher dialogue, for instance through the ability to react to teachers' emotions in a comforting way and create space for value clarification, value development and value communication, and to stay out of the field of value transfer. Next, he or she should have the abilities to prepare and structure meetings in an inviting way, and communicate the expertise of the issue in question, in our case genetic testing, in a comprehensible way. But above all, he or she must be enthusiastic about students, teachers and teaching. And last but not least, a facilitator should make the teachers feel welcome at each meeting.

Analysing moral reasoning

In this section, I will discuss our argumentation for extending the classification of considerations used in informal reasoning in the context of socio-scientific issues, first described by Sadler and Zeidler (2005).

Sadler and Zeidler (2005) distinguished three types of reasoning: intuitive, rationalistic and emotive reasoning. As we explained in chapter 4 (p. 81), we thought it worthwhile to extend emotive reasoning with basic emotions like anger, joy, sorrow, fear and surprise (Evans, 2001). We learned from the theoretical framework of Sadler and Zeidler (2005) that for emotive reasoning, they started from how this kind of reasoning was used by educators *who have long been aware of the importance of the affective domain in engaging students* (p. 115). Sadler and Zeidler only mention higher cognitive emotions; emotions that arise slower and stay alive longer, like sympathy and empathy. These emotional reactions include feelings of concern for other individuals' needs that enable student perspective taking. They placed basic emotions under the umbrella of intuitive considerations which they defined as *immediate feelings*[2] *or reactions* (p. 121). They did not question these intuitive considerations any further. In chapter 4, we differentiated these intuitive considerations into considerations based on gut feelings and considerations based on prima facie duties (cf., Audi, 2004). In line with authors such as Nussbaum (2001) and Evans (2001), we used a more ethical interpretation of emotions, in which emotions are seen as value-indicators. This makes gut feelings certainly worthwhile exploring. If teachers want to improve students' moral reasoning, according to Haidt (2001), they best reflect on intuitive reasoning in order to explore the nature of the values behind students' immediate feelings. In this reflection, it is important to make a distinction between prima facie duties and gut feelings, the first being mostly socially acceptable, which can be doubtful of the latter. From this point of view, the basic emotions behind gut feelings become the object of reflection and are not to be accepted as just intuitions. The example in the story of Anne (see chapter 2, p. 47) illustrates how people voice a prima facie duty, in this case the duty to protect the vulnerable can be considered socially acceptable, and requires no further exploration. In contrast, unarticulated fear or dislike based on gut feelings do ask for an exploration.

A second point concerning moral reasoning was that the experienced teachers as well as the student referents had difficulties in making a clear distinction between emotive and intuitive reasoning. This was not known to us from the literature (e.g., Sadler, 2004; Sadler & Zeidler, 2005). From the way Sadler and

[2] The concepts of feelings and emotions are often matters of dispute in literature. We use a pragmatic stance, that is that we see feelings as *emotions filtered through our cognitive brain centres* (Van Nierop, 1985), and emotions as complex interplay of a *physical arousal, based on the appeal of the situation and resulting in an experienced tendency for action* (cf., Frijda, 2008).

Zeidler used an interview protocol with detailed reading prompts on different scenarios (p. 131) and fixed interview questions, we concluded that they did not ask their student informants whether or not they knew the difference between the two types of consideration, but only used it analytically. We learned from their method description that within each scenario they asked a question similar to the following:

> Did you immediately feel that gene therapy was the right/wrong course of action in this context? Did you know your position on the issue before you had to consciously reflect on the issue? (Ibid, p 134)

In our interviews, we discovered that it mostly did not matter whether we asked the first question or the second. When asked after they had answered the second question: *How did you know your position*? most students responded: *Well it just felt that way*. In retrospect, we think that it is not productive to ask from students such a differentiated view on their reasoning. However, in order to enable teachers to question their students in the right way at the right time, the differentiated classification we propose might be useful for those teachers. Our teachers reported that they felt adequately equipped by this classification. In classroom discussions, teachers can help their students to articulate and substantiate their reasoning if they can label it as a prima facie duty or a gut feeling.

Research limitations

This section starts with a relativising remark. Looking at the empirical findings described above, I want to stress that most of our findings are based on case studies. We studied the expertise development and the connected changes in self-understanding by eight teachers. Scaling up our intervention with more teacher communities concerned with other socio-scientific issues is necessary to generalise our findings.

Though the socio-cultural theory informed us in taking a broad practice-based and multi-perspective approach, we did not include all there is to a socio-cultural understanding of genetics. This study focused on what teachers should know in order to empower their students for personal meaning making with regards to scientific knowledge. We did not include broader socio-cultural aspects. Ideally, as we stated in chapter 2, aspects such as the economic, sociological, the political role of science in our modern world, the sociology of science or the way science is practised and constructed by society can also be discussed (cf. Brickhouse, 2001; Cunningham & Helms, 1998; Lemke, 2001).

It is a good scientific convention that concepts in a thesis are used consequently. In this section, I would like to clarify why the use of some concepts changed during the research process, namely the concepts related to the content aspect of expertise, such as 'teacher knowledge', 'knowledge base' and 'subject matter'. As we explained in chapter 3, teaching is a complex profession because teachers have to fulfil many functions at the same time. Answering to the complexity of the teaching profession, we discerned four areas of expertise that are specifically relevant for learning to teach genetics in context: 1) subject matter expertise, 2) pedagogical content expertise, 3) interpersonal expertise and 4) moral expertise. Except for chapter 2, these concepts are used in this thesis. In chapter 2, where we reported on our exploration of the different practices, we wanted to describe all that was to be known for teaching in the context of genetic testing. We labelled the 'knowledge base' for teaching in context. Because this knowledge base included the content knowledge of what to teach (i.e., genetic concepts) and knowledge of how to teach (i.e., knowledge of teaching and learning activities), the classification of teacher knowledge of Shulman (1986; 1987) seemed most appropriate. Shulman's classification comprises seven categories of teacher knowledge. For example, a) content knowledge, b) pedagogical content knowledge and c) curriculum knowledge (Shulman, 1987, p. 8). However, when we moved on and tried to describe other aspects of teachers' professional development, we could not capture all the necessary aspects in Shulman's classification. Though Shulman's knowledge base comprises pedagogical content knowledge that also encapsulates knowledge of teaching and learning activities, we could not fit, for instance, the way teachers dealt with their role in moral education. In the studies presented in the chapters 3, 4 and 5, we used teacher expertise in order to be able to enclose, for instance, skills, beliefs and behaviour next to knowledge. To be able to enclose contextual information on genetic testing in the teacher knowledge base such as medical information and ethical, legal and social aspects, next to the relevant biological concepts, we did not use concept content knowledge but subject matter expertise.

Suggestions for further research

As I explained above, we did not include broader socio-cultural aspects in our multi-perspective approach. Further research on teaching genetics would benefit from including these aspects since personal meaning making is not simply a matter of accepting facts and logical relationships. Personal meaning making is supported by reflection on one's system of beliefs and values, and also by the understanding that science is a part of larger communities and their cultures (cf. Lemke, 2001).

First, I want to reflect on our teacher learning approach based on situated learning theory. Adhering to the social cultural roots of situated learning, we decided to explore different practices related to teaching genetics in the context of genetic testing: the educational practice, the different contexts in genetic testing and the scientific, professional and life-world contexts, and subsequently interviewed the different participants involved. Taking account of this variety of people and practices led to complementary and also unexpected findings. The perspective of the participants of clinical practice of genetic testing, as reported in chapter 2, gave us a grip on the relevant expertise for situated teaching in that practice. At the same time, the voice of those participants made clear how complex the value-laden character of the context of genetic testing is.

Second, talking to students enabled us to investigate how they reason in dilemmatic situations prior to educational training. Their eagerness to discuss controversial and often rather personal issues supported the assumption that genetic testing was a valuable context for meaningful and motivating education.

But above all, the input of biology teachers was of value throughout the various studies. The teacher perspective was valuable because they showed us the expertise they already had and what expertise they still considered to be difficult. It also brought us practical comments, for example, the consequence of a possible curriculum overload due to the concept-context approach, an issue that was addressed above in the section on practical implications. One of the aims of the CVBO to introduce the context concept approach was to tackle curriculum overload. Next, their perspective showed us how personal their learning process can be, that is to say that learning certain expertise can also affect their identity. Due to this richness in findings, we recommend future research on teacher learning in a situated learning framework to explore the different perspectives in the relevant authentic practices.

This study yielded some evidence of relationships between the different components of teacher identity in terms self-understanding and expertise development. The exact nature of these relationships is not clear yet. From the narratives, it can be derived that contextual and personal factors are influential. Vermunt and Endedijk (in press) stated that next to those factors, the learning patterns of teachers are decisive for the learning outcomes. In this study, we only looked at the learning activities the teachers reported and their motivation to participate in the project. Analysing the role of the other components of the learning patterns in teacher learning, such as teacher beliefs about their own learning and their learning motivation in a more general sense might be informative for the relationship between the development of expertise and the development of

professional identity. More research is needed to further clarify these interrelations.

It can be argued that studying identity development in terms of other identity theories can be worthwhile. Theories starting from the concept of the dialogical self seem particularly valuable in the context of expertise development for teaching socio-scientific issues (e.g., Hermans, 2001). The theory of dialogical self in psychology offers an approach by which identity can be viewed as simultaneously continuous and discontinuous, unitary and multiple and social as well as individual (Akkerman & Meijer, 2011; Hermans, 2001). This approach explicitly leaves room to take positions into account such as *parent*, *religious person* or *patient* in studies of teacher learning. These positions probably influence the way a person performs as a teacher when teaching a socio-scientific issue such as genetics in the context of genetic testing.

Practical implications

Based on the research findings, I will discuss five practical implications. First, I want to stress a finding of the first study that was confirmed by a finding of the last study. It can be stated that, in general, biology teachers were not familiar with the necessary expertise for teaching contemporary genetics in context. We advise that (student) teachers should acquire this expertise, and more broadly, that (initial) teacher education should pay attention to such a situated learning approach of teaching genetics. Teacher education institutes can consider this when they want to prepare their biology students for teaching within new curricula.

Next, I want to highlight one specific part of the required teacher expertise. Learning how to improve students' moral reasoning is not automatically a part of teacher education programs for science teachers. Because of the importance the participants of both the clinical practice of genetic testing and the educational practice attached to the improvement of students' moral reasoning, we think it wise to pay attention to pedagogy concerning moral reasoning in those educational programs. If we really want our students, possibly prospective clients in genetic testing practices, to value what complex scientific genetic information means to them, if we take the role of science teachers in education for citizenship seriously, learning how to apply teaching and learning activities for (reflection) on moral reasoning should have a place in teacher education and professional development after initial teacher education (cf., Jones et al., 2010).

On the curriculum level, I want to emphasise the following finding. We learned from our referents that not only are the concepts in the formal curriculum relevant for teaching in context, but so are additional concepts (see Table 2.2, p. 42). This

shows the importance of updating school curricula according to changes in the field. Initiatives should be taken to update science curricula in the light of recent techno-scientific developments, such as new knowledge and technologies in genomics and their implications for citizens. The first steps on this road have already been made (e.g., Boerwinkel et al., 2008; Dougherty, 2009). However, if each context that will be explored to facilitate situated learning results in extracurricular concepts, the issue of an overloaded biology curriculum must be addressed.

A very practical implication, directly applicable in the daily practice of teaching, results from our finding that a safe atmosphere seems to be a prerequisite for teaching controversial socio-scientific issues. This indicates that it is recommendable for biology teachers in secondary education not to start teaching such socio-scientific issues in the first weeks of a school year with a new group of students, when the so-called storming and forming (Tuckman, 1965) still takes place. First, every student must have found his or her place in the group and must feel safe enough to speak out to his or her peers.

Our last implication for practice concerns teaching the nature of science. The referents of the authentic practice of genetic testing put an emphasis on the characteristics of uncertainty, complexity, probability and morality, underlining the fact that genetic testing is a socio-scientific issue. Addressing these characteristics can help to solve the problem of the deterministic view on genetics we mentioned in the introduction (cf., Jiménez-Aleixandre, 2010; Waarlo, 2005). Ryder (2001) states that knowledge of the role of uncertainty in science is one of the main areas of relevant science knowledge for functional scientific literacy. We recommend teachers to pay attention to these characteristics of the practice of genetic testing, preferably as part of broader attention for teaching about the nature of science.

Epilogue

To me, biology learning, biology teaching and learning to teach biology is all about dialogue. When learning biology, students face many controversial issues, not only in the case of genetics, but also regarding other topics such as sexuality, reproduction technology, food production and consumption, neurobiology, ecology and sustainability. All these topics require personal reflection and positioning.

Though teachers introduce biology concepts and models that have already established cultural and scientifically 'correct' meanings, the challenge for teachers is to empower students to understand these concepts and models and *reason with* them in meaningful situations, for example in moral situations. In our teacher community, we stressed the importance of sound conceptual understanding by our students before they could engage in moral reasoning.

Regarding reasoning processes in different authentic practices, I learned in our studies how accepted genetic concepts can mean different things to different people. Not only will the teacher be aware of with whom he is speaking, and weave this awareness into his utterances. Explaining the concept of a *gene* to a 15 year old high school kid is quite another job than explaining it to a 20 year old biochemistry student. The fact that the concept of *gene* has not just *one meaning* to all of us is important in education. The 15 year old, the 20 year old and a genomics researcher all conceive something else when they hear the word *gene*. Moreover, in Mendel's days, the concept of *gene* was something entirely different from the meaning of the concept *gene* in this genomics era. Gregor Mendel would not understand Francis Collins if they met each other today. A genomics researcher even told me: 'I am not sure any more what this entity is that we used to call *a gene* in the past'.

Finally, learning to teach biology is about dialogue, in the sense of talking with other biology teachers and listening to advice from authentic practices. Through this, more or less experienced biology teachers can learn to see that 'their way of teaching biology' is not the only way to teach, and that their way of teaching is not free from its own school-related and personal values.

In the end, I learned that the goal behind education aims at providing relevance to scientific knowledge, which can best be reached by teaching and learning activities that create room for learners in dialogue.

Any concrete utterance is a link in the chain
of speech communication of a particular sphere
(…) therefore, there can be neither a first
nor a last meaning.

(Bakhtin, 1986)

Samenvatting

Lerenden in gesprek; dit proefschrift is gericht op expertise ontwikkeling van biologieleraren, die genetica in de context van genetisch testen willen behandelen in hun lessen, en op het vinden van manieren om docenten te ondersteunen bij het zich eigen maken van die expertise.

Het eerste hoofdstuk schetste onze onderzoeksachtergrond, het theoretisch kader en de onderzoekstappen om ons doel te bereiken. We omschreven hoe, sinds het begin van de 21e eeuw het accent binnen het Nederlandse middelbaar onderwijs in de natuurwetenschappelijke vakken in toenemende mate is komen te liggen op het lesgeven in contexten. Vanaf 2004 onderzocht de Commissie Vernieuwing Biologie Onderwijs (CVBO) welke consequenties de recente ontwikkelingen in de biologische wetenschap zouden moeten hebben voor het middelbare onderwijs. Een van de doelen van deze 'concept-context' benadering (in dit proefschrift 'gesitueerd leren' genoemd), is om leerlingen te laten zien hoe de wetenschap een belangrijke rol kan en zal spelen in hun toekomstige leven. Hierdoor worden wetenschappelijke concepten relevanter voor leerlingen.

We legden uit waarom ons onderzoeksproject was gericht op het vergroten van de expertise van biologiedocenten in het onderwijzen van genetica binnen de context van genetisch testen. De toename van wetenschappelijke kennis op het gebied van genomics en genetisch testen en de daaraan verbonden consequenties voor besluitvorming in persoonlijke gezondheidssituaties, geven de maatschappelijke relevantie aan van het gesitueerd leren in genetica onderwijs. We stelden dat genetisch testen een sociaalwetenschappelijk onderwerp is, en dat het behandelen van een dergelijk controversieel onderwerp, waarbij leerlingen hun eigen standpunt moeten onderzoeken, het moreel redeneren van leerlingen in het klaslokaal introduceert. Deze onderwijsbenadering gebaseerd op de theorie van gesitueerd leren, vraagt nieuwe expertise van de betrokken leraren. Deze nieuwe expertise bestaat niet alleen uit kennis van de hedendaagse genomics en de gevolgen van deze nieuwe kennis voor de gezondheidszorg. De expertise omvat ook kennis van onderwijsleeractiviteiten gericht op de persoonlijke plaatsbepaling van leerlingen binnen controversiële sociaalwetenschappelijke vraagstukken.

Onze eerste onderzoeksvraag was: Welke expertise hebben docenten nodig die genetica willen behandelen binnen de persoonlijke gezondheidscontext van genetisch testen? In de hoofdstukken 2, 3 en 4 zijn de resultaten van deze deelstudie besproken. Onze tweede vraag, behandeld in hoofdstuk 5, was: Hoe kunnen

docenten de expertise voor het lesgeven in genetica binnen de persoonlijke gezondheidscontext van genetisch testen ontwikkelen?

In onze eerste studie (zie hoofdstuk 2) concentreerden we ons op het vak-inhoudelijke expertisegebied. De vraag was welke vakinhoudelijke kennis biologie docenten nodig hebben voor het onderwijzen van genetica in de persoonlijke gezondheidscontext van genetisch testen. Voor dit expertisegebied onderzochten we twee authentieke praktijken: a) de klinische praktijk van genetisch testen en b) de onderwijspraktijk van ervaren docenten. We interviewden respondenten uit de klinische genetische praktijk (cliënten, klinisch genetici, genetisch consulenten en medische ethici) en ervaren docenten, die de onderwijspraktijk representeerden. Onze bevindingen lieten zien dat de benodigde docentenkennis meerdere lagen omvat, voortkomend uit de genetische testsituaties. Aan de ene kant de kennis van concepten uit het nationale biologiecurriculum en concepten die niet voorkomen in het vastgestelde curriculum, zoals multifactoriële en poligenetische eigenschappen. Aan de andere kant meer kennis van de ethische, wettelijke, en sociale aspecten en van de meer algemene kenmerken van de genetische testpraktijk: onzekerheid, complexiteit, kansberekening en moraliteit. Vervolgens bleek medische informatie rond het genetisch testen, kennis van het moreel redeneren van leerlingen, en kennis van onderwijs en leermethodes die zich richten op de reflectie op het redeneren van leerlingen deel van de gewenste kennisbasis.

In hoofdstuk 3 werden de andere expertise gebieden voor het doceren van genetica in de context van het testen geschetst. Ook hiervoor bestudeerden we de onderwijspraktijk. We interviewden negen ervaren docenten over vakdidactiek, en over inter-persoonlijke en morele expertisegebieden in relatie tot de manier waarop genetica in de persoonlijke gezondheidscontext gedoceerd zou kunnen worden. Daarnaast werden de lessen van vijf van hen geobserveerd. Deze bevindingen lieten zien dat de benodigde docent expertise specifieke onderwijsleeractiviteiten omvat. Bijvoorbeeld narratieve starts, om zo empatische betrokkenheid en een '*need to know*' bij de leerlingen te bereiken, en probleem gestuurde methodes om de genetische concepten bij leerlingen te introduceren. Vervolgens werd specifieke inter-persoonlijke expertise besproken, die docenten in staat stelt om een veilige sfeer te creëren en behouden; onmisbaar voor het discussiëren over waardegeladen sociaal wetenschappelijke onderwerpen in de klas. Tenslotte werd ook het kunnen toepassen van verschillende docentrollen binnen, en onderwijsmethodes voor, morele vorming genoemd als een belangrijke docentexpertise. Daarbij kwam een behoefte aan verdere ontwikkeling van onderwijsleeractiviteiten voor (reflectie op) moreel redeneren naar voren.

In onze derde studie bespraken we het moreel redeneren in genetica onderwijs (zie hoofdstuk 4). We stelden dat, naast de docentenvraag om onderwijsleer-activiteiten voor (reflectie op) moreel redeneren van leerlingen, de behoefte om het moreel redeneren te bestuderen ook relevanter was geworden door recente literatuur. Recent neuropsychologisch onderzoek suggereert dat intuïtie en emotie een rol spelen in ons redeneren als we geconfronteerd worden met morele dilemma's. Het idee om intuïtie en emotie te incorporeren in morele reflectie is vrij nieuw in de onderwijswereld, waar rationeel redeneren de voorkeur heeft. We waren ons ervan bewust dat moreel oordelen wordt veroorzaakt door snelle morele intuïties, en wordt gevolgd (waar nodig) door langzame, *ex-post facto* moreel redeneren. Hiermee sloten we aan bij Haidt's (2001) veronderstelling, dat door de reflectie op deze ex-post facto redenering mensen soms in staat zijn hun intuïties aan te passen. Vertaald naar onderwijs betekent dit dat docenten kunnen proberen om het moreel redeneren van leerlingen te verbeteren, door eigen reflectie, geïnitieerd door een rollenspel, of door sociale overtuiging in klassendiscussies, als leerlingen feedback krijgen van mensen die ze respecteren.

We rapporteerden over onze eerste focus in deze studie: de manier waarop intuïtieve en emotieve overwegingen een rol spelen bij morele vorming. Bovenbouw leerlingen uit de Havo en het Vwo werden geïnterviewd over hun manier van redeneren door ze te confronteren met realistische situaties. Ervaren biologiedocenten werden geïnterviewd over hun benadering van morele vorming en over hun kennis van het moreel redeneren van leerlingen. De bevindingen werden vergeleken met ideeën uit literatuur over moreel redeneren. Onze studie toonde aan dat alle leerlingen zowel intuïtief, emotief als rationeel redeneerden tijdens het interview. Docenten vertelden dat zij zagen dat studenten intuïtie en emotie gebruikten in hun redenering. Zowel de docenten als de leerlingen vonden het moeilijk om een conceptueel verschil tussen intuïtie en emotie aan te geven.

De onderwijsliteratuur en de interviews leverden ons geen uitgesproken vakinhoudelijke aanpak op waarbinnen plaats was voor reflectie op moreel redeneren. We concludeerden dat er nog een onderwijsleerstrategie ontwikkeld moet worden waarbinnen morele reflectie een plaats kan hebben.

Hoofdstuk 5 was erop gericht na te gaan hoe docenten de expertise voor het doceren van genetica in context van genetisch testen kunnen ontwikkelen. Vergelijkbaar met onze benadering van het leren van leerlingen, benaderden we in onze laatste studie het leren van docenten ook als en proces van gesitueerd leren. In dit geval betekende dit dat we veronderstelden dat biologie docenten het beste anders leren lesgeven door dit te oefenen in hun eigen klassen. We deden verslag van onze studie naar een docenten-*community* voor het ontwikkelen van

docentenexpertise voor een onderwijs aanpak gebaseerd op de theorie van gesitueerd leren. Acht biologiedocenten werkten samen om deze gewenste expertise te ontwikkelen. Het gezamenlijke doel van deze *community* was om het onderwijsleeractiviteiten voor geneticaonderwijs in de context van genetisch testen te ontwikkelen, te oefenen, uit te voeren en te evalueren.

We gaven aan dat genetisch testen een controversieel sociaal wetenschappelijk onderwerp is, en dat lesgeven daarover de professionele identiteit van de docenten raakt. We hebben niet alleen gekeken naar het leren van biologie docenten binnen de vier expertisegebieden, waarbij de gewenste expertise was afgeleid van authentieke praktijken, maar ook naar de mogelijke veranderingen in het zelfbegrip van de docent. Individuele ontwikkelingen werden beschreven in geconstrueerde narratieven, en overkoepelende patronen werden ontwikkeld aan de hand van samengevoegde individuele data.

De gepresenteerde bevindingen lieten zien dat de *community* nuttig was voor het ontwikkelen van expertise en dat deze ontwikkeling gerelateerd was aan identiteitsontwikkeling in termen van zelfbegrip. In het begin hadden de meeste docenten geen specifieke expertise voor het doceren in deze context. Hierbij valt te denken aan kennis van genetische concepten die niet in het curriculum staan, het moreel redeneren van leerlingen of het vermogen om onderwijsleeractiviteiten voor (reflectie op) moreel redeneren toe te passen. Na de activiteiten van de docenten-*community* zagen we dat bijna alle docenten verklaarden dat hun expertise voldoende was ontwikkeld. Bijvoorbeeld hun kennis van genetische concepten die geen deel uitmaken van het curriculum, ethische, wettelijke en sociale aspecten, de meer generieke kenmerken van genetische testen en onderwijsleeractiviteiten voor (reflectie op) moreel redeneren.

Een noemenswaardige bevinding uit dit hoofdstuk was dat de docenten belangrijke resultaten meldden, zowel wat betreft de waardering van hun groei in een specifiek expertise gebied als de daarmee samenhangende veranderingen in hun zelfbegrip. Dit geeft aan dat, ondanks dat er groei plaatsvond in alle expertise gebieden, bepaalde groei meer invloed had op hoe docenten zichzelf als professionals zagen. De bevindingen toonden aan dat het feit dat het project een dusdanige impact had op de expertiseontwikkeling en het zelfbegrip van docenten, niet alleen afhing van de docenten-*community* of het sociaal wetenschappelijke onderwerp dat behandeld werd, maar ook van de docenten zelf; de docenten die ze al waren, de expertise en componenten van hun professionele identiteit waarmee ze al worstelden aan het begin van het project. Een eindconclusie was dat een *community* met genoeg tijd voor dialoog tussen docenten ruimte schept voor docenten om zichzelf te positioneren ten opzichte van controversiële sociaal

wetenschappelijke onderwerpen. En als zelfsturing mogelijk is, kunnen ze ook een didactische methode ontwikkelen die past bij henzelf in hun eigen professionele context. Het feit dat alle leden van de *community* vrijwillig meewerkten lijkt van grote invloed te zijn geweest op het succes ervan.

In hoofdstuk 6 werden de resultaten van het empirische onderzoek samengevat. Daarna presenteerden we algemene conclusies en bediscussieerden de bevindingen in relatie tot theorie en praktijk. Onze gesitueerde aanpak van leerling- en docentleren, evenals het ontwikkelde docentexpertise en de toegepaste interventie van een docent-*community* werden samengevat. Met betrekking tot de docent-*community* besteedden we veel aandacht aan de rol van de *facilitator*. Vervolgens werd er speciale aandacht besteed aan de manier waarop we het moreel redeneren van leerlingen analyseerden. We eindigden dit laatste hoofdstuk met de beperkingen van het onderzoek, suggesties voor verder onderzoek en de praktische betekenis hiervan.

Summary

Learners in Dialogue; this thesis aims at the exploration of teacher expertise for teachers who want to teach genetics in the context of genetic testing and at finding ways to foster teacher learning concerning this expertise.

The first chapter sketched our research background and theoretical framework, and the research steps towards our aim. We described how, since the beginning of the 21st century, there has been a growing emphasis in Dutch science education on teaching science in context. From 2004 onwards, the Dutch Biology Curriculum Innovation Board (CVBO) has been investigating what consequences the recent developments in biological science should have for secondary biology education. One of the aims of this so-called concept-context approach, referred to as situated learning in this thesis, is to show students how science can and will play an important role in their (future) lives, and in doing so to make scientific concepts more relevant for students. We explained why our research project was aimed at enhancing biology teacher expertise for teaching genetics situated in the context of genetic testing.

The increasing body of scientific knowledge concerning genomics and genetic testing and the related consequences for decision-making in personal health situations indicate the societal relevance of a situated learning approach in genetics education. We assert that genetic testing is a socio-scientific issue, and that teaching such controversial issues, where students have to clarify their own position, brings student's moral reasoning into the classroom. This educational approach based on situated learning theory requires new expertise of the teachers involved. New expertise is not only concerned with contemporary genetics and its medical implications, but for instance, is also concerned with how to support students in their process of meaning making in controversial socio-scientific issues.

Our first research question was: *What is the needed expertise for teachers who want to teach genetics in the personal health context of genetic testing?* Chapters 2, 3 and 4 reported on the findings related to this question. Our second question: *How can teachers develop the expertise for teaching genetics in the personal health context of genetic testing?* was discussed in chapter 5.

In our first study (see chapter 2), we focused on the subject matter expertise area. The question was what content knowledge biology teachers need for teaching genetics in the personal health context of genetic testing. For this expertise area,

we explored two authentic practices: a) the clinical practice of genetic testing and b) the educational practice of experienced teachers.

Respondents representing clinical genetic practices (clients, medical professionals and medical ethicists) and experienced teachers representing educational practice were interviewed. We described how the findings of this study revealed that the required teacher knowledge consists of multiple layers that are embedded in specific genetic test situations: on the one hand, the knowledge of concepts represented by the curricular framework and some additional concepts (e.g. multifactorial and polygenic disorders) and, on the other hand, more knowledge of the ethical, legal and social aspects and generic characteristics of genetic test practice (uncertainty, complexity, probability and morality). Next, medical information on genetic tests and knowledge of students' moral reasoning and of teaching and learning activities aimed at reflection on student reasoning appeared to be part of the sought-for knowledge base.

In chapter 3, the other expertise areas for teaching genetics in the context of testing were outlined. To be able to do so, we again explored educational practice and experienced teachers were interviewed about the pedagogical content, interpersonal and moral expertise areas concerning how to teach genetics in the personal health context of genetic testing, and the lessons of five of them were observed.

The findings showed that the required teacher expertise encompasses specific teaching and learning activities such as narrative starts so as to achieve empathetic involvement and a need to know by the students, and problem-based approaches to introduce the genetics concepts to the students. Next, specific interpersonal expertise that enables teachers to create and maintain a safe atmosphere, a prerequisite for discussing value-laden socio-scientific issues in class was discussed. Finally, the ability to apply different teacher roles and teaching approaches for moral education was part of the sought-for expertise. A need for further development of teaching and learning activities for (reflection on) moral reasoning came to the fore.

In our third study, we addressed the issue of moral reasoning in genetics education (see chapter 4). We stated that, next to the demand from the teachers for teaching and learning activities concerning student moral reasoning, the urge to study moral reasoning became even more relevant because of contemporary literature. Recent neuropsychological research has suggested that intuition and emotion play a role in our reasoning when we are confronted with moral dilemmas.

The idea to incorporate intuition and emotion in moral reflection is rather new in the educational world, where rationalistic reasoning is preferred. We were aware

that moral judgment is caused by quick moral intuitions, and is followed (when needed) by slow, ex-post facto moral reasoning. Thus, we adopted Haidt's (2001) assumptions that, due to reflection on this ex-post facto reasoning, people may be capable of changing their intuitions. Translated to education, this implied that teachers can try to improve student moral reasoning, either through private reflection, for instance initiated through role-play, or through social persuasion in classroom discussions, when they get feedback from people they respect.

We reported on our first focus in this study: how intuitive and emotive considerations are dealt with in present moral education. Pre-university students were interviewed on their way of reasoning by confronting them with real-life situations, and experienced biology teachers were interviewed about their approach to moral education, and about their views on student reasoning. These findings were confronted with suggestions found in the literature on moral reasoning. Our study revealed that all students used intuitive, emotive and rationalistic considerations during the interviews. Teachers reported that they observed students using intuition and emotion in their reasoning. However, a conceptual distinction between emotive and intuitive reasoning proved to be difficult for students and teachers. Neither the educational literature nor the interviews yielded an articulated pedagogical approach in which these considerations played a role in moral reflection. We concluded that, as yet, a teaching and learning strategy to address this moral reflection still has to be developed.

Chapter 5 is directed at finding out how teachers could develop the expertise for teaching genetics in the context of genetic testing. In line with our approach towards students' learning, in our last study, teacher learning was also approached as a process of situated learning. In the case of teachers' learning, this meant that we assumed that biology teachers could best learn to teach by learning in close relation to their own biology classes. We reported on our study of a teacher community to develop teachers' expertise for a teaching approach based on situated learning theory. Eight biology teachers participated in order to develop the needed expertise. The joint enterprise of the teachers in this teacher community was to develop, plan, discuss, practise and evaluate teaching and learning activities with regard to genetic testing.

We indicated that genetic testing is a controversial socio-scientific issue, and that teaching such issues involves the professional identity of the teachers. So, we explained that besides studying biology teachers' learning in terms of the four expertise areas and required expertise derived from the authentic practices, we looked at possible changes in teachers' self-understanding. Individual developments

were reported using constructed narratives and overall patterns were developed by aggregating individual data.

The presented findings showed that the community was useful for expertise development and that this development was connected to identity development in terms of self-understanding. In the beginning, most of the teachers did not have the specific expertise necessary to teach in this context, such as knowledge of extracurricular genetics concepts or students' moral reasoning, or the ability to apply teaching and learning activities for (reflection on) moral reasoning. After the teacher community activities, we found that almost all of the teachers reported sufficient growth in their expertise, for example, in all of the relevant aspects of genetic testing: extra-curricular genetic concepts; ethical, legal and social aspects; the characteristics of genetic testing and teaching and learning activities for (reflection on) moral reasoning.

A noteworthy finding we mentioned in this chapter was that the teachers reported major outcomes both in terms of their valuation of growth in a specific area of expertise and in the related changes in their self-understanding. This indicated that, although growth was reported in all areas of expertise, some had more of an impact on the teachers in terms of how they understood themselves. The findings indicated that the fact that the project had such an impact on these areas of expertise and on the teachers' self-understanding depended not only on the teacher community or the social scientific issue in question, but also on the teachers themselves; the teachers they already were, and the expertise and components of their professional identity which they were already struggling with at the beginning of the project. A final conclusion was that a community with enough time for dialogue between teachers can provide a normative space for teachers to position themselves regarding controversial social scientific issues, and when self-governance is possible, they can also develop a pedagogical approach that suits them in their own professional context. The stress on the voluntary participation of members of the community seemed to contribute to its success.

In chapter 6, the results of the empirical studies are summarised. Next, we drew general conclusions and discussed the findings in relation to theory and practice. Our situated approach to student and teacher learning, as well as the developed teacher expertise and the applied intervention of a teacher community passed in review. In relation to the teacher community, we zoomed in on the role of the facilitator. Next, special attention was paid to the way we analysed student moral reasoning. We concluded this last chapter with research limitations, suggestions for further research and practical implications.

Curriculum Vitae

Paul van der Zande, son of a pastry baker, was born on March 7th 1956 in Apeldoorn (The Netherlands). He completed his secondary education in 1975 at Veluws College in his hometown, and he studied biology (ecology) at Utrecht University. During his doctorate, he specialised in landscape ecology. From 1982 to 2003, he worked as a teacher at several Dutch schools of secondary education. Most of his teaching years were spent working at public schools in Almere; first at Echnaton and later at Helen Parkhurst, a Dalton school. He was a science teacher for the lower grades and a biology and general science teacher for pre-university classes. From 1993 until 2000, he was head of the senior high school unit. From 1988 until 2000, he participated in several educational projects, mostly concerned with environmental education and cross-curricular initiatives, and for a few years he was the editor of Bulletin, a Dutch trade paper for education in biology. In 2000, he started to work as a biology teacher educator at ILO, the University of Amsterdam, and from 2003 until present he has been working in the same position at IVLOS, Institute of Education, Utrecht University. During these years, he also participated in the CIS (Centre for International Cooperation) of the VU University Amsterdam in two educational projects in Africa, the *Development Teacher Education Programme* at the University of Dar es Salaam, Tanzania (2004) and later for four years in the Practical project, a development teacher education programme for the University of Cape Coast UCC, and the University of Education Winneba (UEW), Ghana. Before he started this thesis, he was a member of the Dutch Biology Curriculum Innovation Board (CVBO) for four years. Currently, he is working as a teacher educator and researcher at the Faculty of Social and Behavioural Science, Utrecht University, which participates in the Centre for Teaching and Learning.

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