The functionality of biological knowledge in the workplace

Integrating school and workplace learning about reproduction

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The functionality of biological knowledge in the workplace

Integrating school and workplace learning about reproduction

De functionaliteit van biologische kennis op de werkplek

Het integreren van leren over voortplanting op school en op de werkplek

(met een samenvatting in het Nederlands)

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Voor Erna, Koen en Anniek

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Chapter 1

Introduction

Generally, students in vocational education are prepared for a workplace environment in which (theoretical) knowledge is used as a tool for solving problems or for exploring and starting innovations (Onstenk, 2010). Pre-vocational secondary vocational education (VMBO) is at the foundation of vocational education and should therefore seed the development of competence of students to use knowledge in the workplace. One step in this direction is to show them that knowledge is actually used in the workplace and that acquiring this knowledge helps them in their vocational development. For this, relationships between school learning and workplace learning in VMBO need to be utilized. However, knowledge on how this can be done needs to be further developed.

In agricultural education, for instance, students learn about biological topics in their biology course, their vocational courses and sometimes during their work placement in a workplace that uses biological knowledge. Often, these three curriculum components are merely incidentally aligned. Besides having their own educational programmes, teachers and supervisors are in need of guidelines on how to benefit from the prospects of connections between the curriculum components. Currently, students often fail to recognize the relationships that may help them in their vocational development.

This research project contributes to the search for guidelines on how to design learning, teaching and supervising in such a way that students recognize these relationships.

1.1. Developments in pre-vocational secondary education

The purpose of VMBO is primarily to prepare students for senior secondary vocational education (MBO) (Van Bijsterveldt-Vliegenthart, 2011, 2012). Nevertheless, VMBO is also meant as general education as it prepares for senior general secondary education (HAVO) as well. This dual purpose, i.e. vocational and general education, can also be identified in the nature of curriculum components in VMBO. Roughly, the curriculum consists of general disciplinary courses (e.g. biology, mathematics, Dutch), vocational courses (e.g. animal husbandry and care, health care) and work placements. Obviously, the vocational courses and work placements are aimed to prepare students for vocations and further professional training. Yet, teachers and management of VMBO-schools also view general disciplinary courses as auxiliary to the vocational courses (Beckers, Ebbers, Jacobs, Haverkamp & Van Lansschot, 2006).

The tension between the vocational and general educational purpose in VMBO is exemplified in a report of the Dutch Council for Secondary Education (Monnik et al., 2010).

Students in the theoretical trajectory continue their education in either MBO or HAVO. According to the council, educators experience the transitions from VMBO to MBO as more problematic than transitions from VMBO to HAVO. However, the council also acknowledges that the theoretical trajectory prepares insufficiently for factual subjects in upper levels of HAVO. The council therefore advises to reinforce the vocational training of the theoretical trajectory and to strengthen the alignment between the factual subjects in VMBO and HAVO (Dutch, mathematics and English).

In other words, VMBO-schools and policy makers struggle with the dual purpose. VMBO is still viewed as fundamentally important in preparing for senior secondary vocational and professional education. In recent years the Ministry of Education, Cultural Affairs and Science (OCW) stimulates initiatives to reinforce the vocationalism of the curriculum and the transitions to continuing education (Van Bijsterveldt-Vliegenthart, 2011; 2012). Transitions to continuing education seem to have priority. Practice driven developments in which VMBOs and MBOs cooperate in creating more vocational-oriented programmes are stimulated (e.g. 'Vakcolleges' and 'VM2-trajecen').

Concurrently with the developments in VMBO, the teacher training institutes that educate future teachers for VMBO and MBO (e.g. NHL University of Applied Sciences) are stimulated to prepare students for teaching in vocational education. These institutes are bound to incorporate two specializations in their curriculum: 'General Education' and 'Vocational Education' (Bussemaker, 2012). The specialization 'Vocational Education' also applies to teacher training trajectories that qualify for teaching in general disciplinary courses (Education Council of the Netherlands, 2011). Teachers in disciplinary courses should be able to put the subject knowledge in the vocational context of the students. This implies that the teacher training institutes are challenged to think about the pedagogical competencies that teachers need to relate topics of their discipline to the vocations relevant to their students.

In line with the aforementioned developments, the Biology Council of the Royal Netherlands Academy of Arts and Sciences (KNAW) poses in its report in 2003 that within VMBO and especially within the sectors Healthcare and Agriculture, educators should seek for ways to connect school biology with vocational curriculum elements.

However, elaboration of such connections also raises questions about the relationships between vocational contexts and biological knowledge and about the required pedagogy. Which biological knowledge is relevant in specific vocational contexts? How to elaborate and fine-tune the pedagogy of biology courses, vocational courses and work placements?

In short, there seems to be a tendency to reinforce vocationalism (cf. Bell & Donnelly, 2006; Donnelly, 2009) of VMBO and the alignment with MBO. What is more, future and current teachers in general disciplinary courses and teacher trainers are challenged to consider how topics of their discipline relate to vocations and how such relationships can be learned and used by students.

1.2. Connections of vocational and disciplinary curriculum components

Against the background described above, there seems to be a need for knowledge on how vocational and disciplinary curriculum components in VMBO can be aligned or integrated. In general, the following alignments and integrations can be identified.

Starting from vocational curriculum components

- Vocational courses enable students to explicate and use disciplinary and vocational knowledge when thinking about the workplace and when simulating participation in vocational actions;
- Work placements enable students to explicate and use disciplinary and vocational knowledge when thinking about the workplace and participating in vocational actions.

Starting from disciplinary curriculum components

- Disciplinary courses enable students to explicate and use disciplinary and vocational knowledge when familiarizing with or elaborating on relevant vocational contexts;
- Disciplinary courses enable students to explicate and use disciplinary knowledge when familiarizing with or elaborating on work placements in which the students are engaged.

VMBO schools choose to elaborate these relationships by rethinking and adjusting classroom learning at school (Van der Sanden, Streumer, Doornekamp, Hoogenberg, & Teurlings, 2003). Subject teachers seek to incorporate examples from vocational practice into their teaching. Besides this, vocational courses include simulations of the workplace. The study of Van der Sanden et al. (2003) indicates that integration of vocational and disciplinary theory with vocational practice is the main purpose of introducing simulations of the workplace in VMBO schools. Simulations are defined by characteristics of the curriculum, the pedagogy and the school. A curriculum that focuses on workplace simulations starts with key problems in vocational practice and integrates vocational and disciplinary courses. Workplace simulation pedagogy is characterized by authentic learning situations such as real assignments from vocational practice, and by a focus on transfer of knowledge.

Regardless of whether the disciplinary topics are integrated through context-rich learning environments in the disciplinary courses or through workplace simulations in the vocational courses, if students are to appreciate that disciplinary knowledge is relevant in the workplace, they should also experience its functionality in the actual workplace (Weelahan, 2009). This implies that students need experiences in the workplace to make meaning of their learning in school. It is for this reason that this research project focuses on promoting workplace experiences of VMBO students.

A second reason to focus on workplace experiences of students is that research on context-based general education and the use of workplace simulations have shown progression in recent years (Van der Sanden et al., 2003; Van Schaik, Van Oers & Terwel,

2011; Wijers, Jonkers & Kemme, 2004), whereas research on optimizing work placements in VMBO aimed at relationships between vocational and disciplinary knowledge have not.

To gain insight into how the functionality of disciplinary knowledge in a vocational environment can be made visible to VMBO students this study seeks to identify characteristics of a workplace- and school-related educational strategy. The purpose of the strategy is to enable students to appreciate the functionality of disciplinary knowledge in the workplace.

1.3. Disciplinary knowledge in the workplace

It has been shown that, in workplaces, disciplinary knowledge of the natural sciences is actually used during work actions or in optimizing work processes (cf. Prins, Bulte, Van Driel, & Pilot, 2008; Westra, Boersma, Waarlo & Savelsbergh, 2007). In cattle farms, embryo transplantation techniques are being used to produce offspring of cows that produce a lot of milk. For that, the cow is injected with hormones to get more egg cells. After that she is inseminated and hopefully fertilized. The developed embryos are rinsed from the womb and implanted in other cows. It goes without saying that engagement in actions like these and understanding what is being done requires biological knowledge of animal reproduction. Thus, the question seems to be not whether disciplinary knowledge is functionally used but how students can experience that this is the case.

However, getting students to understand the relevance of disciplinary knowledge may well be one of the main problems in vocational education (Onstenk, 2009; Tynjälä, 2008). The distance between school knowledge derived from scientific disciplines on the one hand and situated vocational knowledge on the other seems to be large (Griffiths & Guile, 2003). In addition, disciplinary knowledge that is being used in workplaces is not always visible or verbalized, which makes it difficult for students to recognize its relevance (Eraut, 2004a; Guile & Griffiths, 2001; Hewson, 2011).

Studies that focus on overcoming these transfer problems have long been dominated by a cognitive view on learning. In this view, the aim is to apply prior learning in new situations in a single direction from theory to practice (Alexander & Murphy, 1999). There is, however, a growing critique on this view on transfer (Hatano & Greeno 1999; Shreeve & Smith 2011; Simons 1999; Stevenson 2002a; Tuomi-Gröhn & Engeström 2003). More often, research is on ways in which learners are confronted with new situations or practices. Instead of having to apply specific knowledge in a specific way, learners are confronted with new situations or practices, which should challenge them to associate prior and new knowledge (Evans et al., 2010; Griffiths & Guile, 2003; Thompson, 2009). In line with the latter view, this research project focuses on connecting prior and new disciplinary and vocational knowledge at school and during work placement so as to surface the functionality of disciplinary knowledge in the workplace.

Association of these types of knowledge appears to be strongly influenced by the nature of vocational and disciplinary knowledge that is expressed in vocational and school discourse

(Bernstein, 2000). Once engaged in workplace action, a student is confronted with both vocational and disciplinary knowledge. This knowledge is expressed in the discourse held in the specific workplaces. It appears that, contrary to vocational knowledge, disciplinary knowledge is seldom verbalized in workplace discourse (Eraut, 2004a; Schmidt & Boshuizen, 1993).

Discourses in workplaces differ in nature and purpose from classroom discourses (cf. Bernstein, 2000). Where classroom discourse has the purpose to negotiate meanings and reach an agreement on specific knowledge, workplace discourse has the purpose to communicate about work processes so as to eventually produce an outcome. As a consequence, classroom discourse primarily seems to use more strict rules and principles to make meaning negotiation possible, whereas workplace discourse can, to some extent, do without such strict rules and principles that exceed the specific context (Young, 2006).

According to Guile and Young (2003), the knowledge embedded in these classroom and workplace discourses can either be tacit, situated or general. Tacit means that the knowledge is based on experiences of the learner and that it is generally not put into words or symbols. Situated and general knowledge, on the other hand, can be or are being verbalized. Situated knowledge is knowledge that applies to one context, whereas general knowledge applies to a range of contexts. In addition, general knowledge can differ in the extent to which it is general. It can either apply to several contexts, as in social sciences, or to almost all contexts, as in some of the natural sciences (Bernstein, 2000).

From the perspective of these differentiations in knowledge, disciplinary and vocational knowledge will be viewed in this study as follows: vocational knowledge emerges from a variety of workplaces, and consists of a description of these contexts based on systematic analysis. It describes both general knowledge which applies to a large part of the related workplaces or situated knowledge which is context specific; disciplinary knowledge on the other hand, although also debated and socially constructed, is presented in schools as the result of systematic study of phenomena in the world and consists of descriptions of and explanations for these phenomena that claim to apply to (almost) all contexts (Driver, Asoko, Leach, Mortimer & Scott, 1994).

Given the different discourses in disciplinary courses at school and in the workplace and given the primary focus on explanations of phenomena in disciplinary courses, it is not self-evident that disciplinary knowledge is verbalized in the workplace in such a way that its functionality is recognized. This implies that interventions should be made in workplace-related discourses aimed at verbalizing relationships between vocational and disciplinary knowledge.

1.4. Research questions

The aim of this project to search for characteristics of an educational strategy requires further exploration of learning in school and in the workplace. Given that the disciplinary

knowledge used is more or less implicit asks for an in-depth study of the workplace practice to identify instances in which knowledge is verbalized and used.

In this project, specific vocational and disciplinary domains have been chosen. From the teacher's perspective, the relevance of biological knowledge in agricultural VMBO is obvious (Boersma, Van Graft, Harteveld, De Hulu, Mazereeuw et al., 2007). Students in agricultural VMBO learn about biological topics within biology courses, vocational courses (e.g. 'animal husbandry and care' and 'plant care'), and related trainee posts. Knowledge of reproduction is relevant in various types of workplace (e.g. cattle farm, stud farm, plant breeders). In addition, reproduction is one of the key concepts in biology education and included in the Dutch examination programme (Boersma et al., 2007).

Drawing on these considerations the research question is as follows.

What are the design characteristics for a practicable and effective learning, supervising and teaching strategy that enables VMBO students to recognize the functionality of biological knowledge of reproduction in work placement sites?

The wording of this research question suggests a design research project. Educational design research provides a methodological framework for research on characteristics of an educational strategy. Design research aims to design optimal solutions for complex educational problems for which there are no how to do guidelines and it aims to gather knowledge about these problems and their solutions (Edelson, 2002; Juuti & Lavonen, 2006; Plomp & Nieveen, 2009; Van den Akker, Gravemeijer, McKenney & Nieveen, 2006). Design research studies are much alike but they also show a rich diversity on how they are conducted (See Van den Akker et al., 2006). One of these differences concerns the relationship between the intervention and the outcomes of the research. According to McKenney and Reeves (2012) some design research projects use the intervention as a means to explore and explain phenomena in educational practice, while other projects examine the intervention itself resulting in knowledge about the characteristics and effects of the intervention.

The design research presented here which is consistent with the latter, is common in the Freudenthal Institute for Science and Mathematics Education (FIsme). In this type of design research theory-based learning and teaching strategies are tested for their practicability and effectiveness in educational practice in an iterative and developmental process. Optimizing the strategy in a specific context does not only provide solutions to the context-specific problem. Each iteration can also be viewed as a test for the theoretically and empirically grounded design characteristics on which the strategy is based (Boersma & Waarlo, 2009; Kortland & Klaassen, 2009). After a number of iterations in which the (revised) strategy is tested and deemed effective, the question about its wider applicability arises. This is why Boersma and Waarlo (2009) differentiate between a learning and teaching strategy and a didactical structure (see also Boersma, 2011).

The strategy is a detailed description of an intervention to address specific problems in a specific context. The didactical structure is a sequence of learning, teaching and mentoring actions abstracted from the strategy and with potential applicability in other settings. Because research in FIsme is primarily domain specific, questions about the applicability of the didactical structure are usually about other contexts (e.g. types of school, types of workplace) and about other domains (e.g. other biological topics, other disciplinary course). Such a didactical structure with a defined applicability can be conceived as local instruction theory (cf. Cobb, Confrey, diSessa, Lehrer & Schauble, 2003).

It is within this framework of educational design research that the subquestions of the project are sited. This type of research is indeed theory-oriented (Boersma & Waarlo, 2009): i.e. the design of the strategy is appropriately informed by literature and the study of the design should finally contribute to the body of knowledge. Besides this quality criterion, the problem and the solution to that problem should also be relevant to practice. In addition, the design of the strategy should be consistent and in the end the strategy should be practicable and effective (Nieveen, 2009). The subquestions of this design research project are consistent with these quality criteria.

The first two subquestions concern the relevance of the strategy. These questions read as follows.

1. *What does educational literature say about the characteristics of workplace-related learning and supervising that is meant to enable students to articulate and relate disciplinary and vocational knowledge?*
2. *To what extent is current agricultural VMBO practice in accordance with these theory-based characteristics of workplace-related learning and supervising?*

The preparatory research is finalized by determining which knowledge of animal reproduction is being verbalized in specific workplaces as a premise for recognizing its functionality.

3. *What relationships between biological and vocational knowledge of reproduction are being verbalized in specific placement sites in current VMBO-practice?*
4. *How are biological and vocational knowledge related in current VMBO-practice?*

The strategy based on the findings of the preparatory research is field tested on its practicability and effectiveness in VMBO practice. The strategy should function in both the workplace and school. The first field test examines the practicability and effectiveness of the components that should function in the workplace. The effectiveness specifically focuses on conceptual development in students. The corresponding subquestions are:

5. *How practicable and effective are the strategy components of the learning and supervising strategy?*
6. *How do combinations of strategy components of the learning and supervising strategy associate with the learning outcomes?*

Since educational design research is iterative in nature, the revised and complemented strategy is field tested again. The following research questions are being addressed.

7. *How practicable is the learning, teaching and supervising strategy in which work placement and lessons at school are integrated?*
8. *How does student conceptual understanding of the workplace, of biological reproduction and of their interrelatedness develop throughout the strategy?*

1.5. Outline of the thesis

This thesis consists of seven chapters. Each chapter corresponds to the subquestions mentioned above (Figure 1.1). In this section the content of each chapter will be discussed.

Chapter 2 describes a literature study about relationships between vocational and disciplinary knowledge. This study results in the identification of theory-based design characteristics for a learning, teaching and supervising strategy meant to serve in school and in the workplace. The purpose of the strategy is that students recognize that disciplinary knowledge is functional in the workplace.

Chapter 3 reports on an analysis of current VMBO work placements to identify prospects and problems in work placements. These prospects and problems should be addressed when designing the strategy. The theory-based design characteristics of the previous chapter provided the framework for analysis.

Chapter 4 describes a study to gain insight into relationships between biological knowledge of animal reproduction and workplace actions in specific work placement sites. To that end educational materials were analysed and workplace supervisors and biology teachers were interviewed. These insights should further inform the characteristics for the strategy in these specific contexts. The outcome is an overview of relationships found in vocational education practice.

Chapter 5 describes the field testing of a first research-informed workplace-related strategy. The strategy describes and justifies student and supervisor actions and the expected learning outcomes, and mirrors a hypothetical learning trajectory. The field test included six case studies, and focused on the practicability and effectiveness of the strategy. Data was collected at several moments during the work placement period using a multimethod approach. Results were obtained by analysing completed student assignments, recorded supervision talks, and administered interviews with students and supervisors.

Chapter 6 describes the second field test of the revised and complemented strategy *integrating workplace and school learning*. The second field test included four case studies,

and focused on the practicability and effectiveness of the integrated strategy. Again the data was collected during the work placement period using a multi-method approach. Results were obtained by analysing completed student assignments, recorded supervision talks, video recordings of lessons at school and administered interviews with students and supervisors.

Finally, chapter 7 answers the main research question and discusses the prospects to abstract a didactical structure from the tested strategy. The chapter also addresses questions on the applicability of this didactical structure in other disciplinary domains and types of workplace. The chapter concludes with discussing the role of work placements in the vocational education of VMBO students.

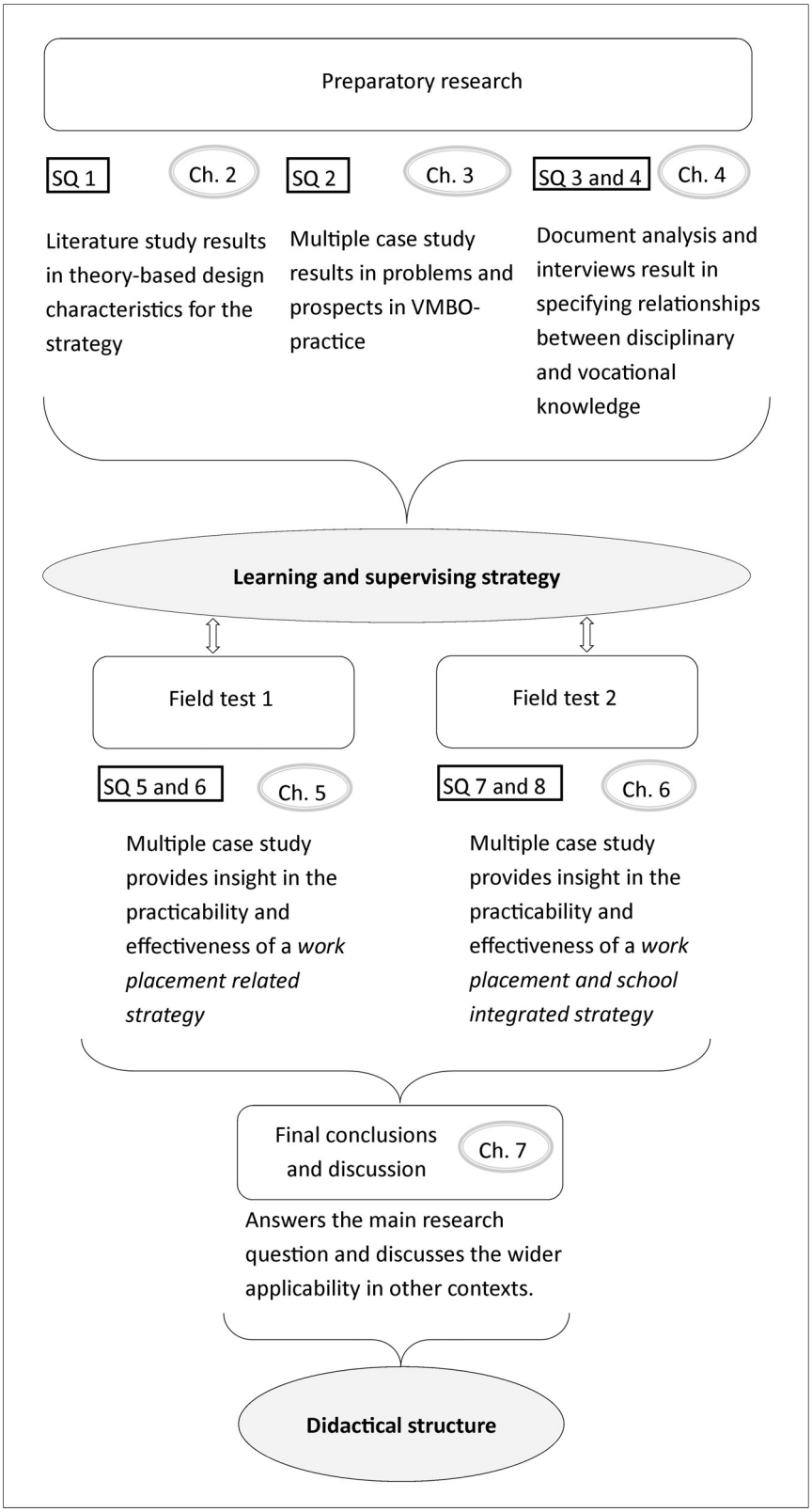

Figure 1.1. **Structure of this design research project**. The figure displays how findings in the preparatory research informed the design of a learning and supervising strategy. It also shows that the strategy is research-supported by conducting two field tests, whereas the didactical structure is research-informed. The figure indicates which chapter (Ch.) reports on which subquestion (SQ).

Chapter 2

Identifying theory-based design characteristics for a school and workplace integrated educational strategy

2.1. Introduction

This chapter reports on a study of the educational literature in search for theory-based design characteristics of a school and workplace integrated learning, teaching and supervising strategy. The latter is meant to challenge students to explicate and relate disciplinary and vocational knowledge. These characteristics should hereafter inform the design of a strategy in agricultural pre-vocational secondary education (VMBO). Besides this, they should also be used to analyse and appreciate work placement in current VMBO-practice. This chapter answers the following research question:

What does educational literature say about characteristics of workplace-related learning and supervising that is meant to enable students to articulate and relate disciplinary and vocational knowledge?

2.2. Methods

For the purpose of informing an educational strategy the search for relevant literature was focused. To answer the research question relevant literature was studied in three steps.

First, while exploring literature on integrations of school and workplace learning, it became clear that cultural-historical activity theory (CHAT) could provide a coherent conceptual framework to develop design characteristics for a workplace-related strategy. One reason for adopting CHAT was that literature on studies that address integrations of workplace and school learning often rely on CHAT as a theoretical framework (e.g. Aarkrog, 2005; Harreveld & Singh, 2009; Konkola, Tuomi-Gröhn, Lambert & Ludvigsen, 2007). Besides this, the purpose of the strategy is to enable students to appreciate the functionality of the workplace. CHAT may contribute to this purpose because it provides both a sociological and a psychological perspective on how working and thinking in the workplace may become meaningful for individuals (Poortman, Illeris & Nieuwenhuis, 2011; Stevenson 2007).

Second, the search engine Google Scholar was used to select more relevant literature. Within a period from 1990 up to 2009, the following terms and synonyms (between parentheses) drawn from CHAT literature were fed into the search engine: school(-based), vocational (professional, job-related) ‘workplace learning’ (apprenticeship, work-based

learning), transfer, ‘boundary crossing’, ‘vocational knowledge’ (professional knowledge, job-related knowledge), ‘disciplinary knowledge’ (general knowledge, theoretical knowledge, scientific knowledge).

Third, the search continued by selecting abstracts that included:

- learning processes of students (learning motives and development of conceptual understanding);
- learning in different practices;
- conceptual development in different practices;
- combination(s) of workplace learning and learning at school specifically.

In addition, abstracts that dealt merely with assessments, teacher education or development, 21st-century communication skills, adult learning, school-to-work transitions and scientific workplaces were excluded.

Finally, a coherent theoretical framework on relating vocational and disciplinary knowledge in the workplace was built. Since then, the framework was maintained by checking for updates in literature which resulted in minor adjustments.

2.3. Results

In this section, the results of the literature research are summarized so as to arrive at theory-based design characteristics. These characteristics are meant to inform the design of the strategy as well as to identify to what extent current work placement practice is in accordance with what such a strategy needs. Because of these purposes, the results of the study present which shared perspectives can be found in literature instead of discussing different manifestations of workplace and school learning at length. Examples of a cattle farm are offered to clarify how the insights from literature can be interpreted.

Applied to workplace learning, CHAT emphasizes that working and learning actions may become meaningful for an individual participant if it is clear how these actions eventually contribute to the outcome pursued by the workplace (cf. Engeström & Sannino, 2010; Leont’ev 1980; Stevenson, 2002b). Taking into account that knowledge may be used to perform these actions, this implies that acquiring this knowledge may also become meaningful if the participant understands how knowledge in the end helps to reach workplace outcomes. In other words, if the purpose is to enable students to appreciate certain knowledge, it should become clear to them what the outcomes of the workplace are and how this knowledge can be used to reach the desired outcomes.

To arrive at that, students should at least conceptually understand the relationships between outcomes, work actions and the knowledge embedded. However, as indicated in the introduction (chapter 1) the knowledge embedded in action may not be expressed in workplaces easily (cf. Bernstein, 2000; Eraut, 2004a; Young, 2006). For this, students and supervisors may have to take small but meaningful steps towards a more complete

understanding of these relationships. Here understanding means both recognizing (being aware of) and conceptual understanding. To structure the literature from which the design characteristics are drawn attainments of such steps were identified in the selected literature. Together they describe how students might recognize (disciplinary) knowledge as functional and how learning about it might become meaningful:

- Students understand the main targets and outcomes pursued by the workplace.
- Students understand that most actions in the workplace serve these main outcomes.
- Students and supervisors understand and, by experience, realize that to perform these actions specific (vocational and disciplinary) knowledge is used.
- Students and supervisors use combinations of disciplinary and vocational knowledge to explain and justify actions, and experience that there is a relationship between what they have learned at school and in the workplace.

Next, these attainments will be justified to arrive at characteristics for the design of the strategy and for evaluating current workplace learning in VMBO.

Understanding the main outcomes

A workplace can be conceived as an activity system in which actions are oriented towards manipulating objects in order to reach a certain outcome (Engeström 1987, 1999; Leont'ev 1980; Stevenson, 2002b). What is more, instruments are used to manipulate the objects. For instance, in a dairy farm, many actions are meant to manipulate cows to produce a large quantity of milk of good quality. Often, workplace instruments like milking machines or inseminations attributes are used to manipulate these cows.

However, in the CHAT literature a different, more broad view on instruments is displayed. It is this view of instruments in which the role of knowledge in the workplace is expressed. Knowledge that is used to perform actions can also be conceived as an adjustable instrument (Davydov 1988; Guile, 2006). In a dairy farm, for example, biological knowledge of reproduction can be seen as an instrument to monitor and influence the reproductive cycle of cows and thus boost milk production. With this in mind, knowledge about reproduction is functional in the dairy farm. However, its functionality will probably not be recognized by students if they do not understand the main outcomes being pursued.

Thus, from this perspective it seems advisable to start work placements with an exploration of the dominant outcomes of the workplace and link these to different actions.

Understanding that most actions serve these main outcomes

The literature on work-process knowledge (e.g. Boreham, Samurcay & Fischer, 2002; Guile & Griffiths, 2001) shows that insightful learning in a workplace starts with experiences and links these experiences to knowledge. Students become aware of their own contribution by being shown that actions in the workplace are organized, social and system-related.

However, being aware of one's own contribution requires that students also understand that the work actions they are engaged in are functional for the workplace. For this, students need to relate work actions to the outcomes. For some work actions, it is easy to relate the action to the outcome and to recognize its functionality. For instance, in case of relating milking cows to produce a large quantity of good milk. In other situations, recognizing the relationship between what is done and what has to be achieved requires a more detailed and coherent conceptual understanding.

In a dairy farm, for example, a student can only understand how cleaning the cowshed contributes to the price that is obtained for the milk if it is clear how the price of milk is set and how it is influenced by the health of the cows. Of course, sick cows produce less milk, but that is not the only relation. In this example, the relationship between cleaning the cowshed and farm profits becomes clear if the student understands that the price of milk depends on the number of white blood cells in the milk, which is a subtle indication for the cow's health. The student should also understand that cleaning the shed prevents sickness among the cattle. Understanding these relationships thus helps to understand why it is important to clean the cowshed which may on its turn make both cleaning the shed and learning about white blood cells and sickness in cows more meaningful.

This example shows that if students are to conceptually understand such intricate relationships they need to work and learn during work placement. To give meaning to their own contribution in situations where the relation is more obscure or to give meaning to work actions in the workplace in general, students need to develop a detailed and coherent conceptual understanding of the workplace. Instead of focusing on parts of the workplace coincidentally guided by the work schedule of the day, a student should be confronted with related instruments, actions and outcomes (Boreham et al., 2002). While engaged in these actions, a student tries to build a coherent image of the workplace. In this process Van Oers (1998, 2001) calls contextualization, students particularize the mental image step by step (Evans et al., 2010; Guile & Young, 2003). The question remains as to how we can support students to experience the purpose of developing such a detailed understanding of the workplace (Billett, 2003; Newton, 2011). Against the background of the insights from literature mentioned above, it seems important to invite students to engage in learning actions that also seem to serve a purpose to them in light of their contribution to the workplace.

Thus, if it is important to challenge students to acquire an in-depth and coherent understanding of the workplace, engagement in different and related work actions is recommended. If supervision is directed towards reflection on the rationale of actions this may make relationships between work actions explicit which can help students to understand the complexity of the workplace.

Understanding that specific knowledge is used

If students recognize that certain knowledge is functional in work action, this knowledge may also become meaningful in light of optimizing work actions and their own contribution as a novice participant. However, to be able to see the function of knowledge and to learn meaningfully the knowledge needs to be verbalized. So, working experts who often use knowledge implicitly must articulate or verbalize their knowledge in supervising students (Roth & Lee, 2007).

Following Eraut (2004b) and others (e.g. Akkerman & Bakker, 2012; Wesselink, Biemans, Mulder & Van den Elsen, 2007), the idea was adopted that reflection on work actions may contribute to the explication of knowledge in a workplace. According to Eraut (2004c), it is important to have a clear focus and purpose while reflecting. Here, the focus of reflection or learning conversation should be on students' conceptual understanding of the workplace (Evans et al., 2010; Tynjälä 2008), discussing its outcomes, actions, instruments and their relationships. By describing, justifying and discussing actions performed in the workplace, students and supervisors are challenged to put implicit knowledge into words (cf. Eraut, 2000; Smith, 2001). Confronted with imperfections in their understanding of the workplace, students may be challenged to actively particularize or adjust their image of the workplace (Guile & Young, 2003). The purpose of reflection thus may be to gain insight into workplace activity.

Billett (2009) advises sequencing the work actions that a student participates in and reflects on. As the expertise of a student develops, (s)he should be allowed to participate in new actions which require additional or new knowledge. Confronted with new work actions and its embedded knowledge, the student may be challenged to manage these actions and therefore experience the need to discuss how to engage. This discussion should surface the knowledge used in these actions. By engaging in and discussing different work actions that require specific knowledge, students may feel the need to particularize or adjust what they have learned about this so far (Griffiths & Guile, 2003).

Thus, engagement in actions that require specific knowledge may promote students to understand that knowledge is used in action. If supervision sequences these actions, it may scaffold the students' learning processes. Supervision directed towards reflection on the actions and students' conceptual understanding of the workplace may support these student learning processes.

Using combinations of disciplinary and vocational knowledge to explain and justify actions

If students are confronted with verbalized workplace-bound knowledge through participation and reflection, this knowledge may well be a combination of disciplinary and vocational knowledge. Our example of the student who justifies why cleaning the stable influences the price of milk indicates this. Confronted with both kinds of knowledge, students should recognize how these relate in particular situations to understand what is

going on in the workplace and to perform the work actions accordingly (Aarkrog, 2005). As a consequence they have to particularize or adjust what they have learned so far (Evans et al., 2010). So, students need to be challenged through confrontations of work actions that require different or more knowledge, which on its turn may stimulate them to reconstruct their existing knowledge.

For example, students who work in a dairy farm are familiar with monitoring the gestation of cows based on exterior, behavioural signs. Let us assume that during their work-placement period an ultrasound scanning device is installed, providing the opportunity to scan cows for gestation. Because of the device, signs of gestation can be detected much earlier and with higher certainty. However, the students have to learn how to use the scanning device in practice. Even if they cannot scan themselves, engagement requires learning how to identify gestation in *the interior* of a cow. This means that they have to recognize the womb, amnion and chorion as well as the embryo. Clearly, reflection on this action will challenge students to verbalize both vocational and disciplinary knowledge of animal reproduction and to particularize their image of cows in gestation. Knowledge of reproduction acquired in school biology courses can in these cases help the students to structure new knowledge in the workplace and workplace knowledge may help them to (re)structure their prior knowledge of reproduction.

However, literature on situated cognition (e.g. Marton 2006) has shown that, if disciplinary and vocational knowledge are verbalized in different contexts, this does not mean that these types of knowledge will automatically be connected by students. Knowledge of animal reproduction learned at school will not spontaneously be called upon in the workplace. According to Van Oers (1998, 2001), while learning at school, knowledge develops within a mental construction of the context school. Likewise, knowledge learned in the workplace develops within a mental construction of this context.

Nevertheless, in some cases students recognize a relationship between school and the workplace. If such a relationship becomes the object of orientation for students and supervisors (cf. Konkola et al., 2007) discussions about it may result in the development of a discourse in which terms and meanings from both contexts are used. The simultaneous use of these terms may result in learning processes in which the student needs to reconstruct his or her vocabulary and the knowledge that is accompanied (Stevenson, 2007).

Likewise, through orientation on such a ‘shared object’ that connects disciplinary and vocational knowledge, the students may connect disciplinary knowledge learned at school and vocational knowledge learned in the workplace. In doing so they may be challenged to restructure their existing disciplinary and vocational knowledge (Griffiths & Guile, 2003; Van Oers, 1998).

For example, assume that students learned about hormones in humans at school. While working, they also come to understand that hormones are injected into cows to induce them to come into heat. If these students recognize that there is a relationship between hormones in humans and hormones in cows, they may be challenged to discuss how hormones should be used in cattle farms. In doing so, they may also be challenged to reconstruct their

understanding of cows being in heat, relating their knowledge of hormones as a regulating factor that they learned about at school and their knowledge of cows being in heat. In this example, recognition of a relationship between disciplinary and vocational knowledge initiates reconstruction of their understanding of both cows being in heat and hormones as learned at school. In the example, 'hormones' can be viewed as the 'shared object'.

So, identification of specific similarities may help students to recognize relationships between disciplinary and vocational knowledge, as it can induce verbalization of these types of knowledge at the same time. Describing and justifying work actions, outcomes and their relationships may help to identify these similarities. It may evoke students and supervisors to use terms from both the workplace and school. By focusing on the meaning of these terms, the relationship between them may become apparent. If the student and supervisor in the example of 'cows in heat' have to justify why they inject something into a cow if she does not come into heat, they may articulate that cows are injected with hormones. By focusing on the meaning of 'hormone' and 'heat', their relationship may be discussed. As a consequence, the student may come to understand that hormones induce the cow to come into heat.

Thus, if we want students to recognize a relationship between vocational and disciplinary knowledge, it seems advisable to use terms and meanings from both discourses while describing and justifying actions. In addition, reflection on these terms and meanings by the students and the supervisors may also promote such a recognition.

2.4. Conclusion and discussion

In this chapter, theory-based design characteristics for a workplace-related learning and supervising strategy were searched that aim at challenging students to explicate and relate vocational and disciplinary knowledge. Here, the results of the literature research will be summarized.

Literature research provided us with the following design characteristics.

1. It seems advisable to start work placements with an exploration of the main outcomes of the workplace and link these to different work actions.
2. If it is important to challenge students to acquire an in-depth and coherent understanding of the workplace, engagement in different and related work actions is recommended. If supervision is directed towards reflection on the rationale of actions this may make relationships between work actions explicit which can help students to understand the complexity of the workplace.
3. Engagement in work actions that require specific knowledge may promote students to understand that knowledge is used in action. If in supervision these actions are sequenced it may scaffold the students' learning processes. Supervision directed towards reflection on the work actions and students' conceptual understanding of the workplace may support these student learning processes.

4. If we want students to recognize a relationship between vocational and disciplinary knowledge, it seems advisable to use terms and meanings from both discourses while describing and justifying actions. In addition, reflection on these terms and meanings by the students and the supervisors may also promote such a recognition.

The outcome perspective of workplaces seems central in thinking about learning in work placement if students are to experience that disciplinary knowledge can be functional. Learning in the workplace is a process of trying to make sense of the environment. Attuning supervision to this learning may imply that students and supervisors undertake learning conversations that focus on the rationale of actions, so as to elicit students' conceptual understanding of the workplace. Terms and their meanings used in this rationale can be discussed and clarified to elicit embedded vocational and disciplinary knowledge.

Chapter 3

Exploring workplace-related learning in agricultural pre-vocational secondary education

3.1. Introduction

This chapter reports on a study to identify problems and prospects of work placement in agricultural VMBO. These should be taken into account when designing an educational strategy aimed at challenging students to explicate and relate disciplinary and vocational knowledge. The theory-based design characteristics identified in the previous chapter are used to analyse and evaluate cases of educational practice in agricultural pre-vocational secondary education. After presenting the results, the chapter ends with recommendations for designing work placement components for an appropriate educational strategy. The study presented here seeks to address the following research question:

To what extent is work placement in agricultural VMBO in accordance with the theory-based design characteristics of workplace-related learning and supervising?

3.2. Methods

To answer the research question nine studies of relevant cases were conducted. To select these cases, work placement reports of students were analysed for the occurrence of terms related to biological reproduction. This provided a list of relevant workplaces. It was assumed that reproduction-related terms indicated that knowledge of reproduction had been verbalized and used in these workplaces.

Based on this list, actual cases were selected within a database out of more than 100 trainee posts provided to us by a VMBO school. Two experienced work placement officers of the school were asked to examine the selection indicate in which workplaces students could come across the phenomenon of reproduction. As a result of their input, the original selection was supplemented with ‘sheep farm’ and ‘zoological garden’. They reasoned that sheep farms are similar to horse-breeding farms and that some zoological gardens have reproduction programmes. Students may therefore come across the phenomenon of reproduction when engaged there. In Table 3.1, the final selection of workplaces, the number of interviewed students and supervisors and the number of additional work placement reports is shown.

Table 3.1. Selection of cases and data collection

Workplace (number of cases)	Interview student	Interview supervisor	Additional work placement reports
Horse-breeding farms and horse-milking farms (3)	3	3	4
Cattle (dairy) farms (2)	2	2	13
Sheep farms (2)	2[a]	2[a]	-
Zoological gardens (1)	2	1[b]	3
Veterinarians (1)	1	1	7

a. The sheep farms included one combination of cattle and sheep.

b. One supervisor did not participate because it did not fit into his time schedule.

In trying to reconstruct if these specific types of work placements were in accordance with the theory-based design characteristics, a case study included semi-structured interviews with students and supervisors of the workplace. In search of confirmation or contradictions, reports of students who did their work placement in similar workplaces in two consecutive school years (2007–2008 and 2008–2009) were analysed.

Because the students in the upper levels of VMBO are aged 14-16, it was insufficient to merely rely on interviews alone. The data from the interviews was verified with the placement reports in earlier years. What is more, the interviews with students preceded the interviews with supervisors which made is possible to verify the information brought forward by students. Besides this, pictures made by students were used in the interviews, which allowed questions about concrete items on the pictures at first (cf. Prosser & Schwartz, 1998). Before conducting the interviews, students (seven female and two male, aged 14–16 years) were invited to make pictures of areas of the workplace that, for whatever reason, had been important to them during the placement period. While doing their work placement, students were provided with disposable cameras, which were collected by the researcher after the placement period. Each interview started with the student making a selection of their own pictures, which were displayed on a table.

After the selection, the interview focused on:

- ‘why’ these pictures were selected;
- ‘why’ these pictures were taken;
- ‘why’ these areas of the workplace were important;
- ‘what’ they were doing there and with ‘whom’;
- ‘why’ they were doing that.

The semi-structured interviews with supervisors (five female and three male) took place within the workplace or their homes and focused on:

- the main objectives of the workplace;
- supervision in the workplace;
- the actions performed by students;
- the knowledge of animal reproduction used;

- the possibilities for students to engage in actions that require knowledge of animal reproduction.

The interviews were audio-taped (partly also video-taped) and transcribed. Subsequently, the interview protocols and work placement reports were analysed by close reading, highlighting the passages that could be linked to theory-based characteristics derived from the literature. This was followed by axial coding, allowing clustering and summarizing the information.

3.3. Results

In this section, the results of data collection and analysis will be presented and categorized in accordance with the theory-based design characteristics that we elaborated upon in the previous chapter.

Exploration of dominant outcomes of the workplace

When asked about the dominant outcomes of their practice or farm, supervisors often brought up more than just making enough profit. In horse-breeding farms, for example, keeping the animals in good health, breeding towards producing first-class horses and creating a market for horse milk were all mentioned. According to the supervisors, these goals become clear to the students. However, supervisors displayed different ways of confronting students with these main outcomes.

After analysing the interviews and work placement reports, it became clear that, while doing work placements, students were oriented both towards the entire workplace and towards parts of it. When asked about their selection of pictures, their answers revealed that their orientation towards animals was stronger than their orientation towards the company.

Students doing their work placement in veterinary practices focused on animals when explaining why they produced a certain picture. They often used words like 'pitiful' or 'cute'. Also, they often sympathized with the pet's owners. Students also tend to talk about exceptional situations during their placement period. For instance, one student indicated a cat with a decaying tongue as being important and another mentioned the removal of a very large tumour in a dog. In the interviews, very little indications were found of thinking on a workplace level.

Interviews with students working in a zoological garden and analyses of reports showed that animal health was one of their major concerns. In both interviews, it became clear that, in their opinion, healthy animals are also important for visitors.

The students on sheep farms both indicated that the health of the animals was their first concern. However, in most situations, they explained that animal health was important from both a personal *and* a company perspective. One student, for instance, stated that if an

animal dies this is a pity for both the animal and the farm. The quote that follows shows how the farm perspective and the personal perspective relate to one another (R: researcher).

Student Sandra (sheep farm)

R: *Okay, you say that you have been taking care of the lambs here. You cleaned here. Why did you do that?*

Sandra: *Because it is better for their wellbeing; for the sheep also.*

R: *Yes.*

Sandra: *Because they can become sick otherwise.*

[...]

R: *Does it trouble you to see that a lamb eh...?*

Sandra: *Becomes sick?*

R: *Yes.*

Sandra: *Sometimes it's really bad and I don't like to see that. Once I saw a lamb that was allergic. Then they contract [their muscles or stomach] all the time and they swing their head backwards. I don't like to see that.*

R: *No, why not?*

Sandra: *Because you see that the animal is in pain.*

R: *So then you think about the lamb?*

Sandra: *Well, eventually you think 'oh heck, it is dying'. But then I don't think 'there goes another fifty euros when it is full-grown'.*

Students participating in horse-breeding farms were also more preoccupied with horses than with the farm itself. However, as well as having this personal perspective, students also seemed to use a farm perspective. When explaining the pictures, they related their actions to the production of milk or foals.

Students on cattle farms tended to have a stronger workplace perspective. Only in exceptional cases did they get involved with the animals. For example, a student called a bull-calf his friend because it followed him around the farm. In all interviews and reports, the students related actions performed to the production of milk, although the relationships mentioned were not very articulated.

Engagement in different, outcome-related actions

Interviews with students and supervisors and analysis of reports revealed that students were mainly engaged in workaday actions. Students in veterinary practices all mentioned taking care of the animals before or after surgery, or welcoming customers and referring them to the counter. They were also deployed to clean, do the dishes and laundry, and make coffee. The supervisor indicated that in many situations students did not actively participate but they often observed actions performed by employees. The main chores in the horse-breeding farms found in the interviews and reports were cleaning out the stables, and grooming and feeding the horses.

One reason for supervisors allowing students to perform these workaday actions seemed to be that they thought that the students could best become acquainted with the workplace by performing these kinds of actions. Some also argued that these actions are often easy to learn because they can be repeated throughout the placement period. The next quote indicates this.

Supervisor Anne (horse-breeding farm)

R: *What else do you do as a supervisor?*

Anne: *Well, Bob is the one in the stables, and Joyce. They are with the girls [students] all day.*

R: *Yes?*

Anne: *I'm not there all day, I must admit.*

R: *Okay.*

Anne: *So, we are trying to teach them sweeping the stables, of course. And how you can bring a horse to the paddocks, that you will have to turn them. We teach them how they have to sweep, these kinds of things, common things. That there has to be regularity, that they have to be fed, these kinds of things.*

R: *Okay.*

Anne: *And of course, it can be different in every stable. There are stables that feed the horses five times a day. Others feed them two times a day. And there they do not have to sweep like this. So, the children get different instructions all the time.*

R: *Yes.*

Anne: *I'm sure about that.*

The students doing their work placement in a sheep farm displayed some differences. In the first practice, the workaday actions usually took up a small part of the day. This student also helped to deliver lambs. The other student was almost solely engaged in workaday chores, as the next quote indicates.

Student Paul (sheep and cattle farm)

Paul: *Yes, I just like lambs.*

R: *Nice animals, you say. Did you work a lot with these lambs?*

Paul: *Yes, I had to feed them every morning.*

R: *Okay.*

Paul: *Giving them water.*

R: *So, here you mainly took care of the lambs.*

Paul: *Well actually, I took care of the sheep. Lambs drink with the sheep.*

R: *Yes, and what do you do with the sheep?*

Paul: *I gave them food and water.*

Engagement in actions that require knowledge of reproduction

The interviews and analysis of work placement reports also gave us insight into the participation of students in actions that require knowledge of animal reproduction. By this, knowledge of animal reproduction, which is required when the action is described in detail and justified is also meant. Work placement reports indicated that, in all selected cases, terms related to animal reproduction were used to describe the workplace and its actions. However, when looked at overall, it seemed that students hardly participated in actions that required knowledge of animal reproduction.

In the veterinary practice, students were mainly confronted with issues of reproduction if an animal was castrated or sterilized. The data indicated that students in these practices did engage in actions that required knowledge of health and hygiene more often.

Apart from mechanically brooding bird eggs, the students in the zoological gardens were not engaged in actions that required knowledge of reproduction. According to one supervisor, reproductive success is seen as a successful integration of the animal in the garden. Reproduction itself was not an aim.

On the horse-breeding farms, it was found that students were confronted with the following working actions directly related to animal reproduction: choice of stallion or mare for breeding, observing behavioural signs of heat with mares, visiting mare to stallion to identify moment of coverage or insemination, coverage or insemination, checking for signs of gestation, keeping watch before birth and guiding birth.

From the interviews with students and supervisors, it became clear that students were present when these actions were performed but often they were not actively engaged. Although these students did not engage in these actions, according to all three supervisors, it is possible for students to participate in some. The following quotes from an interview with one of the supervisors shows that students can engage in these actions.

Supervisor Wendy (horse-breeding farm)

R: *Do you have the impression that they learn something from that?*

Wendy: *Yes, because we try to make it possible for them to bring the mare to the stallion and see for themselves. We ask them if the mare can be covered or not.*

[…]

Wendy: *When mares are in heat, it is important to visit [the mare to stallion] often. Mares are usually in heat for about three to seven days. So you have to keep a close eye.*

R: *Yes?*

Wendy: *So, you have to pay attention and wait for the right moment.*

R: *Okay. Can students also learn to do that?*

Wendy: *Yes, especially with older mares. We know them so well that we can determine quite precisely when she's ready. With these mares, we let the students visit them again and then they have to tell us if the mare is ready or not.*

Supervisors also mentioned that students could identify if a mare is in gestation both by observing signs of heat and interpreting images on an ultrasound scanning device.

Finally, all supervisors mentioned that they keep track of the heat, coverage and gestation of their mares in a calendar or a schedule. Two supervisors mentioned that it should be possible for students to make a schedule for themselves and select times to check certain mares. However, students were also excluded from participation. Assisting with a coverage appears to be too dangerous due to the strength of the horses. Another example is that students are not allowed to inseminate the horses themselves. Piercing through the intestines may be lethal to a horse.

With regard to the actions required for animal reproduction, it was found that cattle (dairy) farms and horse-breeding farms are much alike. Similar to the horse-breeding farms, the students can monitor heat and gestation. In the next quotation of the interview with Tom, a supervisor in a dairy farm, this is indicated:

Supervisor Tom (dairy farm)

R: *Okay, so what can a student do when he works there?*

Tom: *Well, observe the cows. I always say: 'If you sweep the shed, look in that direction [towards the cows].'*

R: *And is that to scan the health?*

Tom: *Health and heat.*

R: *Heat?*

Tom: *If all the cows are calm...and one is restless then it is easy to see.*

Besides this, in cattle farms, students are also not allowed to inseminate the cows themselves because of the risk of lethally wounding an animal. One supervisor added that if the insemination should fail it would cost him.

Sequencing actions

In all cases studied, it was found that, after some time, students were relied upon to perform actions by themselves. In a few cases, students could engage in new actions. Supervisors expressed that in most cases it depended on the student whether or not the supervisor challenged them with new actions. Some indicated that they decided if a student could deal with a new situation or not. A student with more experience would be allowed to perform more difficult actions. Some indicated that they introduced new actions if a student showed interest. One supervisor mentioned that the actions performed by students gradually developed. A quote from supervisor Jill illustrates that determining if a student can deal with a new situation is sometimes based on intuition:

Supervisor Jill (veterinary practice):

Jill: *...and of course not all students are similar. Because they have their own character. Some [students] go to work immediately while others rather wait and see. I think that's fine [...] Just observing for two weeks is okay.*

The interviews with supervisors and content analyses of work placement reports showed that the supervisors often first demonstrated an action before a student engaged in doing it. As mentioned before, these actions could mainly be conceived as workaday actions that were not too complex for the students, according to the supervisors.

Reflection

Analyses of work placement reports and interviews with supervisors taught that conversation about work often consisted of 'what had to be done that day' or supervisors explaining something to students. Whether a supervisor explained usually depended on the questions asked by the student. One supervisor mentioned that she asks students questions and makes them search for the right answer if they are not able to answer correctly. She explained she was instructed by school.

In supervising students, most supervisors seemed to use a three-step model: show, act and discuss. First, they demonstrated to the student how an action should be done. After that, the student tried to perform the action. After performing, the result was discussed. If necessary, more directions were given. Usually, supervisors worked together with students at first and left them alone at a later stage. The next quote shows an example of this.

Supervisor Wendy (horse-breeding farm)

R: *Yes, can students also learn to do that?*

Wendy: *Yes, especially with older mares. We know them [the mares] so well that we can determine quite precisely when she's ready [to be covered]. With these mares, we let the students see for themselves and then they have to tell us if the mare is ready or not.*

R: *Okay, so you say, "Do you want to look at that?"*

Wendy: *Yes.*

R: *Is that sort of a game because you probably saw it already?*

Wendy: *Yes, that's right. We do that so they can learn. We already know the answer and they must tell us.*

R: *Oh, okay. And how do they do?*

Wendy: *When they do this for the first time, they usually tend to say that it's okay [the mare can be covered] too soon.*

R: *No, okay.*

Wendy: *Yes, it is difficult to determine if a mare is ready[...] but the more they do it, the better they can determine it.*

3.4. Conclusions

In this chapter, the theory-based design characteristics were used to find out to what extent current work placement in agricultural VMBO is in line with what is thought to be theoretically desirable. This section reports on what was found in the cases studied: i.e. to what extent work placement in the case studies meet the theory-based characteristics.

Exploration of dominant outcomes of the workplace

Supervisors often seem to accept that students recognize a superficial relationship between actions and outcomes, which they usually already have before participating in the workplace. As a consequence, students may not be challenged to particularize their understanding of these relationships. Outcomes and their relationships with actions appear to be discussed too incidentally to confront students with new relationships. Besides this, it was noticed that students' focus on the workplace as a whole seemed to be underdeveloped and therefore needs to be elaborated. On the other hand, the relationships between outcome and action that students do make can be used as a starting point towards recognition of the purpose of actions.

Engagement in different outcome-related actions

Students are often engaged in workaday actions, which appear to be more difficult to relate to the outcomes. In addition, supervisors indicated that they focused on the skills of students, trying to enable them to perform some actions by themselves instead of also teaching students about the workplace and about the purpose of each action. As a consequence, a student may not develop a coherent and particular understanding of the workplace. However, supervisors reported that it is possible for students to engage in other actions. In some cases, this was already done (e.g. on the sheep and dairy farms).

Engagement in actions that require knowledge of animal reproduction

Supervisors reported that it is possible for students to participate in actions that require knowledge of animal reproduction, although this is not done very often. It appears that in workplaces in which animal reproduction can be related directly to the main outcomes of the workplace, students are able to participate in coherent actions that require this knowledge. Engaging in such coherent actions may contribute to students' development of a coherent understanding of both the workplace and the embedded concepts of animal reproduction. It also appears that, in workplaces where reproduction occurs incidentally and cannot be related to the outcome, students can participate in other clusters of coherent actions (e.g. actions that require knowledge of health). This may indicate that there is a relationship between the outcome, the disciplinary concepts used as tools and the potential

to develop this concept while participating. On the other hand, not all actions can be performed by students. In some cases, the risks of injury or risks of reduced production or profit prevent students from participating.

Sequencing actions

Supervisors said to deliberately allow students to engage in more complex actions, considering the experience and abilities of the students. However, this build-up of actions is usually inspired by their aim to let students eventually perform a combination of actions by themselves. The choice of new actions seems not to be inspired by the idea that students have to learn about the workplace, its outcomes and related actions. A consequence may be that the sequence of actions does not build up towards a conceptual understanding of the complex workplace. In this case, the understanding of the student probably remains the same.

Reflection

The intuitive three-step model used by most supervisors can possibly be elaborated towards a model in which students and supervisors take time to reflect on the rationale of actions and elicit students' conceptual understanding of the workplace, which is meant to clarify terms and their meanings used in this rationale. It was found that actual learning conversations like these occurred incidentally. If so, they often displayed a question and answer format in which the student asked questions and the supervisor answered.

There were no indications that reflection focused on either the rationale of actions or terms and meanings to describe and justify actions in the workplace.

3.5. Discussion

In VMBO, the purpose of work placement is somewhat different from other types of vocational education. Here, the purpose of work placement appears to be 'launching students into work' (cf. Guile & Griffiths, 2001). In current work placements in VMBO, there seems to be a focus on acquiring work experience and developing social competencies instead of learning to understand. Because of this one-sided focus, part of the learning potential of work placement appears to be unused or neglected (cf. Nijhof & Nieuwenhuis, 2008). Teaching students how to deal with a new or changing environment and showing them that knowledge learned at school can be functional in practice may enhance learning in both school and the workplace (Berner, 2010).

The theory-based characteristics allowed systematic categorization of data drawn from cases and work placement reports. However, with hindsight, not enough information related to the characteristic concerning reflection was gathered. When conducting the interviews and analysing the reports, it seemed that, in general, conversations about working and

learning were rare. Because of this, it is believed that the absence of information on reflection indirectly points towards a realistic representation of the cases studied. Empirical data from this study shows that both actions and outcomes were seldom discussed. This may support the aforementioned focus on acquiring work experience and development of social competencies. Another reason may be that, while working and supervising, experts may be unaware of the fact that they use certain knowledge because they have performed the actions many times (Eraut, 2004b; Schmidt & Boshuizen, 1993; Smith, 2001). Difficulties for both students and supervisors in verbalizing what they know and why they act in a certain way may result in a work-focused relationship instead of a learning-focused one.

Implications for an educational design

The aim of this study was to gain insights into agricultural VMBO practice, so as to identify problems and prospects that need to be addressed when designing a workplace-related learning and supervising strategy that enables students to experience that biological knowledge can be functional in the workplace. Reflecting on the results of the study, again the outcome perspective of workplaces seems central in thinking about learning in work placement if students are to experience that disciplinary knowledge can be functional.

To sequence actions in which students engage and reflect on, it seems advisable to start with workaday actions and an orientation on the main outcomes. An orientation like this appears to align with current work placement practice and may enable students to get acquainted with the new workplace environment. In the workplaces studied, actions in which students engage next can be arranged along either a time line or a production line, eventually leading to outcomes. If possible, it may be advisable to confront students with such lines of actions, enabling them to relate actions and outcomes. While working and learning, these relationships can be discussed. Confronting students with actions within such a production or time line may result in the development of a coherent and particular concept of parts of the workplace. Moreover, combined with reflection on terms and their meanings, it may also result in the development of coherent relationships between disciplinary and vocational knowledge.

Thus, by analysing a workplace along these lines of the outcome and embedded knowledge, it may be possible to identify *what* disciplinary knowledge can be learned coherently in a workplace (i.e. related to vocational knowledge in context). If it is possible to identify disciplinary knowledge that can be directly related to the outcome, it seems plausible that actions that require this knowledge can possibly also be sequenced along a time line or production line. This may enable supervisors to select actions along a line that can result in a clear focus and purpose in learning conversations (Eraut, 2004c), i.e. reflecting on relationships between actions and outcomes to understand why an action serves one of the main outcomes. Therefore, when designing a learning and supervising strategy, it will focus on the sequence of actions along lines of production or time lines and the nature and purpose of learning conversations while doing work placement.

Chapter 4

Specifying relationships between biological knowledge of animal reproduction and workplace actions

4.1. Introduction

The previous chapter revealed that horse-breeding and cattle farms seem to be adequate workplaces for agricultural VMBO students to learn to appreciate how biological knowledge of reproduction can be functional in the workplace. In workplaces like these, knowledge of animal reproduction is an integral part of performing actions or grasping what's going on in the workplace (e.g. inseminating cows, monitoring gestation in mares). In this chapter, the focus will be to gain insight into potential relationships between biological knowledge of reproduction and vocational knowledge of cattle and horse-breeding farms. In particular, identification of relationships between biological knowledge and workplace actions and processes. Another purpose of the study is to explore the nature of the identified relationships, i.e. to find out how biological knowledge is functional in these specific contexts. The knowledge gained from this study should be helpful in finding promising learning and supervising actions to incorporate in an educational design for work placement in VMBO.

4.2. Functional knowledge in action

In this section it will be outlined how disciplinary biological knowledge can be *used instrumentally* in workplace actions or how it can be used to *understand* work processes. In workplace practice disciplinary knowledge does not function isolated but is intertwined with vocational knowledge and used in work actions (Barnett, 2006; Young, 2006).

Biological knowledge as an instrument in action

According to cultural historical activity theory (e.g. Engeström, 1999; Leont'ev, 1980) subjects are oriented towards manipulating or influencing an object to produce an outcome. To do so the subject uses different instruments. Figure 4.1 shows an example of a cattle farm workplace. A cattle farmer influences cows (e.g. inseminates, cares for, milks) to produce a certain volume of qualitative good milk. To do so he uses instruments like mechanical milking machines and storage tanks. Less obvious is that the farmer also uses knowledge of animal reproduction (cf. Davydov, 1988).

For instance, if the farmer wants to monitor the heat and gestation of cows, which tells him when to inseminate, he should be able to interpret their behaviour. A cow which has been inseminated three weeks before should not display signs of heat when carrying. So, to a farmer, biological knowledge of animal reproduction is functional in light of pursuing outcomes of the workplace.

When students in vocational education also recognize that biological knowledge is functional in workplace, acquiring this knowledge may become meaningful to them. Students and supervisor who are trying to determine the right moment of an insemination need to observe the cows' behaviour in heat. By stimulating the students to provide a rationale for the moment they think is right, they may be challenged to explicate the relationship between ovulation and behaviour of cows and maybe even that this is due to hormonal inducement. In this example biological knowledge is functional because it is needed to perform and discuss actual actions in the workplace.

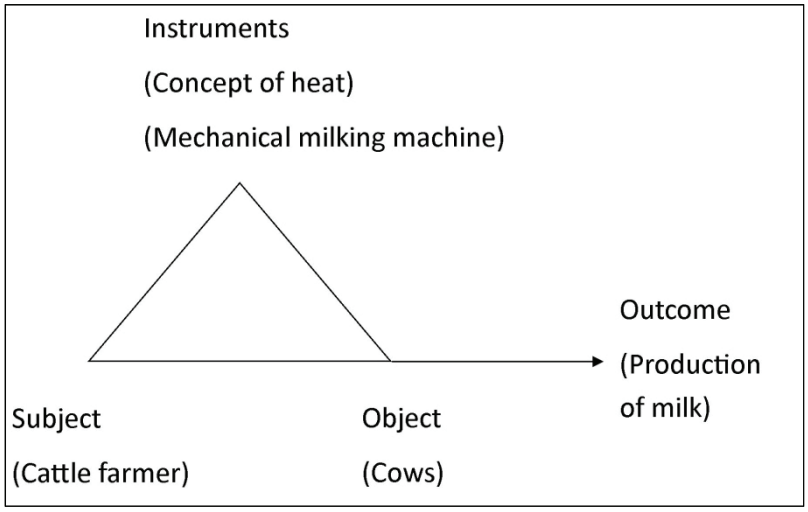

Figure 4.1. Relationships between subject, object, instrument and outcome

Biological knowledge to understand the workplace

Next to providing a rationale for the moment of insemination, students may also be challenged to verbalize biological knowledge when explaining how a successful insemination contributes to farm profits. In the example their explanation should contain fertilization, development of a calf and perhaps birth. Here biological knowledge is needed to understand the workplace.

However, by merely relating each single action to workplace targets students probably verbalize rather shallow relationships, i.e. they will not spontaneously try to connect single actions to each other. A detailed conceptualization of the context is needed. Cows, for example, are manipulated in many ways to eventually produce milk. In trying to acquire insight into single actions as well as an overview of related actions, students seem to need a detailed conceptualization of the workplace and its actions. In this process, which Van Oers

(1998) calls contextualization, both the situated (vocational) and general (vocational and biological) knowledge of the workplace are conceptually intertwined.

Providing new knowledge may also contribute to the student's understanding of the workplace. The different actions that eventually lead to milk production (e.g. identifying signs of heat, inseminating, checking for an embryo) are connected through the reproductive –hormonal– cycle of cows. The introduction of biological knowledge of hormone cycles may support students in trying to relate actions such as 'checking for signs of heat' and 'checking for signs of a coming birth'. It may also support them in creating an overview of all actions and their interrelationships. Introducing biological knowledge may help to understand that the reproductive and hormone cycle influences calf and milk production. This process of integrating disciplinary knowledge (e.g. hormones) into an existing concept of the workplace can be conceived as an example of recontextualization (Guile & Young, 2003; Van Oers, 1998). Interconnecting hormones and workplace goes with adjusting or recontextualizing both concepts.

4.3. Research questions

In the section above it was made clear that biological knowledge can be functional in the workplace as it is interrelated with vocational knowledge. However, being functional does not mean that these relationships are also made explicit in VMBO-practice. For this reason, the study presented here seeks to answer the following research questions.

1. *What relationships between biological and vocational knowledge of animal reproduction are being verbalized in horse-breeding farms, cattle farms and in VMBO-practice?*
    a. *What relationships between biological and vocational knowledge are being verbalized in educational materials of vocational courses and by workplace supervisors?*
    b. *What relationships between biological and vocational knowledge are being verbalized in biology courses according to biology teachers?*
2. *How are biological and vocational knowledge related?*
    a. *What are the explicit relationships about?*
    b. *What is the function of biological knowledge in the explicit relationships?*

4.4. Methods

To answer both research questions, semi-structured interviews with workplace supervisors and biology teachers were held and the educational materials used in vocational courses were analysed.

Interviews with workplace supervisors

Workplaces were selected from a database of a VMBO school. Selection took place based on a previous study that indicated in which types of workplaces biological knowledge seemed to be used (chapter 3).

Two male cattle farmers and three female horse breeders were interviewed. All supervisors had supervised VMBO students in the same year in which the interview was held. The interviewer tried to indirectly elicit information about the knowledge that can be made explicit when supervising. To do so the interviewer suggested not to know much about cattle farms or horse-breeding farms. Besides this, the interview focused on actions that could be performed by students and how these should be performed.

Educational materials

Documents (e.g. school books, assignments, practical instructions, examination programmes) were selected from a shielded online educational content catalogue which included more than 50,000 Dutch agricultural educational materials. The documents were selected, using the following selection criteria. The materials had to be

- about milking and/or breeding cattle and/or horses;
- (partly) about animal reproduction;
- written for VMBO or for the lower levels of MBO.

Eventually, 31 documents , with an average of 8184 words per document, met these criteria.

Interviews biology teachers

Informative conversations with two biology teachers as key informants were held. Based on these conversations, three other biology teachers, two male and one female, were interviewed.

In the interview, the researcher and teachers walked through their text books on the basis of a list of principles of biological reproduction (Reygel, 1997). The teachers were asked if these principles were being taught and how they elaborated these in biology lessons. Follow-up questions focused on examples they said to use when explaining these topics. After that, the teachers were confronted with an overview on the reproductive cycle of cows and horses and related actions in the workplace which were obtained from the document analysis mentioned above. The teachers were asked if they use these workplace actions as examples in their lessons and why (not).

Analysis

The transcribed interviews and the educational materials were analysed by close reading and assigning categories to semantic units. Each unit was categorized in accordance with the analysis scheme as presented in Table 4.1.

In search of semantic units in which both vocational and biological knowledge were manifest 'vocational knowledge' was assigned when terms from cattle farms or horse-breeding farms were used (e.g. gestation, artificial insemination). Likewise a unit was categorized as biological knowledge when terms of the scientific discipline of biology or terms of school biology were used (e.g. sperm, ovary).

After that it was determined what the units were about. Heat, insemination or coverage, gestation and birth were distinguished. A category was assigned if related terms were used. This allowed relating of units with vocational and biological knowledge to the reproductive cycle of cows and horses.

The contents of the semantic units were also analysed on the extent of their relationship with workplace actions. Subject, object, instrument and outcome were distinguished, as explained in the conceptual framework of this article.

After categorising the semantic units, the inter-rater reliability (Cohen's kappa) was determined. A random selection of 105 units were also categorized by a colleague researcher. The kappa's per category are shown in Table 4.1. Because the agreement on the category 'vocational knowledge' was too low (0.55) its description was articulated and the same selection was analysed accordingly. The second time resulted in an agreement of 0.89 (Cohen's kappa).

Table 4.1 Cohen's kappa per category

Category	**Kappa**
Vocational knowledge	0.55 / 0.89
Biological knowledge	0.88
Heat	0.93
Insemination / coverage	0.70
Gestation	0.83
Birth	0.76
Subject	0.85
Object	0.80
Instrument	0.84
Outcome	0.74

To answer the first research question the contents of the semantic units that were categorized as both vocational and biological knowledge were summarized. Per unit links were elicited between:

- stages of the reproductive cycle (e.g. gestation),
- the workplace action, divided in subject, object, instrument and outcome
- biological knowledge.

Before analysis, links were anticipated between the reproductive cycle of cows and horses and biological knowledge represented by the principles of reproduction (Reygel, 1997). When biological knowledge was verbalized and related to workplace action this was identified as *explicit biological knowledge*. If the biological knowledge was verbalized but not related this was identified as *implicit biological knowledge*.

To answer the second research question, selected semantic units were categorized as vocational as well as biological knowledge. The selection was refined by accepting units that contained three or four particularities of workplace action: subject, object, instrument or outcome. Next, these units were categorized based on the functionality of biological knowledge (i.e. if biological knowledge was described as an instrument in action or if it functioned otherwise). Subsequently, the contents of these units were examined, so as to identify what was said about the workplace actions.

4.5. Results

Verbalized relationships

The results of analysing relationships between biological knowledge and workplace action and processes are presented in Table 4.2. The table shows that biological knowledge is often made explicit and is related to workplace actions when the actions are explained. Relationships in 232 out of 701 semantic units were found. The table also shows that explaining work actions does not always result in verbalizing and linking with biological knowledge. In most cases, only vocational knowledge was made explicit. Besides this, 75 semantic units were found in which biological knowledge was described isolated from workplace actions. In these cases, biological knowledge was often described in detail without clarifying how this knowledge is related to the workplace or its actions.

To exemplify the above, examples of two commonly used vocational textbooks are given. In the first quote biological knowledge is portrayed as an instrument of action. This is followed by a similar quote in which such a connection is missing. The third quote is an example in which biological knowledge is described detached from workplace action.

> *Often a cow does not get into gestation because of a wrong timing of insemination. A complete heat lasts about forty hours. The best moment to inseminate is in the second half of this period. […] Ovulation occurs at two-thirds of the heat period. It is of major importance to know when a cow is in heat. So, check often.*
> *Cows that display primary signs of heat in the afternoon or in the evening can best be inseminated the next day.*
> (Nijholt, Oosterwijk, Bouwmans, Van den Berg, Tacken & Brans, 1999, p.30)

A sexually mature cow, not in gestation normally comes into heat every eighteen to twenty four days. A coming heat begins with the development of an egg-cell in the ovary. The cow shows signs of heat. We can see:
[…]
- *Trying to jump on other cows,*
- *Restless behaviour,*
- *[…]*

(Bouwmans, Rietjens en Oosterwijk, 2002, p. 10)

During the cycle different hormones are involved. Hormones are chemical messengers in the body. They are produced in different places and transported through blood. […]
(Bouwmans, Rietjens en Oosterwijk, 2002, p. 25)

The first two examples show that the process of ovulation and behavioural signs of heat are related. However, where in the first quote the functionality of biological knowledge of ovulation is described, the second quote does not.

The overview in Table 4.2 demonstrates that knowledge about hormones, oestrus cycle, and its influence on ovulation and animal behaviour often stays implicit. It is more frequently verbalized in isolation from work action. It was found that in cases where they were related, the semantic units were about:

- determining the moment of insemination or coverage,
- problems with cows or mares coming into heat,
- embryo transplantation.

Comprehensive knowledge on the reproductive cycle of the cows and horses is not explicitly linked to work actions. Nevertheless, the interviews with supervisors and the content analysis revealed that there is an instrument in which the reproductive cycle plays an important role. A (digital) registration instrument seemed to have an important role in monitoring the reproductive cycle of the complete livestock[1]. It was found that semantic units describing the calendar explain its function but not in such detail that the reproductive cycle was explicated. The next quote is an example from educational material in which it is clear to what extent the calendar is explained.

In many farms the fertility of livestock is not optimal. To monitor fertility a farmer must register or manage his data. A farmer can use three systems:
- *fertility/illness card,*
- *cow calendar,*
- *management system on the computer.*

[…]

(Nijholt, Oosterwijk, Bouwmans, Van den Berg, Tacken & Brans, 1999, p.24)

Interviews with biology teachers showed what relationships are made explicit in biology lessons in pre-vocational secondary education. The teachers indicated that they deal with almost all biological knowledge covered by a list of biological principles on reproduction (Reygel, 1997). The exceptions were:

- coinciding processes of animal behaviour and ovulation which enhances the chance of reproductive success: one teacher indicated that this topic had been touched upon implicitly;
- reproduction technology and fertility problems: two teachers indicated that that these topics were not part of the biology lessons;
- artificial insemination: one teacher said that this was not part of the biology curriculum.

In the interviews, teachers often brought up examples from everyday life when asked how the biological principles from the list were elaborated in lessons. Although all of them teach in an agricultural school, they did not mention examples having to do with animal reproduction in a workplace setting (e.g. horse-breeding farms or sheep farms). The examples they brought forward were mainly about humans in everyday life and pet animals. Besides this, they used examples in which biological knowledge should intrigue students (e.g. extreme high reproduction rates of certain animals). The following quote from an interview with biology teacher Fred indicates that he prefers to focus on biological processes in humans (R: Researcher).

Fred (biology teacher)

R: *sometimes a farmer is confronted with silent heat. Cows are in heat but they do not show the accompanying behavioural signs. A veterinarian can feel the ovaries if this is the case. Do you think [interrupted].*

Fred: *If somebody [a student] would bring this up, this is fine. One can talk about how students think this works. For me the comparison with humans is more obvious. […] I would certainly bring up these kinds of comparisons.*

[…]

R: *and insemination.*

Fred: *Insemination is usually addressed in a classroom discussion because fertility problems are increasing in humans and a lot is done in trying to become pregnant. […] So, I would instantly make that connection [fertility problems of humans].*

Nature of verbalized relationships

Analyses of the verbalized relationships between biological knowledge and work actions enabled to distinguish semantic units that only described actions on the one hand and units in which actions are both described and justified on the other. The next quote is an example of a supervisor justifying her actions in the workplace. In this quote the supervisor seems to

unintentionally answer questions like ‘what reason is there to act?’ and ‘how do you know if you have reached your goal?’.

Shirley (supervisor horse-breeding farm)

Shirley: *This morning we had eight three-year-old mares that did not show any signs of heat. Because of this we asked the veterinarian to scan them. During scanning we saw one mare that had a large egg.*

R: *She did not reveal her heat?*

Shirley: *Yes, and the other seemed to be in heat also. We checked them for a decaying corpus luteum.*

The interviews with supervisors and the educational materials revealed that semantic units which only describe an action without justifying it, showed relationships in specific situations. It was found that merely describing ‘checking womb’, ‘checking internal signs of heat’, ‘inseminating cow / mare’, ‘scanning after insemination’, ‘checking for a coming birth’, ‘checking afterbirth’, and ‘embryo transplantation’, all resulted in verbalizing biological knowledge together with elements of action. These purely descriptive semantic units of actions also seem to be actions in which biological knowledge is needed to perform the action properly. As mentioned in section 4.2, there is a distinction made between biological knowledge that is functional because it is needed to perform an action properly and biological knowledge that is needed to understand workplace actions and processes. In search of biological knowledge that is used to understand the reproductive cycle and workplace actions, it was found that these semantic units were about problem situations, monitoring and intervening actions.

The following quote shows that intervening in and monitoring the reproductive cycle may result in making biological knowledge explicit. The quote implies that it is possible to check the ovaries of a mare that does not come into heat with a scanning device without using biological knowledge. However, it also demonstrates that a concept of egg cell development is conditional when it has to be decided if another intervention is necessary.

Edith (supervisor horse-breeding /-milking farm)

[…]

Edith: *On Thursday she will be given an (hormone) injection.*

R: *Ah.*

Edith: *So, after the weekend we will check if she will respond properly. We will scan to see if she is in heat and has the right [stage of] egg development.*

Finally, to support our last statement a quote about ‘planned heat’ extracted from a vocational text book will be presented, which indicates that interventions in the hormone cycle of cows also imply knowing which consequences can be expected. Knowing the consequences implies having conceptual knowledge of the hormone cycle of cows.

Planned heat
Hormone treatments can help with getting a cow in heat at a specific moment. Subsequently, the cow can be inseminated. You can do this blindly. In this case, you will have to precisely determine the expected heat. You can also do this based on signs of heat which can be expected at the same moment.
(Hulsen, 2007, p 41)

Table 4.2. Explicit and implicit relationships between biological knowledge of animal reproduction and workplace actions in cattle farms and horse-breeding farms, specified by subject, object instrument and outcome (in shaded columns).

Stage in reproduction cycle	Action	Subject	Object	Instrument (physical)	Outcome	Explicit biological knowledge	Implicit biological knowledge
Heat	Checking womb (*c*. 40 days after deliverance)	Farmer	Cow Horse	Rinsing equipment	Womb without infection	Form and function of genital and other organs of cow / horse (e.g. womb)	Microbial growth and infection
	Checking for external signs of heat in an early stage	Farmer	Cow Horse	-	Being alert for next stage in heat	Behavioural signs of heat (e.g. interest in other animals)	Coinciding of behavioural change with ovulation under the influence of hormones
	Checking for external signs of heat	Farmer	Cow Horse	-	Knowing when to inseminate or cover	Behavioural signs of heat (e.g. cows: standing still if jumped on; horses: releasing mucous and orange urine when shown to stallion) Coinciding of behavioural change with ovulation under the influence of hormones	-
	Checking internal signs of heat if an animal does not show external signs of heat	Veterinarian	Cow Horse	Scanning device Glove Lubricant	Knowing if an animal is in heat Knowing if there is something wrong (e.g. cyst on ovary)	Internal signs of heat (e.g. ovaries have follicle womb feels hard)	Coinciding of internal change in womb and ovaries with ovulation under the influence of hormones

Stage in reproduction cycle	Action	Subject	Object	Instrument (physical)	Outcome	Explicit biological knowledge	Implicit biological knowledge
Heat	Inducing heat	Veterinarian / Farmer	Cow Horse	Hormone injections	Cow / horse in heat	Coinciding of behavioural change with ovulation under the influence of hormones	-
Insemination / coverage	Having cow/ mare covered by bull / stallion	Farmer	Cow Horse	Bull / Stallion	Cow / horse in gestation	Behaviour of cow and bull / stallion and mare	Morphology genital organs Internal fertilization
	Inseminating cow / mare	Farmer / inseminator	Cow Horse	Pipette and straw with sperm	Cow horse in gestation	Form and function of genital and other organs of cow / horse (e.g. cervix)	Artificial internal insemination and fertilization
Gestation	Cow: check for bleeding two days after coverage or insemination	Farmer	Cow	-	Knowing if coverage / insemination was in time	-	-
	Scanning 18-23 and further days after coverage insemination	Veterinarian / Farmer	Cow Horse	Scanning device checking womb for amnion and ovaries for follicle	Certainty about gestation	Form and function of genital and other organs of cow / horse (e.g. position of ovaries)	Embryo development
	Checking for external signs of heat after 21 days	Farmer	Cow Horse		Certainty about gestation	External, behavioural signs of heat	Hormonal oestrus cycle Hormone production
	Examining womb and ovaries with hand (rectal)	Farmer / veterinarian	Cow Horse	Glove, lubricant	Certainty about gestation	-	Follicle development in ovaries Form and function of genital and other organs of cow / horse (e.g. position of ovaries, endometrium) Signs of gestation and heat

Stage in reproduction cycle	Action	Subject	Object	Instrument (physical)	Outcome	Explicit biological knowledge	Implicit biological knowledge
Gestation	Testing of blood, milk, urine	Lab assistant	Blood / milk / urine	Laboratory devices	Certainty about gestation	-	Hormones (oestrogen)
	Cow: isolating cow	Farmer	Cow	Extra stable	Excluding cow from milking pit	-	-
Deliverance	Checking if animal is about to deliver	Farmer	Cow Horse	-	Knowing when deliverance is coming	External signs (e.g. restless behaviour, filling of udder, horses: waxing teat)	Internal changes (e.g. contractions, widening of birth canal) Influence of hormones
	Checking calf / foal	Farmer	Calf / foal	Towel	Knowing if calf / foal is healthy	-	Check points heart beat Reflexes
	Checking afterbirth	Farmer	Afterbirth	-	Knowing if the afterbirth has come out	Image of a complete afterbirth	Form and function of afterbirth and umbilical cord Womb infection
Overall	Monitoring heat, gestation and deliverance of livestock	Farmer	Livestock	(Cow) calendar Schedule	Overview of actions to be undertaken per day	-	Oestrus cycle Reproductive cycle of cows / horses
	Embryo transplantation	Farmer / veterinarian/ Inseminator	Cows Horses	Hormones Rinsing equipment Microscope	Synchronized cows / mares carrying embryos from a good cow or horse	-Hormone induced - Ovulation Fertilization Implantation of embryo	Oestrus cycle Reproductive cycle of cows horses Vital signs of embryo

4.6. Conclusions

The study in this chapter searched for biological knowledge of reproduction that can be made explicit in vocational courses in a meaningful way, i.e. it searched for relationships between biological knowledge and workplace actions. In Table 4.2 an overview of the relationships is given. The table shows which relationships are made explicit and which remain implicit.

This study also revealed if and how biology teachers used examples of cattle farms and horse-breeding farms. It was found that, when teaching about animal reproduction. the biology teachers who were interviewed seldom related or did not relate biological knowledge with actions in horse-breeding farms or cattle farms. They seemed to prefer using other examples, in particular about humans and pet animals.

The relationships of biological knowledge and workplace actions in horse-breeding and cattle farms, which are made explicit in vocational courses are especially expressed in descriptions or justifications of actions that are meant to monitor and intervene in the reproductive cycle and work processes. In these actions, biological knowledge is needed to perform the actions properly or to make an informed decision.

4.7. Discussion

The results point in two directions. First, it is recommended to focus on hormone cycles when learning about animal reproduction in cattle and horse-breeding farms. Second, reflection on monitoring and intervening actions should be emphasized.

Biological knowledge of hormones and hormone cycles are less often verbalized and related to workplace actions than was expected based on its general use in cattle farms and horse-breeding farms. However, if students are to understand the workplace, knowledge about hormones seems crucial. The previous chapter put forward the idea of engaging students in a sequence of actions that all contribute to the same production line or that follow a certain time line. Confronting a student with these related actions should enable them to understand the workplace in which certain biological concepts are used. In the workplace contexts examined in this study, it would seem possible to come to understand work processes in a cattle farm or horse-breeding farm in which the concept of hormone (cycle) is coherently embedded. The actions portrayed in Table 4.2 are connected. Together they contribute to the outcome of milk or foal production. What is more, they are also connected through the reproductive cycle and hormone cycle of cows and horses. So, one of the main questions that arises from this study is how we can support students in recognizing that the reproductive cycle and the hormone cycle are concepts one needs to develop, when learning about cattle farms or horse-breeding farms.

Based on this study, it is recommended to focus on monitoring and intervening actions when supervising students engaged in these workplaces. As mentioned earlier, describing these actions more often results in verbalizing relationships between biological knowledge

and work actions. Besides this, monitoring and intervening actions seem to be easily related to workplace outcomes. Although almost all workplace actions should contribute to workplace outcomes, some are related more directly than others. Cleaning stables, for instance, is less obviously connected to workplace outcomes than monitoring gestation.

These combined insights and the findings on the functionality of biological knowledge result in the diagram shown in Figure 4.2. The diagram shows how, when monitoring and intervening in the reproductive cycle of cows and horses, biological knowledge is helpful in making well-considered decisions.

However, this is not to say that students are able and allowed to make such decisions which may have major consequences for workplace outcomes. But merely observing may not be enough for students to experience that this knowledge is functional. It is for these reason that further research should focus on the question how these insights can be put to use in VMBO practice.

This chapter provided insights that help to focus learning and supervising actions in the workplace and in school. It identified foci for both biological contents and workplace actions. The overview presented in Table 4.2 may help supervisors and teachers to sequence and fine-tune working and learning activities for students.

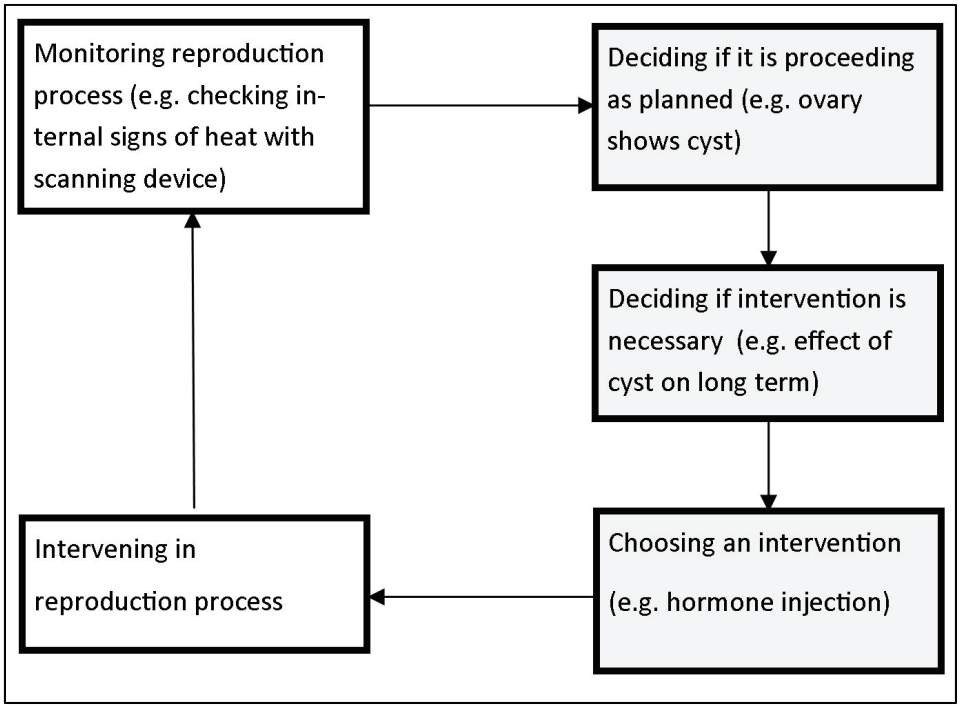

Figure 4.2. Scheme of relationships between interventions and monitoring actions regarding animal reproduction. The shaded text boxes represent moments in which conceptual knowledge is needed.

Notes:

1. This instrument has two purposes. First, it is used as an instrument to monitor in which stage of the reproductive cycle cows or horses are. If, for instance, a cow is inseminated, this is noted on the instrument (calendar) which makes it possible to monitor if the cow is still in gestation in due time. Second, it provides an overview of the actions that need to be performed on specific moments. For instance, the farmer can consult the instrument to see if a specific cow should be checked for signs of heat. If used properly, the instrument will tell the farmer to do so three weeks after insemination.

Chapter 5

Recognizing relationships: towards an educational strategy for learning about animal reproduction in the workplace

5.1. Introduction

This chapter reports the field testing of an educational strategy for learning about animal reproduction in the workplace. The four theory-based design characteristics drawn from cultural historical activity theory presented in chapter 2 and the empirical findings of the studies reported in chapters 3 and 4 were used to elaborate the strategy. The latter describes and justifies interrelated student and supervisor actions as well as the expected learning outcomes. The strategy can be considered as a hypothetical learning trajectory.

Before focusing on the design and the field test of the strategy, an overview will be given of the relationship between the reproductive cycle of cows and work actions in a cattle farm based on the previous chapter's description. This information is needed to read the present chapter. The overview is followed by a description of how the strategy was tested on its practicability and effectiveness. After presenting the results and the conclusions implications for further improvement of the strategy will be discussed against the background of the theory-based design characteristics.

5.2. Fertility in cattle farms

In order to keep giving milk a cow needs to reproduce. Producing as much milk as possible at a low cost, a dairy farmer tries to have as much cows in gestation as is possible in his farm. To arrive at an optimal calving interval (Figure 5.1), dairy farmers need to perform certain work actions that are related to the cow's reproductive cycle. An overview of these actions is portrayed in Figure 5.2.

After calving, a farmer checks if the afterbirth has been delivered and he checks the vitality of the calf. Now, the cow can come into heat again. After having detected that, the farmer can artificially inseminate the cow or have the cow covered by the bull. Being in heat means that the cow is ready to mate and reproduce, i.e. she ovulates and thus she is fertile. If the insemination is successful, the farmer needs to monitor if the cow is in gestation, because a cow that is not in gestation costs money due to not producing milk. A cow that has lost her calf thus preferably needs to be inseminated in the next heat (approximately 21 days later).

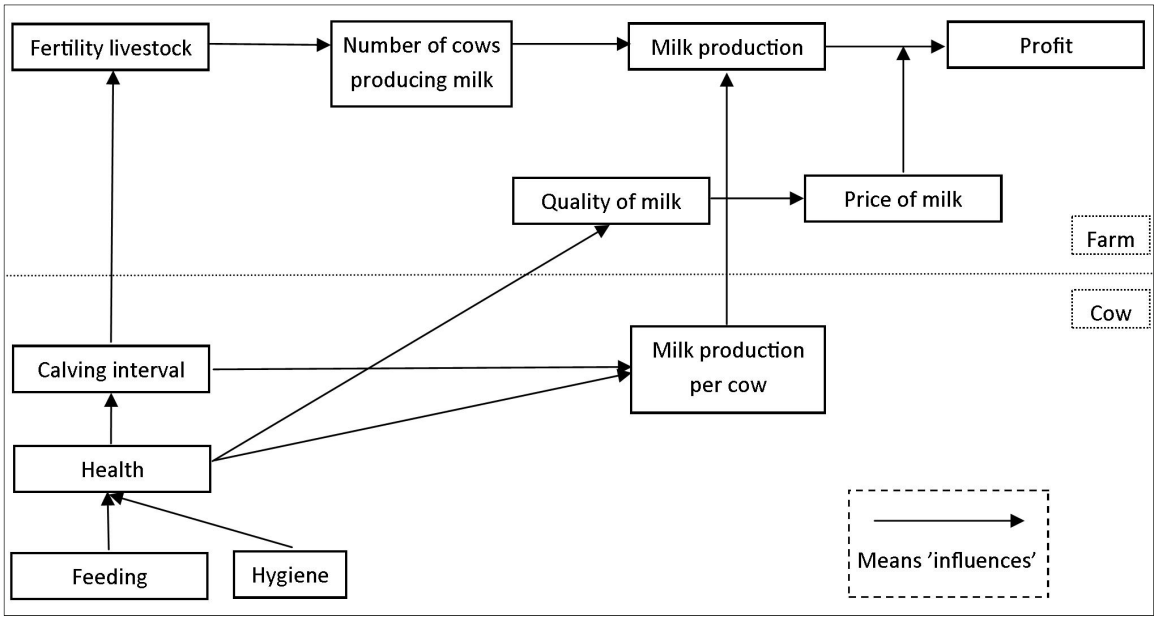

Figure 5.1. Overview of influences on milk production. It shows that, amongst others, the calving interval influences milk production. The fertility of the entire livestock is defined by the average calving interval.

Nine months after the insemination, when the cow is about to calve, the farmer monitors for signs of birth. Sometimes, the cow needs some assistance while giving birth. After birth, the cycle will start anew.

The work of a farmer as it is presented here may seem uncomplicated. However, monitoring heat, choosing the right time to inseminate, the different ways to monitor gestation (feeling, scanning), monitoring a coming birth and assisting birth are not always easy. What is more, work processes do not always go as planned. This combined with the fact that a farmer has 60 - 200 cows or more makes understandable that monitoring and intervening in the reproductive cycle of cows can be a tough job.

5.3. Designing the strategy

Before focusing on the practicability and effectiveness of the strategy, the considerations underlying the design of the strategy are briefly discussed. These are derived from different sources.

First, relevant literature was studied about the interplay between learning in school and the workplace, and in particular about connections between disciplinary knowledge and workplace knowledge (see chapter 2). The resulting framework was used to determine the extent to which current VMBO work placement is accordance with what seems to be theoretically desirable. Differences suggested problems and prospects to take into account when designing the strategy (see chapter 3).

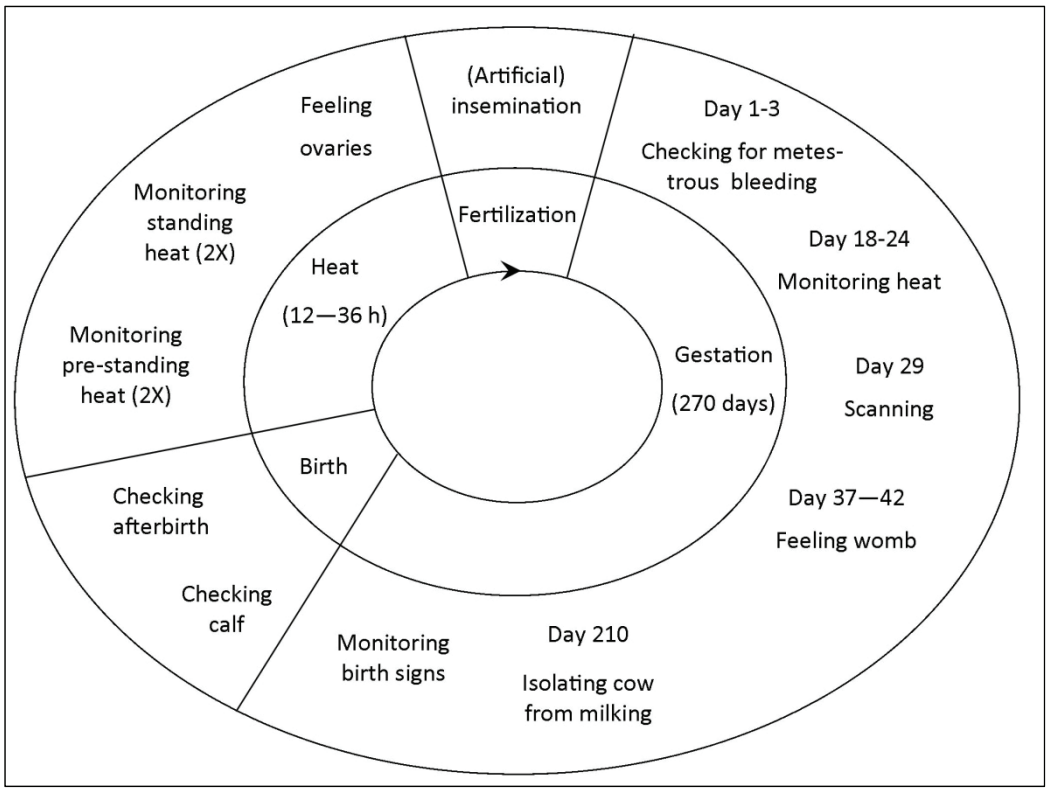

Figure 5.2. Overview of the work actions that are related to the reproductive cycle of cows. In the figure each reproductive stage is indicated in the inner circle (e.g. heat or gestation). The related work actions are indicated in the outer circle.

Then, through content analysis of educational documents and interviewing experts, it was established what biological knowledge of reproduction can be verbalized and how this knowledge is functionally used in the workplace (see chapter 4). Finally, a first design of the strategy was commented on by six cattle farmers who were willing to carry out the strategy at a later moment.

The outcomes from these research activities have been operationalized in an educational strategy for work placement in cattle farms. Table 5.1 represents a schematic overview of this strategy. In the overview, both the actions of the student and the supervisor are presented together with their expected outcomes. Besides this, it is indicated how the strategy components relate to the theory-based design characteristics.

Figure 5.3 shows that the strategy components 'First participation' and 'Monitoring actions' should induce a motive for students to enhance their competence in the workplace, and to learn how to monitor heat, gestation and coming birth in livestock (cf. Klaassen, 1995). i.e. these components provide motives for students to participate in the other strategy components.

The expected outcomes of the strategy components 'Guided tour', 'Overview', 'What and why' and 'Terms and meanings' should contribute to the conceptual understanding of the students (Table 5.1). For instance, the expected outcome of the strategy component 'Guided tour' is that students recognize that animal reproduction is a means to boost milk production and that work actions are thus related.

Table 5.1. Representation of the strategy components and their expected outcomes. Relationships between student and supervisor actions and the expected learning outcomes, and the relationships with the theory-based design characteristics (DC) are indicated (see section 2.4).

First participation			
Student action	**Supervisor action**	**Expected outcome**	**DC**
· Performs work actions together with supervisor	· Adjusts guidance to student competence	· Student experiences the need to increase his competence in the workplace	2
Guided tour			
Student action	**Supervisor action**	**Expected outcome**	**DC**
· Familiarizes himself with the main outcomes of the workplace and related working actions	· Provides a guided tour and shows work actions that directly contribute to milk production	· Student recognizes that animal reproduction contributes to the main outcome and can list related work actions	1
Monitoring actions			
Student action	**Supervisor action**	**Expected outcome**	**DC**
· Monitors heat and coming birth with at least two cows and assists with monitoring gestation	· Appoints cows to monitor and challenges student to reflect on the performed monitoring actions in the live stock	· Student experiences a need to know how. · Student recognizes that monitoring the entire livestock asks for an overview	2 and 3
Overview			
Student action	**Supervisor action**	**Expected outcome**	**DC**
· Incorporates the results of the monitor in a cow calendar or a similar instrument	· Adjusts guidance to student competence · Challenges student to reflect on the relationship between the work actions on the calendar	· Student can produce an overview of related actions. · Student recognizes that work actions are related to the reproductive cycle of cows	2 and 3
What and why?			
Student action	**Supervisor action**	**Expected outcome**	**DC**
· Describes and justifies work actions that are mentioned on the cow calendar	· Monitors the descriptions and justifications · Focuses the justification on goal, methods, moment and problems	· Student uses terms of both the workplace and school biology to describe and justify the work actions	4
Term and meanings			
Student action	**Supervisor action**	**Expected outcome**	**DC**
· Reflects on terms and meanings used in the descriptions and justifications together with the supervisor	· Verbalizes terms and illustrates how they are related to the workplace · Asks questions that challenge the student to relate terms from both practices	· Student produces sentences in which terms from both school biology and the workplace are correctly used	4

The different strategy components are sequential but they also partly overlap. For instance, the strategy component 'Monitoring actions' starts after 'Guided tour'. Nevertheless, the former component still runs when the component 'What and why' starts. Figure 5.3 provides an overview of the sequence and duration of the strategy components.

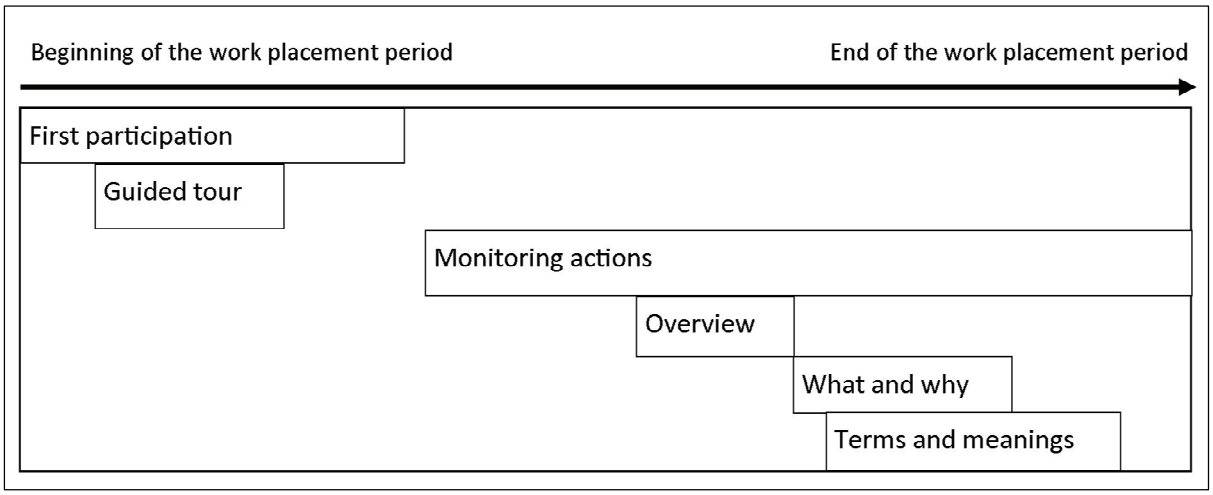

Figure 5.3. Sequence and relative duration of the strategy components. The arrow indicates the sequence of actions. The relative duration of the components is indicated by the width parallel to the arrow.

5.4. Research questions

This study explores the practicability and effectiveness of the strategy and seeks to answer the following research questions.

- *How practicable and effective are the strategy components of the learning and supervising strategy?*
- *How do combinations of strategy components of the learning and supervising strategy associate with the learning outcomes?*

5.5. Methods

The strategy is tested by comparing the expected learning processes and learning outcomes with the observed processes and outcomes in six work placement case studies.

The placement sites were selected for being involved in animal reproduction. A direct relationship between the outcomes of the workplace and animal reproduction, e.g. horse-breeding farms and cattle farms seems to contribute to a more appropriate learning environment (see chapter 4).

Consequently, all students of an agricultural school that did their work placement on a cattle farm or a horse-breeding farm were approached. After that, the farmers that would supervise these students were approached. Out of seven possible candidates, six pairs of a student and a supervisor, all from a cattle farm, agreed to cooperate. This number of cases

allowed to focus on the complex relationships in the conceptual development of students. Chapter 4 showed that the relationships between biological knowledge and work actions can be quite intricate. To provide an overview of the respondents in this study some characteristics of the cases are offered in Table 5.2.

Table 5.2. Background characteristics of the case studies.

Student	Age	Student experience in cattle farms	Student experience in school courses	Professional outlook	Experience of supervisor*
Josh	16	Parents own a cattle farm	Cattle farming Biology	Cattle farmer	10
Cindy	15	Helps a cattle farmer in her spare time	Biology	Veterinarian	> 10
Bob	15	Helps a cattle farmer in his spare time	Biology	Agricultural contractor	5
Colin	16	None	Cattle farming Biology	Agricultural contractor	7
Peter	15	Sometimes visits cattle farms	Cattle farming Biology	Agricultural contractor	> 10
Harry	15	Parent own a cattle farm	Biology	Cattle farmer	2

*Number of supervised students before the placement period.

In each case study, a student participated in a placement period of one day a week for eight weeks. Before and during the placement periods the supervisors were given written and oral supervision instructions for three times. The instructions were given on site and dealt with how to guide the students and how to conduct the supervision talks.

Data was collected throughout the placement period. Figure 5.4 shows how the data collection matched the strategy components. The collection within one case included four interviews with the student and audio recordings of three supervising talks. Besides this the completed assignments of the student were collected two times and the supervisor was interviewed after the placement period. Apart from two student interviews and two supervisor talks all the intended data was gathered.

To establish the effectiveness of the strategy components and the strategy as a whole, the practicability of the strategy was also determined. A strategy component that is not performed as planned cannot properly be assessed on its outcomes. The practicability of the strategy was determined by checking the compliance with the strategy in students and supervisors through analysis of the supervising talks and the supervisor interviews, using the strategy components indicated in the columns ‘student’ and ‘supervisor’ (Table 5.1).

The effectiveness was established by comparing the actual learning outcomes with those intended. For this purpose, the analysis of the student interviews, supervision talks and completed materials focused on the expected outcomes (Table 5.1).

The raw data was fed into a qualitative data analysis programme (ATLAS ti). Semantic units in the data were categorized in accordance with the strategy components. After that, these units were aggregated per case study, so as to create an overview of the practicability and effectiveness of the strategy components per case study.

Since the strategy and the categories relied on theoretical propositions, a cross-case synthesis was enabled (Wester & Peters, 2004; Yin, 2009). The aggregated findings per strategy component provided an overview of the practicability and effectiveness of each component.

Finally, the learning outcomes of the strategy components that were specifically meant to promote the conceptual understanding of the students were determined and the effectiveness of combinations of the strategy components were explored. As mentioned before, the outcomes of the strategy can be in terms of appreciating a certain topic as important and experiencing a need to know or in terms of showing conceptual understanding.

The development of the students' conceptual understanding across the strategy components was mapped by using the Structure of Observed Learning Outcomes (SOLO) taxonomy (Biggs & Collins, 1982). Considering its applicability and because the conceptual understanding of the students is mainly expressed in relatively short answers to (oral and written) questions or a limited set of questions, this taxonomy is considered adequate for this purpose.

Besides this, the taxonomy should be able to map both conceptual understanding of the workplace (e.g. outcomes, work actions) and conceptual understanding of animal reproduction solely as well as their relationships. Therefore the indicators of the taxonomy were slightly adjusted. The purposes was to assess VMBO students in using relevant terms to describe and justify outcomes and work actions of the workplace and to assess the extent to which students can *relate* outcomes, work actions, and reproduction. The results of the adjustments are presented in Table 5.3.

To determine the reliability of the analysis the inter-rater reliability (Cohen's kappa) was determined for the categories concerning the conceptual understanding of the students. Sixty out of 395 quotes were also analysed by a second rater (kappa 0.72).

Table 5.3. Description of the levels of the Structure of Observed Learning Outcomes (SOLO). After Biggs and Collins (1982) and Brabrand and Dahl (2009). The descriptions in italics were used to identify the extent to which students relate terms referring to outcomes, work actions, and reproduction. To give insight into how the indicators were assigned some examples related to cattle farming are given

SOLO level	Description
1. Pre-structural level	A student provides an incorrect answer to the question or assignment *A student cannot relate terms or relates terms which should not be related*
Examples	The student says that gestation cannot be monitored by checking for signs of heat. This is incorrect because if gestation failed the cow would come into heat again after approximately three weeks. *The student says that calving and milk production are not related.*
2. Uni-structural level	A student uses one correct term to answer the question *When provided with a term a student relates it to another correct term*
Examples	The student says that gestation can be monitored through scanning without mentioning the other monitoring actions (e.g. checking for signs of heat after approximately three weeks). *The student says that calving and milk production are related but (s)he is unable to explain how.*
3. Multi-structural level	A student uses several correct terms but (s)he is unable to relate all these terms correctly *A student spontaneously relates two or more terms correctly but (s)he is unable to explain the relationship*
Examples	The student says that a cow needs to be inseminated, monitored for heat, and isolated from milking. However, (s)he cannot put these work actions in the correct sequence and/or explain their relationship. *The student says that milk production is influenced by cow fertility and the calving interval. However, (s)he is unable to explain that a fertile cow has a relatively short calving interval which is why she can produce more milk.*
4. Relational level	A student uses several correct terms and is able to describe the relationships between these terms *A student relates several correct terms and is able to describe the relationship between these terms*
Examples	The student says that a cow can be inseminated if she is in heat. S(he) follows by saying that the gestation needs to be monitored and that this can be done by checking if the cow does not come into heat again or by scanning. And so on. *The student is able to explain that fertile cows have a relatively short calving interval and that milk production increases when a calf is produced; which is why she can produce more milk.*
5. Extended abstract level*	A student relates non-provided terms to formulate an answer *A student relates non-provided terms to formulate an answer*

* The student can formulate an answer similar to the example given with the relational level (SOLO 4) but now (s)he adds information which was not provided. This, however cannot be assessed in this study because it is not possible to exactly follow all the events in the workplace.

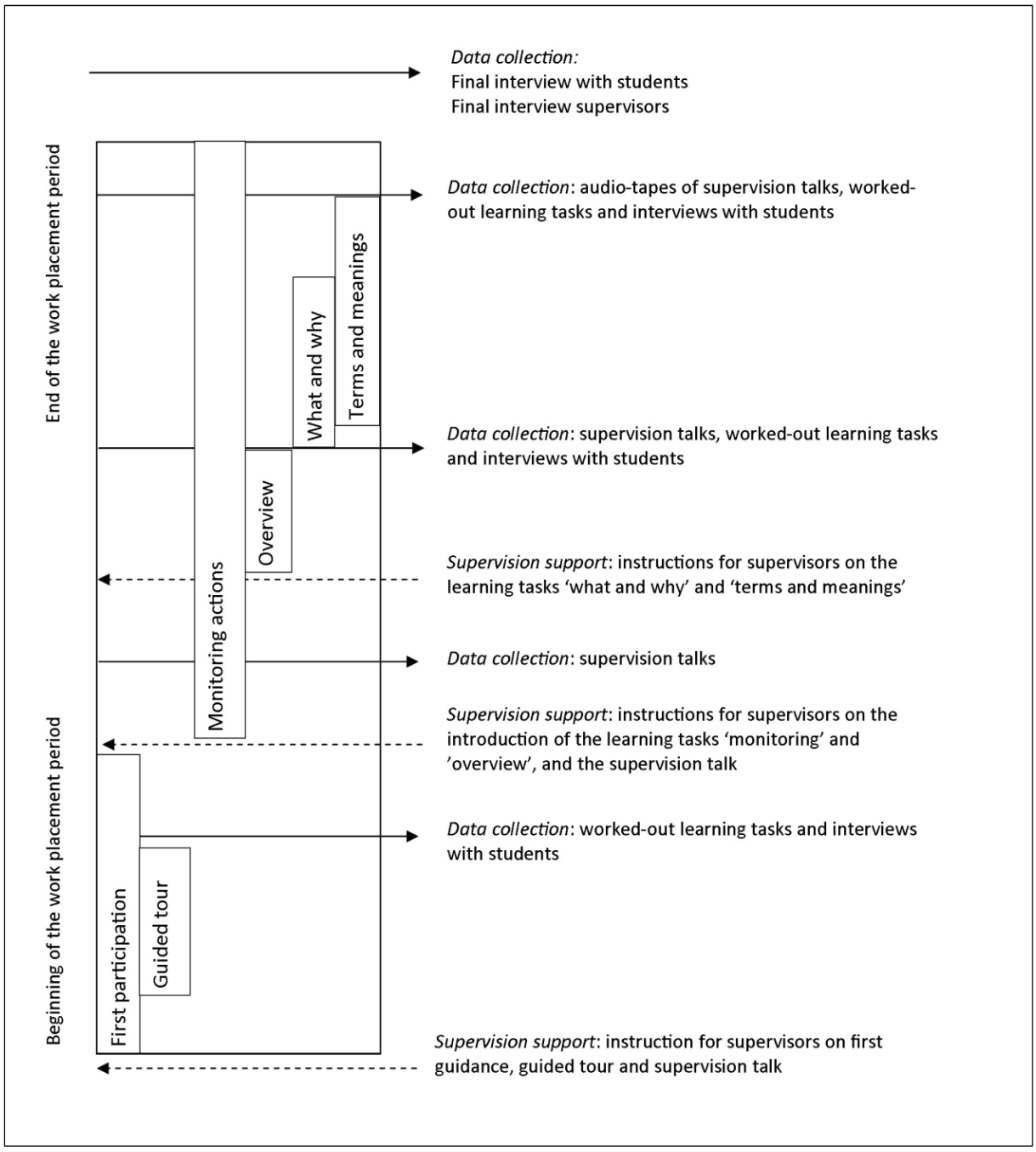

Figure 5.4. Supervision support and data collection during the work placement period matched with the strategy components.

5.6. Results

In this section the results of the first field test of the strategy are outlined. After addressing the practicability and effectiveness of each component across the case studies, the relationships between combinations of strategy components and the learning outcomes will be presented.

First participation

Practicability

In all case studies it was observed that students participated in work actions together with their supervisor. The supervisor talks indicate that this collaboration was also being discussed. The data reveals several modes of collaboration.

- The supervisor and the student work together for most of the placement period;
- At the beginning of the placement they work together and this gradually turns into the student working alone;
- The student primarily works alone but in case of a complication the supervisor helps.

The interviews with supervisors did not clarify whether or not the guidance of the supervisor was adjusted to the competence of the students. However, the interviews with students indicate that this happened.

Effectiveness

The interviews with students showed that participation in the workplace and having a perspective on further participation in similar (future) practices seemed to result in experiencing a need to enhance their competence.

Josh and Harry valued learning during the placement as relevant to their future profession as cattle farmers. Cindy and Peter said that they want to enhance their competence because they sometimes feel lack of skills and knowledge. Colin and Bob indicated that they want to learn about specific work actions, e.g. insemination. However, they aspire to a job as agricultural contractor and not as a cattle farmer.

The following quote from an interview with Josh shows how Josh wants to learn about reproduction in cattle farms to enhance his competence as a cattle farmer.

J: Josh
R: Researcher

R: *What experience of the placement until now has been important to you?*
J: *Mucous secretion, womb infection and scanning because we never talked about that at home.*
R: *Why did you choose these?*
J: *All the other things I experience are normal, this is different. We do not normally talk about this. I can learn something from this for later.*
[…]
R: *Suppose your supervisor asks you to care for his farm for a few days or a week. Do you think you can manage that?*
J: *Yes, I think I can do that. Not that I would do it.*
R: *Are the work actions that you will have to do then doable for you?*
J: *I think there is a lot that I do not know or that my father does not know. Things that other farmers use and that improve farm production. Learning about these things is worthwhile.*

Guided tour

Practicability

The first interviews and supervision talks show that Josh, Cindy, Bob and Peter performed the Tour as planned. The past experience of the student and the possibility to emphasize animal reproduction seem to contribute to the practicability. All supervisors indicated that this component is valuable, especially for less-experienced students.

Josh's supervisor said that Josh had much experience and a tour in the beginning did not add much to his knowledge. That's why he focused on reproduction during work action talks. Because of the past experience of Harry, his supervisor chose not to provide the tour. Peter's supervisor indicated that for someone like Peter such a tour adds to his knowledge.

Effectiveness

The interviews and completed assignments in all cases show that students are capable of identifying the main outcomes of the workplace and to list related work actions. Finally, they mostly seem to relate the outcomes, work actions and animal reproduction. Table 5.4 shows that Bob was the only student who is unable to answer questions on this topic adequately. Referring to Tables 5.2 and 5.4 shows that students with more experience provide more coherent answers than the less experienced students.

The next quote from an interview with Harry indicates that he relates farm profits to reproduction by spontaneously introducing the term 'calving interval'.

H: Harry
R: Researcher

R: *You say that a cow calves on approximately 400 days. What do you mean by that?*
H: *That the calving interval is a little more than 365 days. At a certain moment the milk production decreases and to boost milk production a cow should calve. After calving she will produce milk again.*
R: *What do you mean with calving interval?*
H: *That a cow calves and the same cow calves again after a year.*
R: *So, you want to have the cow to produce a calf as quickly (interrupted).*
H: *No, not as quickly as possible. It depends on the fertility and the milk production of the cow. If milk production is good there is no reason to inseminate the cow so quickly.*

Monitoring actions

Practicability

The completed assignments and the supervision talks show that in all cases this component is performed as intended. In the final interview, four supervisors said that students were unable to perform or observe all the monitoring and intervening actions because they were not present for the whole week. For instance, the veterinarian visited the

farm to scan cows or a cow came into heat on days that students attended school. The supervisors comment that this component is relevant for student development.

Analysis of the supervision talks reveals that supervisors lacked certain pedagogical skills and knowledge. For instance, the supervisors of Cindy and Colin tended to answer the questions they asked themselves. To give another example, Harry's supervisor said he had trouble verbalizing his own knowledge when discussing these actions with the student.

Table 5.4. Coherency of student answers to questions about outcomes, work actions and reproduction, and the relationships between them. The SOLO taxonomy is used to indicate the extent of coherency in the answers of students (see Methods for clarification). 1,3 means that a student provided answers that were categorized as SOLO 1 and SOLO 3. The SOLO level that occurred most frequently is underlined.

Case study	Outcomes of the farm	Work actions	Relationship between outcomes, work actions and reproduction
Josh	3	3,4	4
Cindy	1,2	1,2	2
Bob	1	1	1
Colin	2	2	1,2
Peter	2,3	2,3	2
Harry	4	4	4

Effectiveness

The interviews with students after the assignment displayed that students with less experience (Cindy, Bob, Colin and Peter) expressed a more specific need to know how than Josh and Harry. For instance, Cindy wanted to know more about ways to see if a cow is in heat and Peter expressed his interest in the practice of insemination. Harry and Josh, on the other hand, voiced a more general learning question. Harry said that he wants to expand what he already knows about cattle farms. Josh indicated that he wants to learn about the monitoring process in general.

Students who noticed that the monitoring of the complete livestock requires an overview (Josh, Cindy, Peter and Harry) were able to point to and explain the importance of registering heat, insemination and birth. However, Bob and Colin could not explain why.

The next quote from a supervision talk between Colin and his supervisor shows how Colin recognized the importance of registration, which was supplemented with monitoring by his supervisor.

C: Colin
S: Supervisor

S: How can you see that a yearling is in heat?
C: When they are sweating and jumping on each other.
S: Yes, and the one that jumps, is that one in heat or is the other in heat?
C: The one that stands, but it can also be the other one.
S: Okay, and what do you have to do then?

C: *Write down both numbers and let them check.*

S: *Indeed, you do have to write down their numbers but you also need to monitor their behaviour more often.*

[…]

Suppose the cow is in heat. What do you do then?

C: *The cow is checked by the veterinarian and isolated.*

S: *I don't think so. If a cow calves, how long does it take before she can be inseminated?*

S: *(short interval) After sixty days or four months. So, she should not be put dry.*

Overview

Practicability

Although supervisors undertook several attempts to challenge students in using the registration instrument of the farm (e.g. notebook, whiteboard, computer programme), it was observed that in none of the cases this component was performed as intended.

Cindy's supervisor, for instance, commissioned Cindy to note the heat and embryo transplantation in her diary. However, this did not result in her actually monitoring the cows. Peter's supervisor handed him a print from the cattle management programme of the computer and commissioned him to place specific cows in a year cycle. Their supervision talk makes clear that the supervisor made the cycle complete and Peter tried to understand the schedule provided to him.

It seems that the rationales behind the management programme (in the case of Josh and Peter), the notebook (in the case of Colin), the diary (in the case of Cindy) and the whiteboard (in the case of Bob and Harry) were too complex for the students.

The final interviews with supervisors indicate that students were unable to demonstrate an overview and consequently the supervisors of Josh, Colin, Peter and Harry took time to discuss the reproduction cycle of cows. The next quote from a supervision talk between Peter and his supervisor illustrates this.

P: Peter

S: Supervisor

S: *So, here I have a circle of 365 days. That is the circle of the cow. Besides this, we have got the cycle of the calf that grows and becomes sexually mature after one and a half year.*

[…]

S: *And then the cycle starts all over again. So, here you see her in heat for the third time, what do you do?*

P: *Inseminate.*

S: *Or cover.*

P: *And then she's in gestation.*

S: *Yes, if the insemination or coverage was successful.*

P: *If not, she will be in heat again.*

[…]

S: So, eighty days after she has calved you can inseminate her again. What do you do then?

P: You monitor her and after a while you can isolate her.

S: Yes exactly, that is between forty and fifty days. Minus 365 days is

P: 315 days.

S: So, this period here (draws on paper) is the lactation period.

In the final interview, Josh's supervisor suggested that an outdated cow calendar may be an appropriate instrument to provide students with such an overview. The reproductive cycle and the work actions, together with the lactation period are presented in an overview on most of these monitoring instruments. Feeding this information to the other supervisors shows that they all thought that it may be a promising learning instrument for these purposes.

Effectiveness

Although this strategy component was not performed as intended, we can report on the effects of the focus on the reproductive cycle of cows during the supervision talks. Table 5.5 shows the coherency of student answers to questions on this subject during the interview after the supervision talks. These interviews reveal that Bob could not provide coherent answers to questions on work actions and relationships with the reproductive cycle of cows. Colins answers varied a lot. Cindy could provide an overview of work actions but she could not yet relate them to the reproductive cycle. Josh, Peter and Harry could produce an overview and relate this to the reproductive cycle.

Table 5.5. Coherency of student answers to questions about monitoring and intervening actions and their relationship with the reproductive cycle of cows. The SOLO taxonomy is used to indicate the extent of coherency (see Methods for clarification). 1,3 means that a student provided answers that were categorized as SOLO 1 and SOLO 3. The SOLO level that occurred most frequently is underlined.

Student	Overview of work actions	Relationship between work actions and the reproduction cycle of cows
Josh	4	4
Cindy	2	1
Bob	1	<u>1</u>,2
Colin	1,<u>2</u>	1,<u>2</u>,3
Peter	4	4
Harry	4	4

What and why?

Practicability

The completed assignments and the supervision talks show that this component was performed as intended in all case studies. Within boundaries, the cases showed acceptable differences in ways the assignment is elaborated. Josh and Peter and their supervisors fully stuck to the scenario by making the assignment together and discussing work actions and justifications. During these talks, supervisors brought forward several categories of justifications, i.e. goal oriented, timing, problems and methods. The supervisors of Cindy, Colin and Harry brought forward two types of justification, namely goal-oriented and timing.

Bob and his supervisor chose to separate the making and the discussion of the assignment. Bob completed the assignment on his own. They discussed the result at another moment. In the final interview, the supervisor said that he considered this assignment to be a test. Josh's and Harry's supervisors indicated that they experienced difficulties in justifying their work actions methodically. Peter's supervisor said that his teaching skills were insufficient to discuss the justification thoroughly.

Effectiveness

The interviews that followed the completion of this strategy component show the school biology terms that students used to describe and justify work actions and to explain biological phenomena in the workplace. Table 5.6 summarizes the terms used when being questioned about work actions during a stage of reproduction (heat, insemination, coverage, gestation or birth) and the coherency of their answers.

Table 5.6 demonstrates that this strategy component is appropriate for inviting students to verbalize biological knowledge through describing and justifying work actions. Besides this, the table shows that students used terms of school biology more often when describing work actions compared to justifying them. However, it needs to be said that descriptions of work actions were discussed more often in the supervision talks and as a result also in the interviews. What is more, the table indicates that justifications of timing were discussed the most often, accompanied with the use of terms of school biology.

Concerning the explications of phenomena in the workplace, Table 5.6 shows that explaining changing behaviour in heat, loosening of the ligaments and enlarging the cervical opening involve the use of the term hormone. Questions about the cow coming into heat again after abortion or about a declining milk production, for instance, did not have the same effect.

Table 5.6. The use of school biology terms by students when describing or justifying work actions in the workplace. For example, if under 'Justification' it says 'problem: ovaries, hormones', it means 'when justifying problems, the terms ovaries and hormones were used'.

Stage	Work action	Terms of school biology		
		Description	**Justification**	**Explication**
Heat	Monitoring (pre-)standing heat			Changing behaviour : hormone
	Feeling ovaries		Problem: ovaries, hormones	
Insemination	Artificial insemination	Sperm (cells), egg cell, cervix, womb, fertilization, ovaries,	Timing: ovulation and egg cell	
	Coverage	Sperm	Timing: ovulation	
Gestation	Checking bleeding Monitoring heat	Womb		
	Scanning	Womb, embryo, amniotic fluid	Timing: womb, embryo, ovaries, ovulation and hormones	
	Feeling womb	Womb, ovaries		
	Monitoring birth signs			Loosening of the ligaments and enlarging of the cervical opening: hormone
Birth	Checking calf	Umbilical cord		
	Checking afterbirth	Womb, afterbirth, placenta, amnion fluid, fluid-filled fetal membranes		
	Embryo transplantation	Hormones, egg cell(s), ovulation, fertilization, embryo		

Table 5.7 indicates that the coherency of the answers was higher when students described and justified actions (SOLO 2, 3, 4) compared to explicating phenomena (SOLO 1,2). Note that this may have to do with other terms of school biology being used by students (e.g. egg cell and womb opposed to hormone).

Strikingly, Harry displayed a relatively low coherency in his answers when using terms of school biology (Table 5.7). Colin on the other hand showed high coherency in his answer when explaining embryo transplantation. The next quote illustrates this.

C: Colin

R: Researcher

R: Have you ever heard about embryo transplantation?

C: The cow is injected with hormones to produce a lot of egg cells. A superovulation and then they rinse the egg cells from the womb. These are taken to a laboratory. […]. I think they fertilize the egg cells and put them back in a donor cow.

R: And how do you get a donor cow?

C: They are at the farm.

R: Can any cow be a donor cow?

C: No, a cow needs to be in heat.

Terms and meanings

Practicability

The completed assignments and the interview with student, together with the supervision talks indicate that the students and supervisors used terms of school biology and the workplace simultaneously. However, in none of these cases, student and supervisor discussed the meaning of the terms used and thus the component was not performed as intended. It appears that the awkwardness of supervisors to use terms of school biology and to explicate their own knowledge again contributed to this problem.

The supervisors of Josh and Peter, for instance, admitted to have insufficient knowledge of biology to explain the meaning of certain terms. In the final interviews, the supervisors of Josh, Colin and Peter suggested that school teachers should discuss the meaning of the terms used.

Effectiveness

Since none of the cases performed this strategy component as planned and there were no spontaneous discussions on terms and meanings, it is not possible to establish its effects.

Combinations of strategy components

Analysis of the different learning outcomes per strategy component (Table 5.7) shows that Josh, Colin, Peter and Harry expressed higher coherency in their descriptions and justifications when relating terms of school biology (SOLO ≥ 3) than Cindy and Bob. With the exception of Colin, the table also indicates that these students expressed a higher coherency in their answers on questions about the relationship between workplace outcomes and reproduction (Guided tour) as well as work actions and reproduction (Overview). Besides this, Colin's answers displayed a higher coherency after the strategy component 'Overview'. So, although the students with more experience also showed more coherency in their answers on relationships throughout the strategy, there are other indications that the strategy components 'Guided tour', 'Overview' and 'What and why' may in combination result in the expressed learning outcomes. This is supported by the fact that Bob and Cindy

showed a low coherency after the first two components and that they also displayed a low coherency in their answers after the final component. What is more, Peter gradually built up the coherency in his answers in the course of these three strategy components, which may also suggest a relationship.

Table 5.7. Overview of the coherency of answers produced by students in the interviews that followed the strategy components 'Guided tour', 'Overview' and 'What and Why'. The SOLO taxonomy is used to indicate the extent of coherency (see Methods for clarification). 1,3 means that a student provided answers that were categorized as SOLO 1 and SOLO 3. The SOLO level that occurred most frequently is underlined. The coherency of student answers when explaining biological phenomena in the workplace is given in parentheses.

		Josh	**Cindy**	**Bob**	**Colin**	**Peter**	**Harry**
Guided tour	Animal reproduction and outcome	4	2	1	1,<u>2</u>	2	4
	Work actions	3,<u>4</u>	<u>1</u>,2	1	2	<u>2</u>,3	4
Overview	Reproduction cycle work actions	4	1	<u>1</u>,2	1,<u>3</u>	4	4
	Work actions	4	1	1	1,<u>2</u>	4	4
What and why	Heat					2	1
	Insemination	3 (2)	2	1,2	2	2,3,<u>4</u> (2)	2 (1)
	Gestation	3	2		2	4	2, <u>3</u>, 4
	Birth	3	2	(2)	3	4	
	Embryo-transplantation	2	2		4	4 (2)	2 (1)

5.7. Conclusions

The study presented here explored the practicability and effectiveness of the strategy components. Besides this, it sought to uncover fruitful combinations of the strategy components. In this section those questions are answered. First the effectiveness and practicability of the strategy components is reported. A report on the relationships between strategy components and the learning outcomes follows.

Practicability and effectiveness

The results related to the component 'First participation' indicate that it seems to be practicable to let students and supervisors perform work actions together. The participation of students seems to result in a felt need to enhance their competencies. This need can be conceived as a global motive to engage in the work placement and the assignment specifically. Students seem to appreciate participation and competency development if they know they will also participate in similar workplaces in the future.

The strategy component 'Guided tour' turned out to be practicable: most of the supervisor-student pairs performed the component as intended. However, the perceived relevance of the tour depends on the skills and knowledge of the student. Focusing on reproduction while working seems to be an adequate alternative for students with much past experience. The component also appeared to be effective in five out of six cases.

The component 'Monitoring actions' appears to be practicable as well. Yet, not all monitoring actions can be performed or observed by the students. This is mainly due to the model of work placement. Obviously, a consequence of a placement period in which students are partly in the workplace and partly at school is that they are not enabled to perform certain actions. Nevertheless, the strategy component appears to be effective as all students expressed a need to know how. This need can be conceived as a motive to learn about monitoring and intervening actions in the workplace and to learn about reproduction which is related to these actions. It seems that questions asked by less experienced students are more specific than questions of experienced students. The strategy component is also effective as students recognized that registration is important for monitoring the entire livestock. This recognition can also be conceived as a motive to engage in the next strategy component.

The practicability of the strategy component 'Overview' leaves to be desired. It appears that the monitoring instruments used in the studied practices are too complex for students. This could be attributed to a lack of overview, either in students, or in the representation used in the instrument. Often, it appears to be unclear how work actions and the reproductive cycle of cows are related. Providing an overview to students during one of the supervision talks seems to be an adequate alternative to learn about the relationship between work actions and the reproductive cycle. Students who discussed the overview with their supervisor appear to provide more coherent answers to questions about these relationships.

The component 'What and why' seems to be well practicable in work placements. But, different ways to operationalize this component may surface. The results show that this strategy component may be successful in promoting students to verbalize terms of school biology in the workplace. The assignment to describe artificial insemination, scanning, checking afterbirth and embryo transplantation appears to be most successful in inviting students to use school biology terms. When it comes to justifications, the same goes for

scanning (Table 5.6 for both). Explications of phenomena may also accompany the use of terms of school biology.

Students who use terms of school biology when describing and justifying actions appear to reveal a declining coherency in their answers, compared to their answers after previous strategy components. One reason may be that students and supervisors are challenged when relating biological knowledge to their experiences in the workplace. Likewise, the answers of students seem to be less coherent when they are asked to explicate hormone-related biological phenomena in the workplace.

The strategy component 'Terms and meanings' appeared to be impracticable. One explanation may be that the pedagogical skills and knowledge of the supervisors is insufficient. The component did not result in a discussion between students and supervisors about the meaning of the terms used.

Combinations of strategy components

Although the design of the strategy was meant to be coherent, some components seem to be more connected than others. On the one hand the relationship between components refers to the evocation of a learning motive for components that follow (e.g. First participation). On the other hand the components Guided tour, Overview and Terms and meanings seem related, as their combination seem to contribute to the students conceptual understanding of reproduction in the workplace.

5.8. Discussion

As indicated before, this study is meant to inform further improvements of the strategy and to test the tenability of the theory-based design characteristics. This section reports on the merits of our findings in light of both.

The main purpose of this strategy was to explicate to students that biological knowledge is functionally used in the workplaces where they do their work placement. To arrive at that, biological knowledge needs to be verbalized in relation to work processes. After having assessed the individual components and the strategy as a whole, it seems as if the strategy is effective in challenging students and supervisors to gradually verbalize biological knowledge in the workplace. Nevertheless, there are some findings that indicate that the strategy needs adjustment.

Reflecting on the theory-based design characteristics

The findings support the idea that a sound orientation on the outcomes and work actions of the workplace may in the end provide a framework that enables students to develop a detailed conceptualization of the workplace (theory-based design characteristic 1, chapter

2). It was found that students who were successful at that also displayed a more coherent conceptual understanding in the final stage of the work placement (see Table 5.7).

Participation in reproduction-related work actions seemed to result in the experience that reproduction was important for farm profits. It also seemed to result in a need to know (theory-based design characteristic 3). Although it was not able to establish what the consequences are of participating in work actions that require an overview, it can be established that having such an overview may help to elaborate a detailed conceptualization of the workplace (theory-based design characteristic 2). On its turn, this may help to recognize that biological knowledge is actually being used.

The outcomes of the strategy component 'What and why' suggest that it might have a modest contribution to solving the problem of implicit knowledge in the studied workplaces. Supervisors used biological knowledge to describe and justify their actions to students. Describing and justifying work actions seems to encourage supervisors and students to verbalise biological and vocational knowledge of reproduction that is used during work (theory-based design characteristic 4).

However, the actual experience of students that biological knowledge is functionally used may come under pressure. In the course of the strategy, supervisors explicate to students how they themselves functionally use biological knowledge, which implies that if students want to participate in cattle farms themselves, they will also use biological knowledge. However, this does not mean that students actually *experience* the functionality when doing the work placement.

An obvious solution is that the students should experience that they can actually use biological knowledge themselves while doing work placement. This can be achieved by letting them perform actions for which they require biological knowledge. For that purpose, the most suitable work actions in cattle farms seem to be artificial insemination and monitoring gestation through scanning. Students seem to verbalise more terms of school biology when describing and justifying these actions. However, it is these actions which students cannot perform by themselves. The study in chapter 3 teaches us that participation of students in these actions is uncommon and fully participating may not be feasible. So, taking into account that students cannot perform all actions themselves, the strategy should stimulate supervisors to allow students to help with or observe as many related actions as possible.

The practicability of the strategy component 'Terms and Meanings' seemed insufficient. Consequently, it is not possible to reflect on the effects of students and supervisors who discuss the meanings of the terms they used. Improvements to this strategy component will be discussed in the next section.

Improving the strategy

In this final section, the main improvements that can be made to the strategy are outlined so as to provide tools for and to inform educators and researches in the field of vocational education.

The strategy component 'Guided tour' seems to be both practicable and effective. However, because of the differences between the experience of students in cattle farms, the component may be optimized by discriminating between experienced and less-experienced students. It may therefore be advisable to incorporate the option for supervisors to focus on discussing how work actions contribute to farm profits and the role of reproduction while working, instead of conducting a guided tour.

The practicability and effectiveness of the component 'Monitoring actions' seems to be more than sufficient. Optimizing may occur when it becomes clear to students and supervisors that not all monitoring and intervening actions need to be performed by students themselves. However, as mentioned in the previous section, it is recommended to let students help with or observe some key work actions (e.g. insemination).

It is clear that the strategy component 'Overview' needs adjustment. An important suggestion made by several supervisors is the introduction of an out-of-date cow calendar. This is an instrument that was sometimes used by farmers before the advent of the computer. It was used to monitor the heat, gestation and coming birth of a complete livestock. It displays the reproductive cycle of a cow and the related work actions. Such an instrument is potentially functional in school as it provides an overview for students, and in working environments as it is really helpful in organizing monitoring actions that need to be performed. Because of the functionality in both contexts, a cow calendar may be conceived as a 'boundary (crossing) object' (Star, 1989 as cited in Akkerman & Bakker, 2011).

The component 'What and why' seemed to function adequately. Nevertheless, a possible adjustment may be that this component can partly be performed at school, guided by a teacher. Besides this, to promote supervisors in bringing up a variety of justifications, it is possible to point out that justifications can also focus on possible problems, different methods and the right moment of performing.

It was obvious that 'Terms and meanings' did not function in the workplace as was intended. This part of the strategy could also be performed in school guided by a teacher. The component should focus on making terms and meanings discussible and on how students can be challenged to reconstruct existing meanings of the terms they used while describing and justifying work actions. Besides this, this component or a new component can focus more explicitly on the experience of students that biological knowledge can be functional in the workplace by revisiting key work actions.

Recapitulating, this chapter clarified the practicability and effectiveness of strategy components that were based on insights from literature. Besides this, the theory-based design characteristics have helped us to reflect on possible adjustments of the strategy.

Chapter 6

Completing relationships: towards an educational strategy for learning about animal reproduction in school and in the workplace

6.1. Introduction

This chapter reports on the design and field testing of an adjusted and completed learning and supervising strategy. The adjustments made were based on the outcomes of the field test reported in chapter 5. Especially the strategy components 'Overview' and 'Terms and meanings' seemed to be impracticable and therefore less effective than expected. These and other problems were addressed by introducing strategy components at school and by fine-tuning the components in the workplace.

The chapter starts with an overview of the adjustments made in the strategy and rationale behind these adjustments. This is followed by the research questions that guided the next field test. After presenting the results, the practicability and effectiveness of the revised strategy will be discussed. The chapter ends with reflections on the theory-based design characteristics in light of the outcomes of the field test and recommendations for further improvement and use of the strategy.

6.2. Re-designing the strategy

The findings of the study reported in chapter 5 made the adjusting of certain strategy components imperative. Especially the introduction of learning and teaching actions at school may improve the strategy. Next the inadequacies in the strategy and how to address them will be described.

The strategy component 'Guided tour' seemed less adequate for students with more (practice) knowledge. One of the solutions is to differentiate between students and to initiate discussions about work actions with these students while working. Similarly to the guided tour, this discussion should focus on the relationships between work actions and farm profits.

The strategy component 'Overview' seemed impracticable because students had either insufficient overview over the work actions related to cow fertility and reproduction or the instruments used could not provide the overview needed. A solution suggested by several cattle farmers was the use of a cow calendar, which is an instrument that was formerly used in cattle farms. The rationale of this calendar should be less complex than the ones used in

daily practice nowadays, and may therefore provide an overview for students. Introducing the cow calendar may show students that work actions in a workplace are organized (cf. Boreham, et al., 2002). The cow calendar offers an overview of the working actions that are related to cow reproduction and it shows how the (average) calving interval and (average) lactation period are related to both the production of milk and cow reproduction. A second prospect of the cow calendar is that it can be functional in the cattle farm and in school. This dual functionality may stimulate students to use the calendar and learn at the same time. In the cattle farm it is used to manage fertility of livestock. In school the overview provided by the calendar may serve as a stepping stone for students to particularize their understanding of the workplace (Evans et al., 2010). Because of this double function it can be conceived as a boundary object (Akkerman & Bakker, 2011).

The results concerning the strategy component 'What and why' showed that supervisors experienced difficulties in verbalizing biological knowledge. Besides this, they were unable to discuss a variety of justifications. Both problems may be solved by introducing lessons at school that provide room for reflexive actions. What is more, bringing up authentic problems of a cattle farmer in these lessons may stimulate the more experienced students to verbalize knowledge which would otherwise remain implicit.

The strategy component 'Terms and meanings' seemed impracticable because the pedagogical skills and knowledge of the supervisors to negotiate meanings of the terms as well as their biological knowledge of reproduction fell short. Schools have the expertise to address this. Lessons at school offer students the possibility to reflect on their experiences from the cattle farm under guidance of an expert (Eraut, 2000). Besides reflection on action, lessons at school may also provide the opportunity to focus more intensively on terms and meanings used in the workplace and at school. Apart from the time spent on these reflective actions, school also seems to be a more appropriate context for these actions, as negotiating meaning seems to be more common in schools (Bernstein, 2000).

Bringing together the experiences of the students in the classroom context offers two additional prospects. First, it can help the teacher to show students that cattle farms generally operate in the same way. This may contribute to the recognition that focusing on these similarities may help to learn about cattle farms. Second, putting an emphasis on differences and similarities may also stimulate discussions about optimizing work actions, which on its turn may help students and the teacher to verbalize workplace knowledge.

So, it seems indicated to introduce lessons at school to supplement the strategy components that function in the workplace. However, introducing lessons also means that one has to consider the purpose and the function of these parts of the strategy components and reconsider the existing strategy components that functioned in the workplace. Besides this, the sequence of actions needs to be considered. Learning and teaching actions at school can either precede or succeed the learning and supervising actions at school. The primary function of the strategy is to let students experience and appreciate that biological knowledge is functional in the workplace, so the strategy components at the workplace should initiate student learning.

Finally, the adjustments made to the strategy were reflected on by different groups of experts and the complete strategy was walked through in a focus group interview with three teacher trainers who work at an institute that strongly focuses on training VMBO science teachers. After that, the strategy was individually critiqued by three experienced work placement mentors who also teach vocational courses in VMBO. Just before the beginning of the placement period, the strategy was discussed on its feasibility by cattle farmers who agreed to supervise the students.

The sequence of strategy components at the workplace and at school is given in Table 6.1. The table also shows how each component should be performed and what outcome is expected. Besides this, the table indicates to which theory-based design characteristic the component relates. Figure 6.1 provides an overview of the sequence and duration of the strategy components.

Table 6.1. Description of the strategy components and their expected outcomes. The table distinguishes elements that are performed at school and elements that are performed in the workplace. The relationships with the theory-based design characteristics (DC) are indicated. Differences with the previous strategy (Table 5.1, chapter 5) are displayed in italics. Actions presented on the same line are related. A = assignment.

First participation				
Context	**Supervisor/ teacher action**	**Student action**	**Expected outcome**	**DC**
Workplace	· Supervisor discusses first participation with student	· *Students perform work actions with supervisor* · *Students reflect on first participation*	· Students experience the need to increase competence in the workplace	2

The farm				
Context	**Supervisor/ teacher action**	**Student action**	**Expected outcome**	**DC**
Workplace	· Supervisors provide a guided tour and focusses on the main outcomes of the farm, related work actions and reproduction of cows *(alternative: during working together)*	· Students familiarize themselves with the main outcomes, work actions and the role of reproduction of cows · Students elaborate A1	· Students recognize that animal reproduction contributes to the main outcomes and can list related work actions	1
School	· *Teacher provides feedback by categorising answers of students in a hierarchy schedule*	· *Students share experiences* · *Students list outcomes of the workplace and share their answers* · *Students adjust their answers*	· Students can list the main outcomes of the farm and appoint their hierarchy	1

Monitoring actions				
Context	**Supervisor/ teacher action**	**Student action**	**Expected outcome**	**DC**
Workplace	· Supervisors stimulate *engagement* of students in monitoring and intervening work actions (related to reproduction) · Supervisors discuss half-*completed* assignment with student	· Students monitor heat, coming birth and assists with or observes monitoring gestation and insemination · Students describes experiences with monitoring and intervening actions (A2)	· Students recognize that monitoring the complete livestock asks for an overview	2, 3, 4
School	· *Teacher initiates a group discussion about A2* · *Teacher monitors descriptions of students and puts emphasis on the how and the why of (artificial) insemination*	· *Students identify differences between practices* · Students supplement their own description of *monitoring* and intervening actions	· Students use terms of the workplace and terms of school biology to describe monitoring and intervening actions	3, 4

Cow calendar				
Context	**Supervisor/ teacher action**	**Student action**	**Expected outcome**	**DC**
School	· *Teacher explains the functioning of the cow* calendar *and provides students with a small version*	· *Students try to use the small calendar by incorporating hypothetical cows*	· Students experience that using the cow calendar in their placement site needs guidance from the supervisor	
Workplace	· *Supervisors appoint two cows or more from the real management system* · *Supervisors provide feedback on the use of the calendar, the reproductive cycle of cows and the related sequence of work actions*	· *Students use the cow calendar to determine when to monitor or intervene (A3) with these cows* · *Students re-examine their use of the cow calendar and their answers to A3*	· Students can describe the functioning of the cow calendar · Students recognize that the sequence of work actions are related to the reproductive cycle of cows · Students can list this sequence of work actions	2, 3
School	· *Teacher explains that the* cow *calendar is one of the instruments that is used in cattle farms and that the principle of alternative instruments are the same* · *Teacher starts a group discussion about the use of the cow calendar and focuses* on *the calving interval and the lactation period*	· *Students present how they* used *the cow calendar and with what outcome* · *Students identify the calving interval and the lactation* period *on the cow calendar*	· Students can describe the relationship between milk production and the reproductive cycle of cows in terms of calving interval and lactation period	2, 3

What and why?				
Context	**Supervisor/ teacher action**	**Student action**	**Expected outcome**	**DC**
Workplace	· Supervisors monitor the descriptions and justifications · Supervisors focus on goal-oriented, method-oriented, time-oriented and problem-oriented justifications	· Students describe and justify work actions that have been previously discussed in relation to the cow calendar (A4) · Students adjust and supplement their descriptions and justifications	· Students use terms from both school biology and the workplace to describe and justify the work actions	4
School	· *Teacher monitors if students address the most* important *topics (e.g. feeling ovaries, scanning, signs of birth)*	· *Students explains to teacher and other students what they have written down so far*	· Students (again) use terms from both school biology and the workplace to describe and justify the work actions	4
	· *Teacher makes notes of the phenomena that students describe* · *Teacher asks questions about these phenomena (e.g. changing behaviour of cows)*	· *Students take turns in answering questions and complement other students*	· Students use the term *hormone* to explain these phenomena and indicate that processes within the cow may be regulated by hormones	
	· *Teacher provides students with dilemmas of a cattle farmer (e.g. a cow does not come into heat; a cow is susceptible to abortion)* · *Teacher summarizes and indicates pro- and cons of each solution*	· *Students individually describes what he would do (A5)* · *Students discuss answers in a group discussion and come to a best solution*	· Students use terms of school *biology* to provide an argument of their choice	

Terms and meanings				
Context	**Supervisor/ teacher action**	**Student action**	**Expected outcome**	**DC**
School	· *Teacher asks students what the biological terms they used have to do with (working in) a cattle farm*	· *Group discussion about the relationship between terms of school biology and work actions*	· Students relates meanings of terms of school biology to actions in the workplace	4
	· *Teacher hands over an envelope that carries cards with terms of the workplace and terms of school biology*	· *Students make sentences of the terms provided to them in one envelope* · *Students discuss the meaning of terms of school biology and the workplace*	· Students connect terms of school biology and the workplace	

Improving farm profits				
Context	**Supervisor/ teacher action**	**Student action**	**Expected outcome**	**DC**
School	· *Teacher asks students to describe embryo transplantation with help of the supervisor (A6)*	· *Students complete A6 together with their supervisor*	· Students use terms of school biology and recognize that biological knowledge is (functionally) used in the workplace for embryo transplantation	4

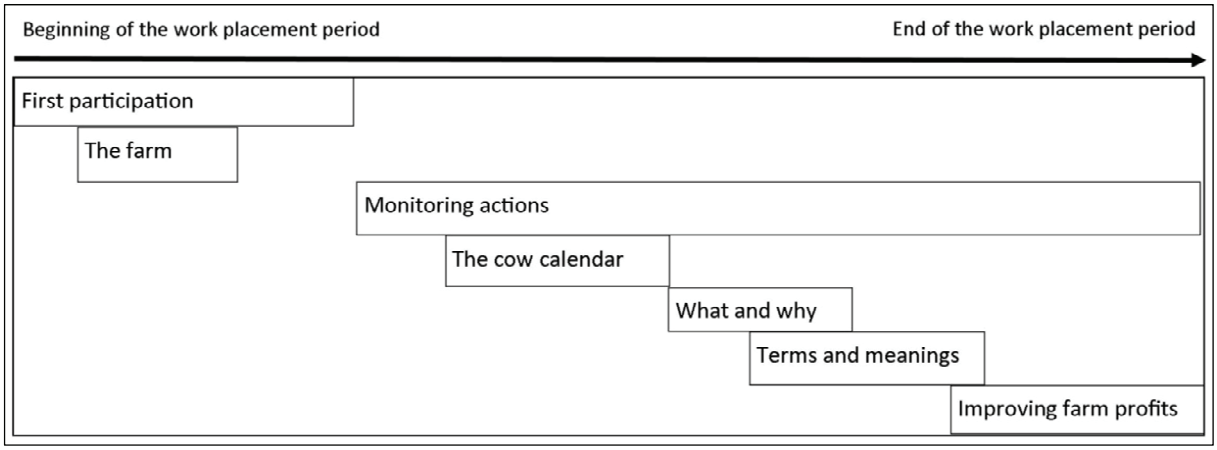

Figure 6.1. Sequence and relative duration of the strategy components. The arrow indicates the sequence of actions. The relative duration of the components is indicated by the length parallel to the arrow.

6.3. Research questions

The study in this chapter seeks to answer the following research questions.

- *How practicable is the learning, teaching and supervising strategy in which work placement and lessons at school are integrated?*
- *How does student conceptual understanding of the workplace, animal reproduction and their interrelatedness develop throughout the strategy?*

6.4. Methods

The strategy is tested by comparing the expected learning processes and learning outcomes with the observed processes and outcomes in four work placement case studies. Similarly to the first field test (chapter 5), the placement sites were selected for being involved in animal reproduction. A direct relationship between the outcomes of the workplace and animal reproduction seems to contribute to a more appropriate learning environment (chapter 3). Consequently, all students of an agricultural school were approached that did their work placement on a cattle farm or a horse breeding farm. After that, the farmers that would supervise these students were approached. The four possible candidates, who all did their work placement in a cattle farm, agreed to cooperate. This number of cases allowed to focus on the complex relationships in the conceptual

development of students. Chapter 4 showed that the relationships between biological knowledge and work actions can be quite intricate.

Relevant characteristics of the respondents of these case studies are presented in Table 6.2.

Table 6.2. Background characteristics of the case studies.

Student	Age	Student experience in cattle farms	Student experience in school courses	Professional outlook	Experience of supervisor*
Kirk	15	Parents own a cattle farm	Cattle farming Biology	Cattle farmer	4
Tobias	16	Parents own a cattle farm	Cattle farming Biology	Cattle farmer	> 10
Jack	15	Parent own a mixed farm, including cattle	Biology	Agricultural contractor	4
Sheldon	15	None	Biology	Animal care	5

* Number of supervised students before the placement period.

In each case study, a student participated in a placement period of one day a week for eight weeks. Before and during the placement periods, the supervisors were given written and oral supervision instructions. The instructions were given on site and dealt with how to guide the students and how to conduct the supervision talks (Figure 6.2).

The five lessons at school, in which the students were mentored as a group, were given by a female biology teacher who grew up at a cattle farm. She can therefore be characterized as an intermediate between school and the workplace. Such an intermediate is referred to as a broker by Snyder and Wenger (2010). The lessons were given once a week and lasted forty minutes each. Before each lesson, the teacher was fully instructed about how to teach and mentor the students. These instructions took about one and a half hours per lesson.

Data was collected throughout the placement period. The collection in the workplace within one case included three interviews with the student and audio-recordings of two supervision talks. Besides this, the supervisor was interviewed afterwards and the placement reports of the students were collected. The data collection in school included video-recordings of five lessons and audio-recordings of group discussions and talks between students and teacher, and discussions among students themselves. Besides this, the (half)completed assignments of students were collected four times. Figure 6.2 shows how the data collection matched the strategy components.

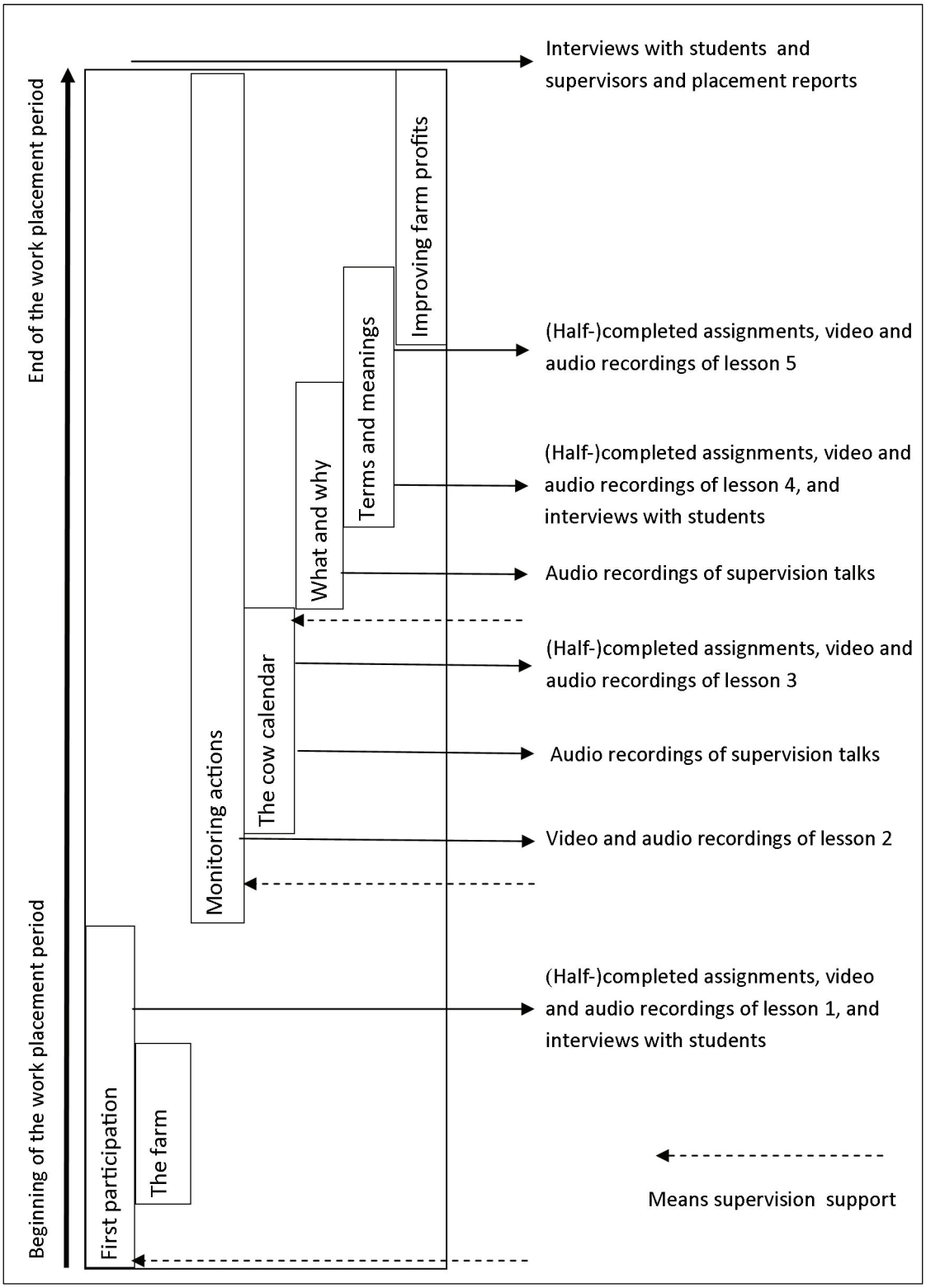

Figure 6.2. Supervision support and data collection during the work placement period matched with the strategy components.

To establish the effectiveness in terms of students' development of conceptual understanding, the practicability of the strategy needed to be determined first. A strategy component that is not performed as planned cannot properly be assessed on its outcomes. The practicability of the strategy was determined by checking the correspondence of the

expected and the actual supervisor, teacher and student actions throughout the strategy. In case of deviations, explanations were searched for in the interviews with students and supervisors. Besides this, each lesson was discussed afterwards with the teacher.

The development of the conceptual understanding in students was also established by comparing the actual learning outcomes with those intended. For this purpose, the analysis of the supervision talks and the placement reports on the one hand and the video and audio tapes of the lessons and the completed materials on the other focused on the expected learning outcomes presented in Table 6.1. Besides this, the conceptual understanding of the students was also assessed in the interviews by interrogating the students, verifying the data from lessons and the completed assignments. The development of students' conceptual understanding was determined by analysing their answers to questions asked in lessons and interviews and their texts in completed assignments by using the SOLO taxonomy (Biggs & Collins, 1982). The descriptions of the indicators and examples are given in Table 5.3 (chapter 5).

Since the strategy and the categories relied on both theoretical propositions and empirical finding of the previous field test, cross case analysis was enabled (Wester & Peters, 2004; Yin, 2009). The aggregated findings per strategy component provided an overview of the practicability and effectiveness of each component.

The results that follow this section will be presented in thick description, meaning that important results are presented together with relevant contextual information, which enables external validation (Maso & Smaling, 2003; Smaling, 2009). Adding contextual information makes it possible to consider whether the results and phenomena that are presented here may apply to other contexts.

6.5. Results

The results are presented per strategy component. Under each component, the results concerning the practicability are described first. After these results, the effectiveness will be presented. The combined results regarding the effectiveness of the successive strategy components show how students' conceptual understanding developed.

Because the results are presented per strategy component, it is advisable to simultaneously consult the overview of learning, supervising and teaching actions and the expected outcomes in Table 6.1.

First participation

At the workplace

Analysis of video and audio recordings of the first lesson, completed assignments and the interviews with students and supervisors show that in all cases students worked together with their supervisors. With the exception of Kirk, the analyses reveal that the students and the supervisor cooperated in work actions and also discussed these actions.

According to Jack's supervisor, their discussions were superficial because of the minimal responses from Jack. Kirk's supervisor said he did not discuss the actions because Kirk is very experienced and because Kirk is more of a worker than a talker. Intensively discussing the actions did not seem relevant to him. Video recordings of the first lesson and interview with students show that Kirk is the only one who does not experience the need to expand his competence. At this stage, he indicates that he knows everything. However, he also thinks his professional skills are insufficient to take over the cattle farm at home for a week.

The other students said that they can and want to expand their competence. Tobias, for instance says he wants to learn more about breeding cattle because he may become a cattle farmer himself: the farm where he does his work placement has good quality cows and he wants to know how this can be achieved.

Jack has a more general learning need: he is interested in small differences between the cattle farm at his home and the placement site, which may teach him how to improve the workplace. Sheldon is very specific: he wants to learn how to milk and how to mow an extensive area of grass.

When it comes to assignments, the students have different opinions. At this stage of the strategy Kirk and Jack think they know enough to function at the placement site. More knowledge of reproduction seems interesting to them but not necessary. Tobias and Sheldon say that the assignments can help them to understand how the workplace works.

The fact that Tobias works in a modern and innovative environment compared to the farm at home and that for Sheldon everything is new may explain their need to better understand the workplace. Kirk and Jack both mentioned that work in a cattle farm is not new to them and their placement site is not innovative when it comes to improving cattle through reproduction.

The farm

At the workplace

Except for Sheldon whose supervisor conducted a guided tour, the other supervisors chose a different approach. The supervisors of Tobias and Jack chose to focus on outcomes of the workplace and related work actions during working together, because of the available experience of the students with cattle farms. Jack's supervisor said to have difficulties in relating reproduction because his farm uses a bull which makes a lot of monitoring and intervening actions redundant.

Kirk's supervisor skipped both options. According to him, Kirk is experienced enough and he knows the placement site well because he lives in a farm across the street.

All four students elaborated their learning in assignment one. The half-completed assignments show that the students recognize that animal reproduction is important for attaining the pursued outcomes of the cattle farm. The quote from an interview with Kirk shows how, according to him, reproduction is important in cattle farms.

K: Kirk

R: Researcher

R: According to you, what are the most important outcomes of the cattle farm you are working?

K: First of all, making money. That is why the farmer does it.

R: Yes.

K: Milk production is also important because milk brings money. And if the cows are strong they will give more milk because they are sick less often. They also eat more and their fertility is better, which is also important because infertile cows in the end stop producing milk.

R: That's it?

K: Yes, in summary.

At school

Video recordings of the lessons show that this component is performed as planned. During the lesson, the teacher leads a class discussion about preferred outcomes of a workplace and the most important work actions that contribute to these outcomes. The discussion ends with the teacher summarizing what has been said and prioritizing and relating the different outcomes and work actions.

Video recordings of the first lesson and the first interviews show that the combination of learning, teaching and supervising actions resulted in all students relating fertility of the livestock, cattle breeding or calving to producing milk. A draft version of the assignment that students had to make before starting the real assignment did not reveal this relationship. More often, the students merely related health and feeding or specifics of that, such as feeding corn or using decontamination powder in the stables.

The descriptions of the workplace outcomes and the work actions of the students show coherences of SOLO 2 and 3. The relationship between outcomes and work actions described by the students also displays coherences of SOLO 2 and 3.

Monitoring actions

At the workplace

The interviews with Kirk and Jack and the interviews with their supervisors demonstrate that the supervisors pointed the students to the assignment but they did not stimulate the students to perform the monitoring actions. However, these supervisors also said they involved students in these actions if they occurred. On the contrary, the supervisors of Tobias and Sheldon deliberately engaged them in monitoring and intervening actions.

Except for Sheldon's supervisor none of the supervisors has discussed the actions with the students. The reasons they brought forward are twofold. The supervisors said that the same actions will also be discussed in assignment four and that they thought that it would be discussed at school. Jack's supervisor added that the use of a bull in his farm makes performing these actions and discussing them redundant.

At school

Video recordings of lesson two reveal that this part of the strategy component was performed as expected. After a start-up of the lesson in which students exchanged experiences, the teacher led a class discussion about assignment two. Particularly Tobias and Kirk discussed the differences between their cattle farms, both of the placement site and of the cattle farm at home. The teacher drew Sheldon into the discussion. Jack was absent that day. The quote below taken from the lesson shows how the discussion was conducted.

T: Teacher
K: Kirk
Tb: Tobias
S: Sheldon.

T: *What happens if you see a cow in heat?*
K: *The cow is restless and is being jumped on.*
T: *What happens more? Is there more that may tell you that the cow is in heat, Sheldon?*
S: *Constantly moving her ears?*
T: *Very good.*
K: *Is that a sign?*
Tb: *I've never noticed that.*
K: *Oh, look a cow is constantly moving her ears.*
T: *Is there more?*
K: *The cow can also be bothered by flies.*
T: *But it is a sign of heat.*
Tb: *At my placement site a red light illuminates.*
T: *What does that mean?*
Tb: *They have a device that measures when a cow is in heat and then a red light illuminates.*
T: *Okay.*
K: *A step counter (pedometer).*
Tb: *No, but something like that.*
K: *With a collar?*
T: *A motion sensor.*
Tb: *Yes, some kind of collar.*
T: *Could you explain to Sheldon how that works?*
Tb: *Well, a cow carries a collar which measures the number of movements and if the cow moves more than usual, the lamp illuminates.*
K: *Are you sure? I think that a ball-bearing moves backwards if the cow jumps, or something like that.*
Tb: *No, not this one.*
T: *There are also devices that measure if cows cross a certain height.*
T: *How do they do that in the farm at home, Kirk?*
K: *They watch for signs of heat. At my placement site they don't do anything. They have a bull.*

T: *And at home?*
K: *We watch for signs.*

The video recordings and the completed assignments demonstrate that the descriptions of work actions produced by the students show the following coherence (SOLO) levels. The SOLO level that occurred most frequently is underlined.

Kirk: SOLO 2, 3
Tobias: SOLO 2,3
Jack: SOLO 2,3
Sheldon: SOLO 1,2,3

The terms of school biology the students use to describe the monitoring and intervening actions at this stage of the strategy tare portrayed in Table 6.3.

Cow calendar

At school

The video recordings of lesson two show that at the end of the lesson the teacher demonstrates how to operate the cow calendar. After that, the students practise with a smaller version of the calendar. The remarks made by the students affirm that, at that time, they could not operate the calendar without help. To help the students, the teacher answered a few questions of the students and gave another demonstration. In the end, she told the students that they should also ask their supervisors how to operate it.

At the workplace

The supervision talks with the students reveal that Jack and Sheldon used the cow calendar together with their supervisor to time the working actions for cows. Both talks show that operating the calendar is quite a challenge. In the end, both pairs manage to operate the calendar quickly and effectively. Sheldon's supervisor even shows his appreciation for the instrument, as is shown in the following quote from their supervision talk.

S: Sheldon
C: cattle farmer / supervisor
C: *Then you spin the wheel. Scanning is after forty days. You see, it says that after forty days it can be scanned. Do you know what date that is?*
S: *25 June.*
C: *Yes, I think it is 25 June.*
S: *Feeling for calf?*
C: *The same cow has the date 20 July when the calf needs to be felt.*
S: *And then we go to December.*

C: *I think that is right because gestation lasts for nine months and then you arrive at … February. Yes, that's right, you have to isolate the cow from milking at December the 10th.*

S: *Writing down 10 December … calving and comes into heat again. No, 10 February.*

C: *And then exactly one year has passed. Okay, I was not familiar with this instrument but it works nicely.*

Table 6.3. Terms of school biology used by the students to describe monitoring and intervening actions in the cattle farms.

Stage of Reproduction	Work action	School biology terms*
Heat	Monitoring (pre) standing heat	
	Feeling ovaries	Ovaries
Insemi-nation	Artificial insemination	Semen, egg-cell, fertilization, fertile
	Coverage	
Gestation	Checking bleeding	
	Monitoring heat	
	Scanning	Womb, cells
	Feeling womb	
	Monitoring birth signs	
Birth	Checking calf	
	Checking afterbirth	Womb

* Rows that do not carry terms indicate that when describing this work action no terms of school biology were used. Terms of the workplace (cattle farm) were used in each description.

Tobias and his supervisor also tried to use the cow calendar. The supervision talk, however, only reveals that Tobias mentions the dates that the work actions should be performed for each cow and the dates when certain phenomena can be observed (e.g. seeing the cow in heat). In the interview with Tobias that follows, he explains that the

recordings demonstrate the results of an intensive discussion between him and his supervisor in which they discussed the functioning of the cow calendar. According to Tobias, the cattle farmer could not operate the calendar properly in the end. During the interview, the supervisor confirmed that the discussion had taken place before the recordings and said that they only recorded the result. Contrary to Sheldon's supervisor, Tobias' supervisor adds that the cow calendar is an out-of-date instrument and that there is software that does the same. The interview with Tobias shows that he and his supervisor think alike, as he also characterizes the calendar as old fashioned.

The recordings of the supervision talk of Kirk and his supervisor are not about the cow calendar. Instead they discuss monitoring and intervening actions. In the interview with Kirk's supervisor he explains that they did use the calendar. The video recording of lesson three seems to support this, as Kirk operates it skilfully.

Notably, the interviews with the three more experienced students indicate that these students experienced using the cow calendar as unpleasant. The most heard reason they put forward is that the calendar is an out-of-date instrument which they will never use in their farms at home. Another reason seems to be that calculating the dates can also be done by heart or on a paper. By contrast, Sheldon characterized the calendar as useful for cattle farmers and for learning about the farm. Note that the calendar is used to monitor up to 200 cows, which makes keeping an overview by mere calculation undoable.

At school

After a short explanation by the teacher about the history of the use of cow calendars and how these instruments are similar to modern cattle managing programmes on the computer, students were given time to prepare their presentation of assignment three: demonstrating how they used the cow calendar at the placement site. After that, the students present how they used the cow calendar.

The recordings show that the teacher ended with a teacher-led class discussion about the relationship between milk production and the cow calendar, focusing on the calving interval and lactation period. The recordings reveal that Jack and Sheldon did not know what these terms mean and how they are related. Tobias and Kirk on the other hand could describe both terms properly and indicate them on the cow calendar.

The outcomes of this strategy, revealed by the interviews with students and the completed assignment, is that Kirk, Tobias and Sheldon were capable of listing the monitoring and intervening work actions related to the different stages of cow reproduction if the stages heat, insemination, gestation and calving are given. If the stages are not given, some of the working actions are left out or they get mixed up. Tobias, for instance, could not explain what other actions, besides scanning, can be undertaken to monitor gestation (in this case feeling womb, for example). Strikingly, Sheldon outlined the most complete row of monitoring and intervening actions.

The coherency of the answers to the interview questions about the outcome of the workplace, the working actions, reproduction and their relationships as well as the meaning of the terms calving interval and lactation period are given in Table 6.4.

Table 6.4. Coherency of student answers to questions about the outcome of the workplace, the working actions, reproduction and their relationships as well as to questions about the calving interval and lactation period. The SOLO taxonomy is used to indicate the extent of coherency (see Methods for clarification). 1,3 means that a student provided answers that were categorized as SOLO 1 and SOLO 3. The SOLO level that occurred most frequently is underlined.

	Kirk	**Tobias**	**Jack**	**Sheldon**
Outcome	<u>3</u>, 4	4	3	1, <u>3</u>
Relationship outcome work actions	4	3	2, 3	2, <u>3</u>
Relationship outcome reproduction	4	4	1, <u>2</u>	2, <u>3</u>
Calving interval and lactation period	2, <u>3</u>	3, <u>4</u>	<u>1</u>,2	2

The quote below demonstrates how Sheldon relates values of proteins, fat and contamination with penicillin and the quality of the milk. However, he is incapable of explaining this relationship which justifies SOLO 3.

R: researcher
S: Sheldon

R: You said that the farmer needs to produce milk. Is that as much milk as possible or milk of good quality?
S: Yes, it is also about much milk but also about the right values of fat and proteins and such.
R: The more the better?
S: Yes, as long as there are no diseases in the milk?
R: There are diseases in the milk?
S: Yes, if a cow has udder inflammation the milk must not go into the tank. Because it is penicillin milk or something like that.
R: Okay.
S: And he disposes that
R: Can you explain to me how that works?
S: No.
R: I mean, why penicillin milk needs to be disposed of.
S: No.

What and why

At the workplace

The audio recordings of the supervision talks indicate that all supervisors encouraged the students to elaborate in assignment four: describing and justifying monitoring and intervening work actions. The recordings also show that they supplemented the student answers after discussing the contribution of the student.

Because Sheldon had worked out the assignment quite extensively, the pair mainly discussed what was written down. In the other cases, the supervisor and the student completed the assignment together on site. Often, the format they followed was as follows. The student had to describe or justify the working actions first. After that, the supervisor made additional suggestions which sometimes resulted in a discussion between the student and the supervisor.

The supervision talks and the interviews with supervisors made clear that, similarly to the previous study, the supervisors experienced difficulties in bringing up different types of justification (e.g. choice of method, moment of undertaking the action). Often they brought forward one aspect to justify their actions (mostly goal-oriented justifications). The following quote from a supervision talk between Jack and his supervisor demonstrates this.

J: Jack
C: cattle farmer / supervisor

C: And why does one scan?
J: To see if the cow carries a calf.
C: Just to see if there is a calf or more?
J: No.
C: It can be useful to see in what stage of development the calf is.
J: Yes, that too.
C: That's why it is done.

Sheldon's supervisor on the other hand shows that other justifications can be brought up.

S: Sheldon
C: cattle farmer/ supervisor

S: The cow jumps on other cows or is being jumped on.
[…]
C: Is it possible for a cow to be in heat and not show any signs of heat? Yes, that's possible. What do you have to do when a cow does not come into heat?
S: Can something be done?
C: Yes, one can inject a cow to get her into heat. Imagine that the cow is not properly clean because something in the womb is left behind. In that case the cow will not come into heat because something is in the womb and the womb thinks, then she will not come into heat. Some white stuff comes out. Then you can inject the cow to get her in heat or you can rinse the womb with tetra. They say that injections

are the most effective because this activates everything. The injections can be given by a veterinarian or an inseminator.

For that matter, the completed assignments of the students indicate that they also tend to put forward a goal-oriented justification.

At school

The video recordings of the fourth lesson show that all students elaborated in assignment four. After letting the students work individually on their assignment, the teacher led a class discussion that focused on justifications of work actions. As to each work action, questions were asked about the moment of acting, the choice of method, addressing any problems and the effects of the action. The following quote from the lesson shows how the teacher focused on the advantages and disadvantages of certain methods.

T: Teacher
K: Kirk
J: Jack
S: Sheldon

T: *What can be a disadvantage of having a bull instead of insemination?*
K: *No pen and paper.*
T: *No.*
K: *You don't know when the cow is covered.*
T: *Can you mention another difference?*
K: *You can be injured by the bull.*
T: *Jack, can you think of an advantage or disadvantage of having a bull?*
J: *No, not really.*
T: *Sheldon, do you know why cattle farmers may choose artificial insemination?*
S: *No.*
T: *Why does your father do that, Kirk?*
K: *Then you do not have to keep a bull.*
T: *What would you do if you had a cattle farm?*
J: *I would use a bull, that's how we do it at home.*
K: *I would use artificial insemination because otherwise I would have to keep a Holsteijn bull and these are vicious.*
T: *Yes, but if you think about it, is there another reason to opt for insemination or a bull?*
K: *No, because insemination allows you to inject the cow with a bull of choice. I think it is undoable to buy a first-class bull.*
T: *No, indeed that is very expensive.*
K: *It also allows you to inject different bulls.*
T: *And Sheldon, if you bought a farm, what would you do?*
S: *I think insemination. It allows me to keep track of everything.*
T: *What can be tracked?*
S: *When to inseminate and isolate them and those kind of things.*

The recordings also reveal that the teacher asked students about certain phenomena they encountered during work placement and which they reported in their assignments. For example, she asked the following question: 'If a cow is in gestation, she does not come into heat again. However, if the cow loses the calf (miscarriages) she comes into heat again. Do you have an explanation for that?'

The recordings also show how the teacher confronted students with dilemmas of a cattle farmer. First, students individually thought of what they would do in that situation. After that, they discussed their choice of action with another student. Finally, students were stimulated to further elaborate in their assignment four.

During the learning and teaching activity, it became clear that the more experienced students tended to choose the solution that is also chosen at their farm at home. The following quote shows how questions meant to evoke subtle considerations were overshadowed by the remark that they also act that way in the farm at home.

T: Teacher
K: Kirk
J: Jack

T: *What would you do in situation A [cow has not shown heat for several periods], Jack?*
J: *The last choice. I had three. Selling the cow for meat and buying new cows.*
T: *And what is the advantage of that?*
J: *Then you get better cows, I think.*
T: *And a disadvantage?*
J: *It is expensive and you lose a cow.*
T: *So, it would be a shame to sell a very good cow?*
J: *Yes, if that is the case.*
T: *Did you hear what Jack said, Kirk?*
K: *Yes.*
T: *What do you think?*
K: *I think it is better to keep your own cows. If you purchase new cows, you never know what you get, with diseases and all.*
T: *What would you do then?*
K: *I would choose two. Injecting the cows to induce heat. We do that at home and it works fine.*

The completed assignments and the interviews with students show that the results of the combined learning, supervising and teaching actions is that students seem to use more terms of school biology compared to what they used to elaborate in assignment two (Monitoring actions). Table 6.5 shows which school biology terms were used to describe and justify work actions and which were used to explain phenomena, and the coherence of the descriptions, justifications and explanations for the strategy component 'What and why' are given in Table 6.6.

Table 6.5. The use of school biology terms by students when describing or justifying work actions and explaining phenomena in the workplace. For example, if under 'Justification' it says 'Method: fertilization' it means 'when justifying the method, the term fertilization was used'.

Stage	Work action	School biology terms		Explication
		Description	Justification	
Heat	Monitoring (pre) standing heat	Fertilization, womb	Timing: womb	Changing behaviour: hormone, ovaries, corpus luteum[a], egg-cell
	Feeling ovaries	Ovaries, corpus luteum[a]		
Insemination	Artificial insemination	Cervix, womb, egg-cell, sperm cell, fertile, fertilization, fallopian tube, vagina	Timing: ovulation, egg-cell Method: fertilization	
	Coverage			
Gestation	Checking bleeding			
	Monitoring heat			Changing behaviour after miscarriage: hormone, embryo, corpus luteum[a]
	Scanning	Womb, embryo, endometrium[b], cells	Timing: embryo	
	Feeling womb	Womb, fertilized egg-cell		
	Monitoring birth signs			Declining milk production: hormone Loosening of the ligaments: hormone
Birth	Checking calf	Umbilical cord		
	Checking afterbirth	Afterbirth, womb, fluid-filled fetal membranes[c]	Afterbirth, cervix	

[a–c]The non-formal terms used in Dutch were: [a]geel lichaam, [b]baarmoederslijmvlies, [c]vruchtvliezen

Table 6.6. The coherency of answers produced by students in the interviews that followed the strategy component 'What and why'. The SOLO taxonomy is used to indicate the extent of coherency (see Methods for clarification). 1,3 means that a student provided answers that were categorized as SOLO 1 and SOLO 3. The SOLO levels that occurred most frequently are underlined.

Stage	Work action	Kirk	Tobias	Jack	Sheldon
Heat	Monitoring (pre) standing heat	2, 3	2		2
	Feeling ovaries				
Insemination	Artificial insemination	3	2, 4	2	2, 4
	Coverage				
Gestation	Checking bleeding				
	Monitoring heat				
	Scanning	3	3, 4		1, 2, 3
	Feeling womb	4	1, 2	2	2, 3
	Monitoring birth signs				
Birth	Checking calf				
	Checking afterbirth	3, 4	2	2	2, 3
Phenomena	Changing behaviour in heat	3	2, 3	3	4
	Changing behaviour after miscarriage	2	3		2
	Declining milk production before birth	2		1	2

Terms and meanings

At school

Video recordings of lesson five demonstrate that the teacher started the lesson by confronting students with terms they used themselves to elaborate assignment four and asked them what these terms have to with the cattle farm. One example of a question was 'Can you explain to me what sperm cells have to do with the cattle farm?'

After that, the teacher handed each couple of students an envelope with cards that carry terms and asked the students to make a proper sentence of the words in one envelope. While the students are constructing the sentence, the teacher added a card with a new word on it and asked the students to rephrase the sentence. The following quote from the lesson demonstrates how students negotiated the meanings of the terms while constructing the sentence.

T: Teacher
Tb: Tobias
S: Sheldon

T: Let's take another envelope.
Tb: Losing an embryo or calf, what is meant by that?
T: That it is thrown away?
Tb: A miscarriage?
T: Indeed a miscarriage.
Tb: The cow is in heat and because there are not enough hormones she loses the embryo.
T: Is the cow in heat?
Tb: Yes, the cow is in heat and carries an embryo if she is fertilized. And if there is no contact through hormones the cow loses the embryo. Something like that. I heard that in biology lessons.
T: What do you think Sheldon?
S: I don't know.
T: I think that she becomes in heat..[interrupted]
S: That she comes into heat again?
T: Yes, tell me more.
S: If the cow loses the embryo she will come into heat again.
T: Exactly.

The result of the first learning and teaching activities is that students were not inclined to connect school biology terms and workplace terms. More often they seemed to express what they knew about the biology of the cow without incorporating terms of the workplace. In the next quote, we see how Kirk made a connection first, and then how Sheldon provided a strictly biological answer.

T: Teacher
K: Kirk
S: Sheldon

T: [explains that the words were taken from their own schedules] A word you used a lot was egg-cell. But what does an egg-cell have to do with a cattle farm?
K: If cows do not produce an egg-cell, they will not become gestated and they will not produce milk.
[…]
T: I also came across the word womb a lot. Sheldon, what does this have to do with the cattle farm?
S: The calf grows in there.

Sheldon's answer was correct. However, he could also combine womb with feeling the womb to monitor gestation, scanning, inseminating, etcetera. In this case, the workplace knowledge remained implicit.

A similar phenomenon was observed when students were constructing sentences. Only the results of this learning and teaching activity shows that terms and meaning were not only discussed, but they were mostly also connected. Analysis of the lesson reveals moments in which students make use of terms related to monitoring and intervening actions and terms of school biology when constructing a sentence (see first fragment below). It also reveals moments in which students do not make use of terms of the workplace. In the latter constructions the cow functions as an example of a biological object (see second fragment below).

T: teacher
Tb: Tobias
S: Sheldon

S: *What is meant by 'cotyledon' (Dutch: rozetten)?*
Tb: *Yes, I also wondered.*
T: *These are thickenings in the placenta in which the blood of the calf and the mother come together.*
S: *Feeling should be the final word ?*
Tb: *I am not sure yet. I am still looking.*
S: *If the cow is not in gestation, this will not be developed?*
T: *No.*
S: *Then, this one goes here, I think.*
T: *Shall I help?*
Tb: *Yes.*
T: *I think this word goes there.*
Tb: *Do we get another word?*
T: *No, not this time.*
T: *When a cow is in gestation, you can...*
Tb: *…determine this by feeling the membranes or the placenta and the cotyledons.*

T: Teacher
Tb: Tobias
S: Sheldon

T: *Please, take the next envelope. What's in it?*
Tb: *Heat, egg-cell, fertilization, sperm-cell, ovulation.*
T: *What are you doing?*
Tb: *I am putting them in order [student moves cards in a different order].*
Tb: *When in heat, an egg-cell is released and a sperm-cell joins and then fertilization occurs.*
T: *Do not write the sentence down yet, I have got another one.*
S: *This needs to come first, no.*
Tb: *Let's see, yes it does.*
T: *The cow comes into heat because of the hormones?*
Tb: *Yes, because of the hormones the cow comes into heat and has an ovulation.*
T: *Very good. Yes.*

S: *So, how can I write that down?*
Tb: *In a sentence that begins with hormones and ends with fertilization.*

The last quote lacks a focus on acting in the cattle farm. Tobias and Sheldon also constructed a sentence that began with cows having problems with getting in heat.

Improving farm profits

At school

The video-recordings of the final lesson show that the teacher introduced the assignment on embryo transplantation. The student materials also reveal that all students elaborated the assignment.

From the completed assignments and the final interview in which the students were also assessed on their conceptual understanding of embryo transplantation it is clear that the students used terms of school biology to describe embryo transplantation. The terms they used are presented in Table 6.7.

Table 6.7. The use of school biology terms by students when describing embryo transplantation. The SOLO taxonomy is used to indicate the extent of coherency (see Methods for clarification). 1,3 means that a student provided answers that were categorized as SOLO 1 and SOLO 3. The SOLO level that occurred most frequently is underlined.

Student	Terms of school biology used	Coherency (SOLO)
Kirk	Hormone, egg-cell, fertilization, embryo	4
Tobias	Embryo, endometrium	3, 4
Jack	Egg-cell	1, 2
Sheldon	Hormone, egg-cell, fertilization	2, 3

Concerning the functionality of biological knowledge in cattle farms experienced by students, the final interviews with students show that, with the exception of Jack, all students recognized that a cattle farmer should have biological knowledge of animal reproduction to function properly. According to these students, the biological knowledge of reproduction can be used by a cattle farmer when a veterinarian needs to be consulted. Sheldon and Tobias added that the knowledge is also functional for a cattle farmer if he wants to optimize cattle or milk production or if he wants to apply embryo transplantation. These students also said that the assignment was sometimes very comprehensive. They said that so much knowledge is not relevant to them at this stage of their education. Tobias and Kirk, for instance, mentioned that they probably will also be confronted with this knowledge when they are in senior secondary vocational education.

6.6. Conclusions

This study field tested the adjusted and completed learning, supervising and teaching strategy. This section reports the practicability and effectiveness of the strategy and compares the results with those of the previous study.

Practicability

As the teacher was well prepared and performed as expected, this section will mainly focus on the practicability of the strategy within the cattle farms and the potential of the lessons to address the observed flaws in the work placement strategy reported in chapter 5.

The results of the study show that under the given circumstances it is feasible for students and supervisors to collaborate in work actions. Besides this, it seems practicable to discuss this first participation, as the component is generally performed as intended.

The adjustment made in the component 'The farm' appears to have worked out. Pairs of experienced students and supervisors prefer the alternative including that reproduction is brought up during work. Based on the results of both field tests, pairs of less experienced students and supervisors prefer a guided tour.

Assisting or observing monitoring and intervening work actions during the component 'Monitoring actions' appear to be equally practicable in both field tests. The results again show that not all actions can be performed. This study indicates that the discussion of these actions is sometimes postponed for practical reasons. On the other hand, the lessons at school have shown to succeed in initiating the expected discussions between students.

The component 'Cow calendar' was mainly, but not entirely, performed as intended. Familiarity with the instrument seems to play an important role. For supervisors, being unable to instrumentally use, the calendar may result in a loss of perceived functionality in the workplace. For students and supervisors, their perception of the instrument as being out-of-date had the same effect.

Similarly to the previous study, the results regarding the component 'What and why' show that it is well practicable to supervise the students as intended. Again, giving multiple justifications for work actions seems to be an obstacle for both students and supervisors. The learning and teaching actions at school appear to address this problem.

The components 'Terms and meanings' and 'Improving farm profits' were performed as planned in the lessons at school.

Students' development of conceptual understanding

The strategy component 'First participation' generally seems to stimulate the need of students to enhance their competence in the workplace. This need can be conceived as a motive to start with the assignments.

The exploration of the main outcomes of the farm and the accompanying assignment of the component ‘The farm’ stimulates students to recognize that animal reproduction is essential to cattle farming. Besides this, it also appears to encourage them to bring up related work actions. The description of these relationships by the students shows sufficient coherence for this explorative stage of the strategy (SOLO 2 or 3).

After the strategy component ‘Monitoring actions’, students are able to mention the most important workplace-bound and school biology-bound terms when describing monitoring and intervening work actions. However, they do not yet describe the relationships between these terms (SOLO 2 and 3).

The component ‘Cow calendar’ has a positive effect on students’ conceptual understanding of both the outcomes of the workplace and the relationship between outcomes and work actions. Compared to their description after the component ‘The farm’, the coherence in their answers increased to SOLO 3 and 4. Besides this, the component appears to enable students to explicate comprehensive relationships between milk production and animal reproduction (SOLO 2, 3 and 4), as well as to correctly use the terms calving interval and lactation period.

Regarding the understanding of work actions, the student descriptions of these actions after the component ‘What and why’ show an increase in the use of biological terms compared to the component ‘Monitoring actions’. The use of these terms also increased compared to the component ‘What and why’ in the previous study, which indicates improvement of the component. Especially in describing insemination and scanning, students use terms of school biology. Justifying insemination also seems to stimulate the use of these terms. Besides this, questions about explanations for the changes in cow behaviour or internal changes (e.g. loosening of the ligaments before calving) again stimulate the students to use the term hormone.

Concurrently with the increase in the use of biological terms, the coherency of the descriptions and justifications also increased compared to the results after ‘Monitoring actions’. The learning and teaching actions seem to have a positive effect on the connection of biological and workplace-related terms. More terms of school biology were used and the answers are coherent.

The results of the component ‘Terms and meanings’ show that the effect of challenging students to explain how terms of school biology relate to the cattle farm differs from the effect of constructing sentences of school biology and workplace terms. Challenging students to explain the relationship may result in taking the perspective of school biology while losing sight of the workplace. In these cases, cows can be conceived as a biological object instead of a workplace object.

Challenging students to actively construct sentences with terms from both contexts seems more successful. This part of the component initiated discussions between students in which terms and meanings were negotiated. However, in some cases, this may also result in conceiving the cow as a solely biological object.

After completing the strategy component 'Improving farm profits', the students are capable of using biological terms coherently when describing embryo transplantation.

Although students in current VMBO indicate that the knowledge they acquired could also be taught in their continuing education in senior secondary vocational education, it can be concluded that the strategy contributes to the experience of students that biological knowledge is relevant in cattle farms.

6.7. Discussion

In this section, the results and conclusions will be discussed in light of integrating school and workplace learning. First, it will focus on the questions that arise from the study reported here. After that, it discusses the implications of the results in terms of further improvement of the strategy.

Reflections on combinations of school and workplace learning

In the course of this study, features of a boundary object (Akkerman and Bakker, 2011; Kent, Noss, Guile, Hoyles & Bakker, 2007) emerged. Recent studies in vocational training (Akkerman & Bakker, 2011; Schaap, De Bruijn & Baartman, 2012; Tanggaard, 2007; Wegener, 2013) and professional training (Kokola et al., 2007; Tynjälä & Hakkinen, 2005; Zitter, De Bruijn, Simons & Ten Cate, 2012) recognize that such objects may potentially facilitate the connection of learning in the workplace and in school. In general, the boundary object can be conceived as an artefact that should function in two different contexts and help the student, teacher and supervisor to make connections between these contexts (Akkerman & Bakker, 2011). In the case of integrating workplace and school learning, this includes that the boundary object should help the learner to coherently associate knowledge from both contexts. Specific features of the object should initiate recognition of similarities and differences between these contexts. Next to this, when focused on the object, collaboration and communication about the object should initiate discussions about it in both school and the workplace. These discussions can, for example, be about the purpose of the object or the outcomes of its use, but also about how students, teachers and supervisors deal with it. Such discussions may result in the use of terms from both contexts.

So, the collaborative use of the boundary object in both school and the workplace, and the discussions about the object in these contexts may result in a discourse in which terms from both school and the workplace are *coherently* embedded. Coherently is emphasized because the purpose is not only that students recognize similarities and differences between the two contexts but also that they associate the knowledge from these.

The literature on boundary objects mentioned above identifies several features of them that may serve these purposes. The most indicated features are as follows. The object should be functional in both contexts. In the case of integrating school and workplace learning, this means that the object contributes to both work action and learning action. The

object should be flexible in the sense that it should allow the participants of both contexts to work with it in their own preferred manner. Because of this, it also should allow multiple perspectives from each of student, teacher and supervisor. The object should facilitate the discussion about their views. Finally, it should be a tool for collaboration and communication. For instance, assignments that ask for collaborative use of the object or that ask for discussions about the object can be accompanied by the object itself.

The cow calendar (Figure 6.3) and its accompanying assignments may display these features. It can be used by both supervisors and students to perform actions in the workplace, and it can be used to learn about the workplace, its actions and cow reproduction. Regarding facilitating recognition of the relationships between vocational and disciplinary knowledge, the cow calendar may carry some other crucial additional features:

- portraying the monitoring and intervening work actions that require disciplinary knowledge (e.g. monitoring heat, scanning);
- visualising the relationship between the main outcome and the related work actions (calving and producing milk) by showing the calving interval and lactation period;
- displaying the reproductive cycle of cows in coherence with the work actions and the outcome of calving and producing milk.

So, the calendar can function in both school and the workplace, and it embodies relationships between outcome (production of milk), work actions (e.g. monitoring gestation) and embedded (biological) knowledge (e.g. reproductive cycle of cows). Such an instrument may facilitate the integration of school and workplace learning by enabling a discourse of its own.

Learning processes that accompany the development of such a discourse may be described by what Van Oers (1998; 2001) calls contextualization and recontextualization. As mentioned in section 2.3, contextualization can, in this case, be described as the process in which a student tries to build a coherent and detailed mental construction of the workplace. Recontextualization can be described as the process in which a relationship between two contexts (e.g. school and the workplace) becomes the focus of attention. In this case, the focus of attention can turn to an object like the cow calendar in which the relationships are embedded. Because of the recognition of the relationships (e.g. reproductive cycle and the work actions), the student may need to rethink how the object, and with it the reproductive cycle of cows, is coherently connected to the workplace. Recontextualization is the process in which the student contextualizes the object in a new way (Van Oers, 1998, p. 483). Collaborative use of the object and the discussions between students and supervisors about the object may result in the use of terms from both contexts. As mentioned above, this may result in a discourse in which terms from both school and workplace are *coherently* embedded.

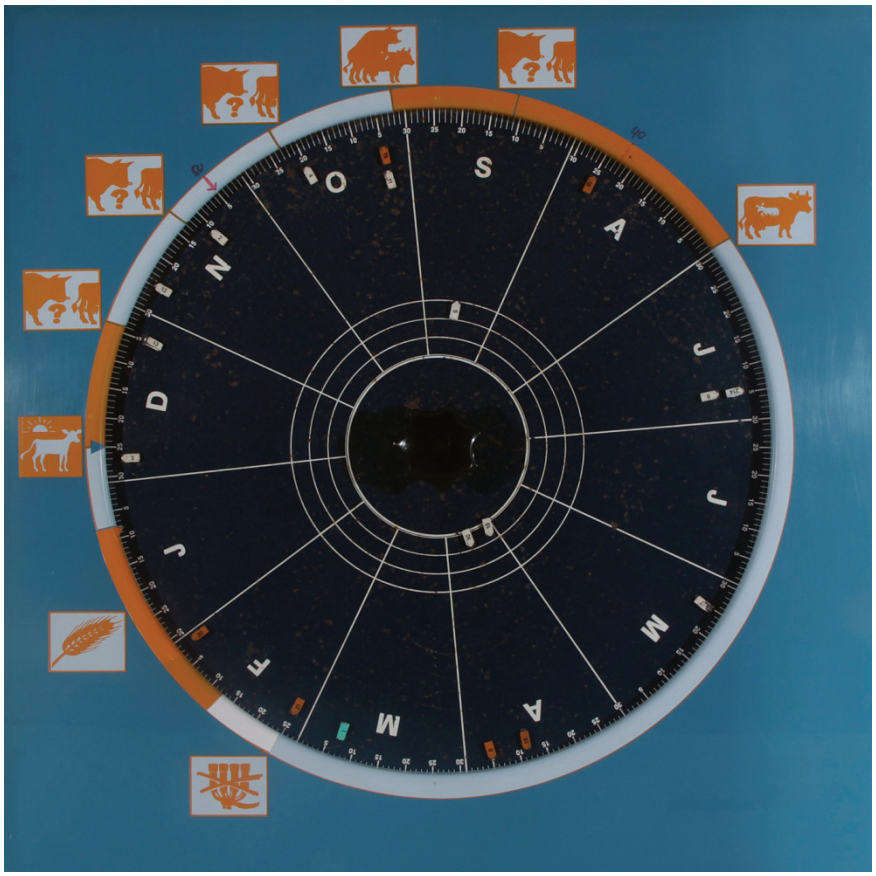

Figure 6.3. The cow calendar. The pictograms on the calendar *represent* work actions that need to be performed by the cattle farmer on specific moments. The pictograms with the question mark, for instance, represents monitoring heat, and the pictogram with the calf within the cow represents monitoring gestation. The letters in the black circle represent the months of the year (e.g. J: January; F: February). Note that these are counter clockwise. The white, red and blue magnets that stick to the black circle represent the cows. Each day, a cattle farmer turns the black circle one day forward. If a magnet reaches a pictogram the related work action needs to be performed. The cattle farmer that owned this calendar drew two red marks on the circle himself to remind him of certain work actions. Because of the pictograms, the reproductive cycle of cows is also represented. Note for example that heat should be monitored each three weeks and that the entire gestation is represented by the period from coverage (the pictogram on top) until birth (the pictogram of the calf in the sun), and lasts nine months. The calving interval is portrayed as one whole circle (from calf to calf) and the milk production of one cow starts at birth and ends with isolating the cow from milking (pictogram of a milking machine that is crossed out).

By combining the insights from literature that contextualization and recontextualization should be facilitated, it can be seen that the boundary object – and the cow calendar

specifically – may provide the means to do this. The cow calendar can facilitate contextualization because it initiates discussions about workplace actions. It also initiates discussions about the relationships between workplace outcomes, work actions and the knowledge embedded. It may therefore facilitate recontextualization as it can initiate discussions about relationships between workplace outcomes and work actions on the one hand and work actions and disciplinary knowledge on the other. Both relationships are probably associated with terms of the workplace. The second may also be associated with terms of disciplinary courses in school.

The results of this study show that the assignments of the component 'Cow calendar' resulted in students having an overview of the main work actions and their relationships with milk production and the reproductive cycle of cows. Such an overview can contribute to the students' further conceptual understanding as it helps to arrange and elaborate comprehensive relationships between outcomes, work actions and embedded knowledge.

Nevertheless, the interactions between school and workplace is also not optimal in the cases presented in this study. It seems as if the perceived functionality of the instrument also influences the learning outcomes. The instruments used in the strategy of the first field test (e.g. cow management software) are completely functional in the workplace but they seemed too comprehensive for students because using these instruments requires an overview. The cow calendar, on the other hand, provides such an overview but loses functionality because cattle farmers experience difficulties in using the instrument and because it is perceived as being out-of-date.

A second strategy component in which the problems and prospects of combinations of school learning and workplace learning are expressed is the component 'What and why'. In both field tests the results show that supervisors and students are unfamiliar or uncomfortable with providing multiple justifications for work actions. Choices made by the cattle farmer in the past (e.g. choosing for artificial insemination or using a bull) is not reconsidered when discussing work actions with students. As a consequence the embedded knowledge and/or its function is not fully verbalized.

The parts of the component 'What and why' at school appear to compensate for this. But then, the discussion of dilemmas deviates from what was expected. Especially the more experienced students tend to choose methods they know and they tend to voice the arguments which are used in their familiar environment, instead of thinking for themselves.

The results of the component 'Terms and meanings' made clear that the use of school biology terms in the school context can result in students giving school-like answers instead of answers in which school-bound and workplace-bound terms are integrated. Although not easy, it seems plausible that to maintain a perspective on work actions in school, simultaneously stimulating the use of terms of the workplace may help to overcome this problem.

As regards to students' appreciation of biological knowledge in the workplace, the results of this study show that the expectations of students before they engage in work placement

may strongly influence the perceived functionality of this knowledge. Students said that they recognize that biological knowledge is functional in the workplace but they also indicate that, to them, learning about these relationships is not relevant in this stage of their education. Maybe the role of work placement in the curriculum and the 'learning to work focus' mentioned in chapter 3 should be discussed and addressed in VMBO schools before introducing strategies like the one presented in this study. A workplace- and school-integrated strategy needs a curriculum in which work placement also focuses on learning.

Based on the outcomes of this study, the strategy appears to be practicable and effective. Nevertheless, there are some adjustments needed to further optimize the strategy.

First, it is recommended to put more emphasis on the functionality of the cow calendar in modern farms. This can be achieved by using other, more up-to-date, instruments next to the cow calendar and by showing what these instruments have in common.

Second, it is recommended to make the dilemmas of an imaginary cattle farmer more authentic for students. This may be attained by discussing dilemmas of real farmers and by relating these to their own experiences. Such dilemmas may also challenge more experienced students to compare and discuss rationales of their familiar working environments.

Finally, teachers are recommended to maintain a work action perspective when mentoring the component 'Terms and meanings'. The perspective should stimulate the use of workplace-bound terms in school by both teacher and students.

Recapitulating, the study reported on in this chapter demonstrated the practicability and effectiveness of an educational strategy in which workplace and school learning are integrated.

Chapter 7

Conclusions and discussion

7.1. Introduction

This research project searched to provide theoretically and empirically grounded design characteristics for a workplace- and school-related educational strategy. The purpose of the strategy was to enable students to recognize the functionality of disciplinary knowledge in the workplace. It searched for these characteristics in the context of agricultural VMBO and school biology. To answer the main question, this chapter will discuss the theory-based design characteristics in light of the outcomes of the five studies which were presented in chapters 2 to 6. The outcomes supplement and articulate the theory-based design characteristics in such a way that they show how the characteristics can be operationalized and how learning, teaching and supervising may occur. Besides the answer to the main research question, the wider applicability of the strategy is discussed by reflecting on the whole strategy and its components. Finally, the role of work placement in the VMBO-curriculum will be discussed in terms of its relationships with vocational and disciplinary courses.

7.2. Design characteristics for integrating school and workplace learning about reproduction

The main question of this design research project was articulated as follows.

What are the design characteristics for a practicable and effective learning, supervising and teaching strategy that enables VMBO students to recognize the functionality of biological knowledge of reproduction in work placement sites?

To answer this research question, the outcomes of the studies that were reported on in chapters 2 to 6 will be summarized, interrelated and discussed.

The literature study presented in chapter 2 gave insight into what the literature with a CHAT-perspective says about workplace-related learning in terms of how disciplinary and vocational knowledge are articulated and related. It provided the following characteristics.

1. it seems advisable to start work placements with an exploration of the main outcomes of the workplace and to link these to different work actions.

2. If it is important to challenge students to acquire an in-depth and coherent understanding of the workplace, engagement in different and related work actions is recommended. If supervision is directed towards reflection on the rationale of actions this may make relationships between work actions explicit which can help students to understand the complexity of the workplace.
3. Engagement in actions that require specific knowledge may promote students to understand that knowledge is used in action. If supervision sequences these actions it may scaffold the students' learning processes. Supervision directed towards reflection on the actions and students' conceptual understanding of the workplace may support these learning processes.
4. If we want students to recognize a relationship between vocational and disciplinary knowledge, it seems advisable to use terms and meanings from both discourses while describing and justifying actions. In addition, reflection on these terms and meanings by the students and the supervisors may also promote such a recognition.

The exploration of current agricultural VMBO practice on the basis of these characteristics in chapter 3 showed that there is a strong work focus in both students and supervisors. Students are not automatically inclined to explore the whole workplace. Participation in work action may not be informed by learning objectives nor is this participation often discussed. Instead, students and the supervisors mainly focus on performing work-a-day actions. This study concludes that the theory-based design characteristics can best be operationalized by aligning to this routine of working, and by stimulating student engagement in coherent work actions. Coherent means that, if possible, these work actions should contribute to one workplace outcome and they should relate to the same disciplinary topic: for instance, work actions aimed at optimizing calving interval, for which knowledge of animal reproduction is needed.

In chapter 4 it was explored how biological knowledge of reproduction is being verbalized in relation to vocational knowledge. It turned out that, engagement in monitoring and intervening actions may help students to conceptually understand the relationships between biological knowledge of reproduction and farm profits. Compared to many other work actions, these work actions seem central in the students' development of conceptual understanding of the workplace because they can be related to farm profits relatively easy. Besides this, describing and justifying these monitoring or intervening actions can help students with verbalizing relationships between biological and vocational knowledge. It was concluded that the characteristics can best be operationalized by encouraging engagement in monitoring and intervening work actions.

In chapter 5, a field test of a workplace-related strategy based on the insights from the previous three studies proved to be practicable and effective for a large part. The results of the study show that:

· the exploration of outcomes and related work actions seemed to function as planned;

- participation in different but related work actions that require knowledge of reproduction helped students to realize that reproduction contributes to farm profits and that the knowledge is used in action;
- the sequence of strategy components seem to scaffold the students learning processes both in evoking a learning motive and in supporting conceptual understanding;
- reflection on the rationale of monitoring and intervening actions stimulated the verbalization of relationships between biological and vocational knowledge;
- the reflection on terms and meanings from biology courses, vocational courses and the workplace could not be assessed on its effects.

Two insights regarding the practicability from this study stand out. It seemed impracticable to use monitoring instruments that require extensive overview of the workplace and also impracticable to rely on the pedagogical skills and disciplinary knowledge of the workplace supervisors. This field test adds that providing an overview of the main work actions may be central to the development of students' conceptual understanding of the workplace and its embedded biological and vocational knowledge.

The field test of an adjusted workplace- and school-related strategy was discussed in chapter 6 and provided insights into the integration of school and workplace learning in VMBO. The additional learning and teaching actions in school seemed to reinforce the desired effects. In the end, the insightful use of school biology terms when describing or justifying work actions increased. Besides this, students recognized the functionality of knowledge of reproduction in cattle farms.

The learning, teaching and supervising actions presented in Table 6.1, although in need of fine-tuning, were generally practicable and effective in the cases studied. This implies that the use of terms of the workplace and school biology while describing and justifying work actions and reflecting on the meanings of these terms may result in the intended learning outcomes.

The field test also showed that the learning, supervising and teaching actions of the component 'Cow calendar' may have provided students with a crucial overview of the workplace and related work actions that require knowledge of animal reproduction. Because of this, the instrument and the accompanying assignments can be conceived as a potential boundary object (see chapter 6). Features mentioned in literature are also present in this strategy component. What is more, the cow calendar may have additional features that facilitate boundary crossing. One of the features is that monitoring and intervening work actions are portrayed on the calendar (e.g. monitoring heat, scanning). Another feature is that the calendar visualizes the relationship between the main outcome and these related work actions (calving and producing milk). The outcome is visualized by showing the calving interval and lactation period. Finally, the calendar displays the reproductive cycle of cows in coherence with the work actions and the outcome of calving and producing milk (see section 6.6 for more details).

Hence, this field test resulted in the recommendation to search for an instrument in which the relationships between outcomes, work actions and specific knowledge are expressed. Besides this, for proper use, the instrument should require conceptual understanding of these relationships. However, the study also shows that the intended dual use and purpose for both education and work is fragile. The calendar and the related assignments were less functional than expected due to contextual factors (e.g. appreciation by the cattle farmer).

Finally, the field test indicates that the experience of the functionality of biological knowledge can be established in two ways. First, from a student point of view, biological knowledge can be experienced as functional when it is used in action (e.g. helping to scan when monitoring gestation; discussing problems with veterinarians). Second, it can be experienced as functional when it helps to conceptually understand developments or innovations of the workplace (e.g. grasping embryo transplantation). Therefore, it is recommended to stimulate students to orient themselves on innovations in the workplace that require knowledge of the disciplinary domain.

To sum up, if the aim is to design a practicable and effective learning, supervising and teaching strategy that enables VMBO students to recognize the functionality of biological knowledge of reproduction in animal husbandry work placement sites it is recommended to:

1. start work placements with an exploration of the main outcomes of the workplace and link these to different work actions;
2. stimulate student engagement in a sequence of monitoring and intervening work actions that require the same disciplinary knowledge and that contribute to the same outcome;
3. stimulate student engagement in work actions that require overview and encourage the use of workplace instruments in which the relationships between outcomes, work actions and specific knowledge is expressed, and in which the conceptual understanding of these relationships is required when it is used;
4. direct supervision towards reflection on the rationale of these actions and to students' conceptual understanding of the workplace;
5. stimulate the use of terms and meanings from both discourses while describing and justifying actions;
6. stimulate reflection on these terms and meanings by the students and the supervisors;
7. stimulate orientation on innovations in the workplace that require knowledge of the domain.

7.3. Towards a didactical structure

Generalizations and this design research

The characteristics above originated from design research in a specific context and concerning a specific disciplinary domain. The question therefore arises if these design characteristics can also be applicable to other contexts and domains. To explore the wider applicability, this type of educational design research can rely on so-called analogical generalization (Smaling, 2003; 2009). Instead of aiming at statistical representative sampling or covering all variation beforehand, this type of generalization implies case-to-case or context-to-context generalizations. Analogies between research outcomes in different complex contexts are examined to generate theory step-by-step, thus avoiding over-generalizations.

This section describes how, in this design research, measures have been taken to enable analogical generalization. What is more, it describes a so-called didactical structure that can function as a mean to communicate about expected generalizations.

In this design research, three distinct measures were taken to enable analogical generalization. First, the research builds on theory which allows other researchers within the domain to search for analogies with research that uses a similar theoretical framework (Smaling, 2003; Yin, 2009).

Second, the results are presented through thick description (Geertz, 1994). For this, important results are presented together with relevant contextual information. This enables other researchers to search for analogies in the results while taking the contextual factors in account. This so-called communicative generalization is usually conducted through in-depth examination of the results of relatively similar contexts in which the research was conducted (Maso & Smaling, 2003; Smaling, 2009).

Third, the generalizability of the outcomes of the entire research project (e.g. the design characteristics stated above) are reflected on by the researcher who conducted the research. The researcher has in-depth information of the context in which the research was done. Based on this information, he can underpin expected generalizations.

The didactical structure

The final reflections on the outcomes of this project and the obtained characteristics of the *strategy* should eventually result in formulating general features. These more general features will here be portrayed in a so called *didactical structure* (Boersma & Waarlo, 2009; Lijnse & Klaassen, 2004). In this case, the didactical structure can be conceived as an abstracted sequence of learning, teaching and supervising actions in which school and workplace learning are integrated, so as to enable students to recognize the functionality of disciplinary knowledge in work placement sites. The didactical structure should facilitate

communication between researchers and enable a modest and careful step towards generalization of the design characteristics.

To arrive at the didactical structure, the potential applicability of the design characteristics to two examples of combinations of a work placement site and a science topic will be explored upon. This finger exercise may reveal contextual factors that influence the generalizability of the characteristics.

Nearby examples were selected from those sectors of VMBO that include science topics. Next, typical vocations of each sector were determined together with the domain specific topic that can be related to an outcome. This resulted in selecting the example of the workplace of an electrical technician in which students learn about the topic of electricity and the example of the workplace of a geriatric caretaker in which students learn about the topic of micro-organisms. Next, the applicability of the design characteristics in these examples will be indicated.

Electrical technician

For an electrical technician, one of the main outcomes is that the electricity in, for example, newly built houses functions properly. Several intervening (e.g. installing new equipment) and monitoring actions (e.g. checking if the wiring functions properly) are undertaken to arrive at that. So, it could be possible for a student to recognize this outcome and the related work actions (characteristic 1). Besides this, it may also be possible to engage in intervening and monitoring actions (checking if the wiring functions properly) (characteristic 2).

Before the wiring can be placed, the electrical technician needs to read, interpret and check the blueprint of the house in which the wiring is drawn. After that, the work schedule needs to be discussed and assigned. Engagement in this action may ask for overview of the electrical parts, the work actions and the expected outcome (characteristic 3). Besides this, the supervisor can discuss this action and its rationale with the student (characteristic 4).

The work actions that underlie the blueprint and that are mentioned on the work schedule can be described and justified by a student and his or her supervisor (characteristic 5). However, the terms that are used to describe and justify may well be (quite) similar to the words used in school physics. Discussing these terms will probably be limited to discussing its meaning. Combinations of school-bound and work-bound terms may not have to be discussed (characteristic 6).

Finally, several innovations in the workplaces of electrical technicians can probably be found (e.g. solar panels). However, for now, it is not clear what work actions are related and which knowledge is required to understand such innovations and to perform the related actions (characteristic 7).

Geriatric caretaker (caregiver)

For a geriatric caretaker, one of the main outcomes is to safeguard the hygiene of the care-receivers. Several (intervening) work actions contribute to that outcome (e.g. cleaning the kitchen, washing the care-receiver). Besides this, the caretaker monitors the personal hygiene of the elderly. So, it should be able for students to explore this outcome and its related work actions (characteristic 1). Besides this, the student should also be able to engage in monitoring and intervening actions (characteristic 2).

To prevent hygiene problems, a caretaker should use hygiene instructions or guidelines which are provided by the occupational group of caretakers. These instructions can describe the actions that need to be undertaken to prevent hygiene problems, to identify problems and to solve problems. Such instructions can be used to provide students with an overview of the work actions related to hygiene.

Knowledge of micro-organisms is often required to understand the relationship between the averting and solving actions (characteristic 3). However, it is not clear if using the instructions calls upon knowledge of micro-organisms. On the other hand, having the knowledge should help students and caretakers to improve their competence. A discussion about the rationale of these actions and about the conceptual understanding of the student may stimulate the verbalization of this knowledge (characteristic 4).

The terms used to describe work actions and their rationale may include both terms of the workplace (Rashes; medical: intertrigo; in Dutch: smetplekken) and of school biology (microbial growth) (characteristic 5). In the case of a rash, a discussion on the meaning of these terms may result in the recognition that microbial growth can cause complications that can become severe and that personal hygiene may decrease microbial growth (characteristic 6).

Finally, innovations in these workplaces may occur. For instance, the hygiene instructions for the occupational group may change or bathing and showering techniques may alter. However, again it is unclear if trying to conceptually understand these innovations calls upon knowledge of microbial growth. Maybe searching for appropriate innovations that requires disciplinary knowledge is quite an endeavour (characteristic 7).

The descriptions show that most characteristics may apply to the contexts of the electrical technician and the geriatric caretaker. However, it also suggests that there are some reservations about the applicability of the characteristics. These reservations will now be discussed.

First, the attention is drawn to the stimulation of engagement in work actions that require an overview (characteristic 3). Instruments that are similar to the cow calendar may not meet critical features of such an instrument. The following features can be extracted from the cow calendar.

The (use of the) instrument should:

- express relationships between outcome and work action (the calendar expresses lactation period, calving interval and related work actions);
- provide an overview of related work actions (on the calendar most work actions are portrayed or they can be indicated);
- relate these work actions to the domain specific topic (the calendar also portrays the reproductive cycle of a cow by indicating a heat cycle of three weeks and gestation for nine months).

It is obvious that it may be quite a challenge to find an instrument with similar combined features as the cow calendar. To explore this, the example of the electrical technician using a blueprint and the geriatric caretaker using a hygiene instruction will be discussed.

In the example of the electrical technician the blueprint does not illustrate the relationship between the outcomes and the work actions. These work actions are summed up in the work schedule, which may provide the required overview. However, the relationships between these actions and the outcome are missing and need to be made explicit. The use of the blueprint itself requires much domain specific knowledge. However, because the work actions are not explicitly related to this knowledge, it does not relate work actions and outcome.

The hygiene manual of the caretaker both sums up the main work actions and it illustrates the relationship between these work actions and the outcome. In this example not the work actions but the use of knowledge remains implicit in the hygiene instructions. Often instructions say what has to be done but they do not make explicit why this has to be done and what the consequences may be if it is not done. So the work actions described on the hygiene instructions lack relationships with the knowledge that is required to act insightfully (knowledge of micro-organisms). In this case, reflection on precautionary measures may ask for the required rationale.

To sum up, the examples make clear that the relationships between outcome, work actions and embedded knowledge cannot always be made explicit. Assignments that accompany such an instrument could facilitate that through reflections on the rationale of actions and on students' conceptual understanding.

A minor reserve to the applicability of the design characteristics concerns the reflection on terms and meanings. The example of the electrical technician suggests that reflections on terms from school physics and the workplace may be unnecessary because the terms used are almost the same. Nevertheless, reflections on the meaning of these terms may still be necessary because these terms may have different meanings.

Finally, the orientation on innovations that require disciplinary knowledge may be applicable to other contexts. However, the relationship between an innovation and the knowledge embedded can be quite intricate. The examples above suggest that searching for such relationships may call for in-depth information of the workplace and the innovation. Maybe the search for such innovations or developments needs cooperation between teachers and supervisors.

Based on the findings of the study and the expected applicability of the design characteristics, a *didactical structure* as a means to communicate the applicability of the characteristics was outlined. This didactical structure is presented in Table 7.1.

Table 7.1. The didactical structure for recognizing the functionality of disciplinary knowledge in work placement sites. Actions in the workplace and actions at school alternate to attain the expected outcomes.

Workplace actions	**School actions**	**Expected outcome**
Participation in workplace with supervisor.	Exploration of the main outcomes of the workplace.	Students experience a need to enhance their competence.
Participation in and reflection on work actions that require specific disciplinary knowledge and that contribute to the same outcome.	Reflection on participation and on the relationships between work actions and outcome	Students recognize that the disciplinary topic is relevant in the workplace.
Participation in a work action in which an instrument is used that requires an overview of the workplace.	Reflection on the use and the functionality of the instrument in the workplace Reflection on relationships between outcome, work actions and disciplinary knowledge.	Students conceptually understand the relationships between outcome, work actions and the embedded knowledge.
Describing and justifying work actions related to the instrument. Stimulation of the use of workplace-bound terms.	Describing and justifying work actions related to the instrument. Stimulation of the use of terms of the disciplinary course.	Students use disciplinary and vocational terms to describe and justify work actions.
	Reflection on and negotiation of the meanings of these terms and the workplace-bound terms.	Students connect disciplinary and vocational terms.
Participation in innovative work actions that require combinations of disciplinary and vocational knowledge.	Reflection on participation in these work actions. Reflection on innovations in the workplace.	Students experience that combinations of disciplinary and vocational knowledge are functional in workplaces.

7.4. Limitations to this design research

Each study has its limitations. In this section, the limitations of this design research as a whole will be discussed against the background of its purpose. The aim of this research was to provide theoretically and empirically grounded design characteristics for a workplace- and school-related educational strategy to enable students to recognize the functionality of disciplinary knowledge in the workplace. The practicability and effectiveness of these design characteristics should be further tested within the same theoretical framework but in various contexts. However, this may not be easily done because of the complexity of the present educational problem addressed. The complexity of the problem addressed in this study involves how different contexts (school and workplace), different courses (vocational courses and disciplinary courses) and different types of knowledge are interrelated. Because of this interrelatedness and the need for in-depth research in specific contexts, the generalizability may be limited. Two limitations regarding the context particularity will be discussed next.

Design characteristics drawn from literature need to be translated to an educational strategy that can be applied in a specific context. These translations may be accompanied by a loss of what was originally intended. For instance, literature needs to be interpreted before it can be used to design a strategy, and limits of the context may also limit the possibilities of the researcher to carry out the strategy as planned. e.g. fixed lesson schedules in school limit the time that can be spent. Literature does usually not provide guidelines on how to address these local problems. Conducting a design research based on the characteristics of this study in another context will probably result in a confrontation with other local problems. So, in an attempt to find analogies further research should be well aware of the local problems in this study. To arrive at that, it is again recommended to search for contexts that are quite similar to the context of this study. Besides this, it is recommended to enter into dialogue with the researcher.

Communicative generalization implies that other researchers have to judge if the findings of the research apply to their own context. Such a researcher has to have in-depth understanding of the context in which the research was conducted. Thick description may help to reach this aim. In this project it became clear that understanding the complex relationships in the cases studied requires tremendous effort. It should be questioned if it is possible for novices in the agricultural domain to fully understand the results and implications. Again, dialogue between researchers may be necessary to allow sound analogical reasoning (Smaling, 2003).

7.5. Implications for pre-vocational secondary education

Strengthening the vocational training in VMBO will not be easy. The question is how the curriculum components of VMBO should develop, integrate or change to arrive at a vocationally-oriented curriculum. The three curriculum components can be viewed as three

overlapping circles. Each with its own distinct aims and characteristics but also with shared aims and characteristics. Disciplinary courses, vocational courses and work placement in VMBO should not be worlds of their own. In this research project, the overlap between work placement, vocational training and biology education was examined. Depending on the starting point, different questions can be asked. How can vocational courses prepare students for learning in work placement and in disciplinary courses? How can work placement prepare students for learning in vocational and disciplinary courses? How can disciplinary courses prepare students for learning vocational courses and work placement? These questions are directional. This discussion about the preferred interactions of curriculum components in VMBO uses work placement as a starting point. Based on the outcomes of this research, the view on the development of conceptual understanding in the curriculum components is as follows.

Work placement should make students sensitive to knowledge in the workplace by showing them that vocational and disciplinary knowledge is functional in these workplaces. This sensitivity to knowledge can subsequently be used in vocational and disciplinary courses by showing students how the knowledge to be acquired in these courses is also functional in other workplaces. For this, learning about different workplace contexts and learning about disciplinary topics should go hand in hand. This type of integrated learning may imply the processes of contextualization and recontextualization as described in chapters 2 and 6. These processes should be stimulated in each curriculum component. Work placement and vocational courses should focus on conceptual understanding of the workplace at hand (contextualization) or several similar workplaces.

However, work placement and vocational courses should also focus on the functionality of disciplinary knowledge in these workplaces. Verbalizing disciplinary knowledge in the vocational courses in ways similar to the didactical structure may result in the need to reconstruct students' understanding of the workplace (recontextualization). What is more, in vocational courses students can orient themselves on more than one workplace in which the same disciplinary topic is relevant. Students who verbalize knowledge of the same disciplinary topic from the perspective of different contexts may also experience a need to reconstruct their knowledge of both the workplaces and the disciplinary topic.

Where it concerns disciplinary courses such as biology, the primary purpose is to stimulate the conceptual development of biological topics. However, relating these topics to the vocational sector of the student may result in more meaningful learning. Biological knowledge is more relevant in certain sectors than in others. The topic of reproduction, for instance, is relevant to both agriculture and health care. Such concepts may well be relevant to many different workplaces of the sector. Besides husbandry, reproduction is also relevant to plant-breeders, horticulturists, etcetera. So to the agricultural sector, reproduction can be seen as a key concept. Another example of such a key concept in biology that may be relevant to health care and agriculture is heredity. Both heredity and reproduction may help students in learning about relevant workplaces as it also helps them to conceptually understand vocational knowledge that is used in these sectors.

Thus, besides the purpose of stimulating the conceptual understanding of disciplinary topics, disciplinary courses can also help students in relating disciplinary and vocational knowledge. Existing relationships between key concepts and vocational sectors may help teachers of disciplinary and vocational courses to take steps in this direction.

Next, other implications of this view on the VMBO-curriculum will be discussed briefly.

The purpose of work placement (cf. Guile & Griffiths, 2001) can be different in each VMBO-school. The study in chapter 3 shows that current work placement in VMBO is meant to 'launch' students into work. However, as seen above, integrations of school and workplace learning are usually also meant to acquire knowledge. Work placement that is oriented towards knowledge acquisition and not just work socialisation processes needs to be constructed differently.

Using the didactical structure as a means to elaborate such learning may imply a paradigm shift from work-focused placements to learning-focused placements with consequences for the workplace supervisors. Teachers and workplace supervisors from school tend to have a learning focus. Workplace supervisors, on the other hand, do not and may therefore be the most critical actor in the curriculum change. So, besides providing sufficient instructions, these supervisors can best be instructed face-to-face before the placement period.

The vocational courses may be a connecting pin in integrating school and workplace learning at VMBO. In a VMBO with learning-focused placements, the vocational courses can serve several functions. They also seem to be the obvious course in which students learn about certain workplaces, but also the appropriate learning environment for sharing their workplace experiences. Finally, vocational courses may provide the reflexive environment that is needed during work placement to step back from working life and to concentrate on gained experiences in the workplace.

The current situation in VMBO is that integration of disciplinary and vocational courses is mostly limited to projects in which topics of both are incorporated (Van der Sanden et al., 2003). Besides this, integration of workplace learning and learning in disciplinary courses is mostly absent, as workplace and school learning are separate units that only interact incidentally. A curriculum that includes relationships between key concepts and VMBO sectors has consequences for teachers in disciplinary courses. These teachers should be able to determine which relationships are central to the sector. This implies that they have a clear picture of the vocations and workplaces that represent the sector and of the disciplinary knowledge that is functionally used.

7.6. Suggestions for further research

Taking the above into account, this research project brings up new relevant research questions. Although the educational strategy presented in this thesis was optimized through

two successive field tests, it is still in need of further optimization. Two questions concerning the strategy stand out.

The first question is about motives for students to engage in the learning actions. For most strategy components, it seemed possible to ground and incorporate learning, teaching and supervising actions that could evoke a learning motive in students (cf. Klaassen, 1995). However, for the strategy components that were solely performed at school ('What and why' and 'Terms and meanings'), it seemed hard to design them in such a way that they evoke learning motives. It is for this reason that further research on the strategy itself should focus on learning motives in these strategy components.

The second question deals with the features of the cow calendar as a boundary object. How can this instrument and its related assignments be fine-tuned in such a way that the loss of functionality in either context (school and workplace) is diminished? Furthermore, it seems recommendable to search for instruments with similar features in order to test if these features contribute to the boundary crossing function of such an instrument.

The wider applicability of the strategy was tentatively explored which resulted in the abstracted didactical structure. However, empirical studies should provide more insight. It is recommended to start such research with contexts and topics that are quite similar to the ones presented in chapters 2 to 6. To be more precise, it is recommended to search for applicability of the didactical structure in a producing workplace and a topic of one of the natural sciences.

The discussion about relationships between the VMBO curriculum components raises questions that need to be addressed, so it is recommended to direct future research into all three curriculum components and their relationships. What is more, further study should also focus on students' workplace experiences as a start for integrating workplace and school learning.

Summary

This thesis reports on a design research project about a learning, supervising and teaching strategy to enable preparatory vocational secondary education (VMBO) students in agricultural education to recognize the functionality of biological knowledge of reproduction in work placement sites. The purpose of the project was to provide theoretically and empirically grounded design characteristics for a workplace- and school-related educational strategy. This strategy should serve as a starting point for further research on the role of work placement in VMBO curricula that aim to integrate school and workplace learning. Besides this, the strategy may inspire VMBO teachers and student and teachers in teacher trainer institutes who want to promote such integrations in VMBO.

Chapter 1 describes how the curriculum components in VMBO are merely incidentally aligned and how developments in VMBO and teacher trainer institutes raise questions on how vocational and disciplinary curriculum components in VMBO can be integrated. Vocationalism in VMBO is stimulated by policy makers and teacher trainer institutes are encouraged to incorporate a specialization, 'Vocational Education', in their curriculum. The consequence is that future teachers in disciplinary courses and teacher trainers are challenged to think about how topics of their discipline relate to the vocations relevant to their students. Besides this, they are challenged to think about how such relationships can be made by students. One way to make a connection is by introducing vocational contexts in disciplinary courses. Another is by introducing workplace simulations in which both are integrated. While research on vocational contexts within disciplinary courses and research on workplace simulations in VMBO is proceeding, research on optimizing the role of work placements seems to be underdeveloped. Nevertheless, the experiences of students in vocational practice may have a valuable contribution to the integration of knowledge of disciplinary and vocational courses. By means of an example, this research project seeks to fine-tune the disciplinary course of biology and work placements in animal husbandry. Although biological knowledge can be functionally used in many work placement sites, literature shows that it is not evident that students recognize that this is the case. Workplace characteristics, participation in work actions and workplace discourse strongly influence which knowledge is being verbalized and what can be learned in a workplace. The main question of this research project is therefore:

What are the design characteristics for a practicable and effective learning, supervising and teaching strategy that enables VMBO students to recognize the functionality of biological knowledge of reproduction in work placement sites?

The question for design characteristics of such a strategy is consistent with domain-specific design research which is common in the Freudenthal Institute for science and mathematics

education (FIsme). In this type of design research, a theory-based strategy is repeatedly tested on its practicability and effectiveness in practice. Such iterative testing should yield a solution for the problem in a specific context and it is meant to test the theory-based characteristics that were used to design the strategy. Interventions in this type of research are characterised by the quality criteria of relevance, consistency, practicability and effectiveness. These criteria guided the subquestions that are elaborated in the next chapters.

Chapter 2 describes the literature study for theory-based design characteristics of the strategy that establish the theoretical relevance. The study sought to answer the following research question:

What does educational literature say about the characteristics of workplace-related learning and supervising that is meant to enable students to articulate and relate disciplinary and vocational knowledge?

To select literature relevant terms and synonyms were entered into a search engine. After that, the abstracts of the retrieved documents were searched for specific criteria. The final selection of literature was used to develop a coherent theoretical framework from which design characteristics could be drawn. While reading the literature, it became clear that cultural-historical activity theory (CHAT) could provide a coherent framework. The literature shows that it is advisable to

- start work placements with an exploration of the main outcomes of the workplace and to link these to different work actions as a seed for understanding the whole workplace;
- stimulate engagement in different and related work actions and to stimulate reflection on the rationale of actions;
- stimulate engagement in actions that require specific knowledge and in which the sequence of actions increases in complexity as much as possible;
- use terms that are common in school courses and terms that are common in the workplace while describing and justifying actions, and to reflect on the meanings of these terms to establish relationships between school and vocational practice.

Chapter 3 describes how these theory-based design characteristics were used to analyze current work placements in agricultural VMBO. The purpose of the analysis was to identify the prospects and problems that need to be addressed in the design of the strategy. The subquestion of the study that is answered in this chapter is:

To what extent is current agricultural VMBO practice in accordance with these theory-based characteristics of workplace-related learning and supervising?

Nine case studies from the sector Agriculture were selected based on the relevance of biological knowledge in the placement site. A case study included interviews with students and supervisors of the workplace. Besides this, reports of students who did their work placement in similar workplaces in previous school years were analysed. The results show that In current work placements there seems to be a focus on acquiring work experience and that the learning potential of the relatively short work placements appear not to be fully used. Because of their focus on work experience many theory-based design characteristics did not apply. For example, students' focus on the workplace as a whole seemed to be underdeveloped and supervisors often chose to engage students in workaday actions. Such workaday actions seem to be more difficult to relate to the outcomes of the workplace. At the same time supervisors reported that it is possible for students to engage in work actions that are more obviously related to the outcome. The focus on acquiring work experience is also expressed in the supervision and ways in which work actions are being discussed. This study revealed that some placement sites are more suitable for selecting different and interrelated work actions in which students can participate and in which biological knowledge is functional. When selecting a placement site an important consideration seems to be what can be learned in that particular workplace.

Chapter 4 reports on a study in which the purpose was to gain insight into relationships between biological knowledge of reproduction and work actions in horse breeding farms and cattle farms. It concerns relationships that students can make when participating in these practices. These types of workplaces were indicated as suitable for students to learn about animal reproduction and to recognize the functionality of this knowledge. The study seeks to answer the following questions.

- *What relationships between biological and vocational knowledge of animal reproduction are being verbalized in horse-breeding farms, cattle farms and in agricultural VMBO-practice?*
- *How are biological and vocational knowledge related in agricultural VMBO-practice?*

To uncover these relationships and clarify their nature, interviews with workplace supervisors and biology teachers were conducted. Besides this, educational materials such as school books and practical instructions were analyzed. In the transcripts of the interviews and the documents, biological knowledge was distinguished from vocational knowledge. Subsequently, semantic units were selected in which both vocational and biological knowledge were manifest. Within these units, verbalized relationships between vocational and biological knowledge were inspected. The result is an overview of relationships between biological knowledge and work actions that can be verbalized in these specific placement sites. It seems that biological knowledge is especially verbalized in descriptions and justifications of intervening (e.g. inseminating, inducing heat through injections) and

monitoring work actions (scanning, calving). The chapter ends with a discussion on the functionality of biological knowledge in the latter types of work actions.

Chapter 5 reports the first field test of an educational strategy based on the studies reported in the previous chapters. This strategy describes and justifies interrelated student and supervisor actions as well as the expected learning outcomes. The research questions are:

- *How practicable and effective are the strategy components of the learning and supervising strategy?*
- *How do combinations of strategy components of the learning and supervising strategy associate with the learning outcomes?*

The strategy is tested by comparing the expected learning processes and learning outcomes with the observed processes and outcomes in six work placement case studies. Each case study consisted of a pair of student and supervisor. Data was collected at several moments during the placement period using a multi-method approach. Results were obtained by analysing completed student assignments, recorded supervision talks, and administered interviews with students and supervisors. The results show that the strategy seems to be effective: students describe and relate biological knowledge of reproduction and workplace actions in dairy farms. It appears that discussions of some work actions more frequently result in verbalizing biological knowledge than others. Students' conceptual understanding of the workplace, its work actions and coherent biological knowledge increase in the course of the placement period. However, the differences between students are also apparent. For instance, supervisors of the more experienced students and these students themselves handle the assignments differently compared to the inexperienced students. Two strategy components seem to be impracticable. Instruments from the workplace (e.g. cattle management programme or a note book of the cattle farmer) fail to provide an overview which is needed to use the instrument properly. Besides this, discussing the meanings of the used terms is problematic. Supervisors indicated that their pedagogical skills and knowledge may be insufficient to adequately mentor the students. The chapter ends with a reflection on the results of this study and on the theory-based design characteristics on which the strategy was based. Furthermore, it addresses the possible adjustments of the strategy, especially how lessons at school can optimize the strategy.

Chapter 6 describes an empirical research of the adjusted and completed strategy in which workplace and school learning are integrated. During the placement period students are also mentored at school while elaborating and discussing the assignments and discussing their experiences in the workplace. After describing the adjustments made in the strategy, the following research questions are presented:

- *How practicable is the learning, teaching and supervising strategy in which work placement and lessons at school are integrated?*
- *How does student conceptual understanding of the workplace, animal reproduction and their interrelatedness develop throughout the strategy?*

Four case studies were conducted in the test. As in the previous study, data was collected at several moments during the placement period using a multi-method approach. Results were obtained by analysing completed student assignments, audio recordings of supervision talks, video and audio recordings of the lessons at school and administered interviews with students and supervisors. Again the results show that the strategy was effective for the larger part. Compared to the previous study, students do not only use more biological knowledge, their answers when elaborating assignments also show more coherency. However, the integration of school and workplace learning also brings other problems. Amongst others, these problems are expressed in the use of a so-called cow calendar which is an instrument for planning intervening and monitoring work actions. The results of assignments with the cow calendar show that these assignments are practicable in the school context. Students appear to be helped by the structure of work actions that the calendar offers. This structure may help them to obtain an overview that functions as a framework for elaborating the other assignments. However, the results also show that the calendar does not adequately function in the workplace context because the instrument may be perceived as out-of-date. Besides this, both supervisor and student may not be used to working with it. The results also show that discussing terms and meanings helps students to verbalize biological and vocational knowledge. However, such discussions may also result in using terms from both contexts with a school biology perspective. For instance, a cow can also be conceived as a biological object instead of a workplace object. The chapter ends with reflections on the strategy components. Some components are brought into focus because of the expression of relationships between school and workplace practice, as is the case with the functioning of the cow calendar and maintaining a workplace focus at school.

Chapter 7 discusses the theoretical contribution of this design research project. To answer the main research question, the theory-based design characteristics are supplemented. Apart from the theory-based design characteristics mentioned in chapter 2, integrating school and work place learning about animal reproduction so as to enable VMBO students to recognize the functionality of biological knowledge can be realized through

- stimulating student engagement in a sequence of monitoring and intervening work actions that require the same disciplinary knowledge and that contribute to the same outcome;
- stimulating student engagement in work actions that require overview and encourage the use of workplace instruments in which the relationships between outcomes, work actions and specific knowledge is expressed, and in which the conceptual understanding of these relationships is required when it is used;

- stimulating orientation on innovations in the workplace that require knowledge of the domain.

The chapter continues with an exploration on how parts of the learning, teaching and supervising strategy in which these design characteristics are embedded are possibly applicable to other contexts. For this, it discusses how the design characteristics can be elaborated for other work placements in which disciplinary knowledge can be functional. Here, specifically electrical engineering and geriatric care. The exploration suggests that most design characteristics are potentially applicable. However, such applicability is bound to have its limits. For instance, 'the instrument in which the relationships between outcomes, work actions and specific knowledge is expressed, and in which the conceptual understanding of these relationships is required when it is used' is possibly not easy to identify in other contexts. Based on these explorations, a didactical structure is presented. In this project, the didactical structure can be conceived as an abstracted version of the strategy that is based on the outcomes of the projects and the exploration mentioned. The didactical structure should facilitate communication between researchers and enable a modest and careful step towards generalization of the design characteristics. The chapter ends with implications for VMBO-practice and suggestions for further research. Besides the question how courses at school can prepare students for learning in work placement, it also discusses the question how work placement can prepare students for learning in school. It is recommended that work placements should make students sensitive to knowledge in the workplace by showing them that both vocational and disciplinary knowledge are functional in these workplaces. These experiences can subsequently be used by vocational and disciplinary courses at school. Finally, it discusses the central role of the vocational courses in integrating school and workplace learning and the role of the disciplinary courses to emphasize the relevance of key concepts for the vocational sectors.

Samenvatting

Dit proefschrift beschrijft een ontwerponderzoek naar een onderwijsleerstrategie om leerlingen in het groene vmbo op het stagebedrijf te laten ervaren dat biologische kennis over voortplanting daar functioneel is. Het doel van het onderzoek was te komen tot een theoretisch en empirisch gefundeerde strategie. Een strategie die als uitgangspunt kan dienen voor verder onderzoek naar de rol van stageplaatsen in vmbo-curricula waarin integratie van algemeen vormende en beroepsgerichte schoolvakken een doel is. Maar ook een strategie die kan dienen als inspiratie voor huidige docenten in het vmbo en studenten en docenten in tweedegraads lerarenopleidingen die deze integraties aan willen pakken in het vmbo.

Hoofdstuk 1 beschrijft hoe de aansluiting tussen de verschillende curriculumonderdelen van het vmbo ontbreekt en hoe ontwikkelingen in het vmbo en de tweedegraads lerarenopleidingen vragen oproepen naar de mogelijkheden om beroepsgerichte en algemeen vormende onderdelen in het vmbo te integreren. De beroepsgerichtheid van het vmbo wordt door beleidsmakers gestimuleerd en tweedegraads lerarenopleidingen van de algemeen vormende vakken worden aangemoedigd om een afstudeerrichting 'Beroepsonderwijs' in het curriculum op te nemen. Het gevolg is dat toekomstige en huidige leraren van de algemeen vormende vakken en lerarenopleiders worden uitgedaagd om na te denken over de vraag hoe onderwerpen van hun vakgebied verbonden kunnen worden met de beroepsrichtingen van leerlingen. Daarnaast worden ze uitgedaagd na te denken over de vraag hoe dergelijke verbindingen het beste door leerlingen gemaakt kunnen worden.
Een manier om verbindingen te leggen is bijvoorbeeld door beroepscontexten te introduceren in de algemeen vormende vakken of door werkpleksimulaties te introduceren waarin beide geïntegreerd zijn. Onderzoek naar beroepscontexten bij algemeen vormende vakken en onderzoek naar werkpleksimulaties in het vmbo zijn al gevorderd. De rol van stages met dit doel is nog onderbelicht. Dit terwijl de ervaringen van studenten in de beroepspraktijk een waardevolle bijdrage kunnen leveren aan de integratie van kennis van de algemeen vormende en de beroepsgerichte vakken. In dit onderzoek wordt bij wijze van voorbeeld nagegaan hoe dat voor het schoolvak biologie en stages bij dierhouderijen kan worden uitgewerkt. Echter, hoewel biologische kennis in een groot aantal stagebedrijven functioneel is, laat literatuur zien dat het niet vanzelfsprekend is dat leerlingen dat ook inzien. Kenmerken van de werkplek, de participatie in werkzaamheden en het werkplekdiscours bepalen in sterke mate welke kennis er geëxpliciteerd wordt en wat er geleerd kan worden op een werkplek. De hoofdvraag van het onderzoek luidt dan ook:

Wat zijn ontwerpkenmerken voor een uitvoerbare en effectieve leer-, onderwijs- en begeleidingsstrategie waarmee VMBO-leerlingen de functionaliteit van biologische kennis over voortplanting in stagebedrijven van dierhouderij erkennen?

De vraag naar ontwerpkenmerken van zo'n strategie past binnen het kader van vakdidactisch ontwerponderzoek dat binnen het Freudenthal Institute for Science and Mathematics Education ontwikkeld is. Een op theorie gebaseerde strategie wordt in een iteratief onderzoeksproces getest op bruikbaarheid en effectiviteit in de praktijk. Behalve dat dit leidt tot een oplossing voor het probleem in een specifieke context, is het ook een test voor de, op theorie gebaseerde, kenmerken die gebruikt zijn bij het ontwerpen. Interventies van dit type onderzoek kenmerken zich door de kwaliteitscriteria relevantie, consistentie, uitvoerbaarheid en effectiviteit. Deze criteria hebben de deelvragen gestuurd die in de volgende hoofdstukken worden uitgewerkt.

Hoofdstuk 2 beschrijft de literatuurstudie naar theorie-gebaseerde ontwerpkenmerken voor de te ontwerpen strategie die bedoeld zijn om de theoretische relevantie te borgen. De studie beantwoordt de volgende onderzoeksvraag.

Wat zegt literatuur over ontwerpkenmerken van werkplek-gerelateerd leren en begeleiden dat leerlingen in staat stelt om disciplinaire kennis en beroepskennis te verbaliseren en verbinden?

Literatuur is geselecteerd door relevante zoektermen en synoniemen in te voeren in een zoekmachine. Vervolgens zijn documenten geselecteerd op basis van de samenvattingen. De uiteindelijk geselecteerde literatuur is gebruikt om te komen tot een samenhangend theoretisch raamwerk waaruit ontwerpkenmerken konden worden gedistilleerd. Bij het lezen van de literatuur werd het duidelijk dat cultuur-historische theorie een samenhangend raamwerk bood om de kenmerken te ontwikkelen. De literatuur laat zien dat het aan te raden is om

- stages te starten met een oriëntatie op de belangrijkste doelen van het stagebedrijf en daaraan gerelateerde werkzaamheden als kiem voor het leren begrijpen van de gehele werkplek;
- leerlingen in verschillende maar onderling samenhangende werkzaamheden te laten participeren en reflectie op de rationale van deze werkzaamheden te stimuleren;
- leerlingen te laten participeren in werkzaamheden waarbij disciplinaire kennis nodig is om deze goed te kunnen uitvoeren en waarbij in de volgorde zoveel mogelijk sprake is van een toenemende complexiteit;
- termen van de schoolvakken en termen van de beroepspraktijk te (laten) gebruiken bij het beschrijven en verantwoorden van werkzaamheden en te reflecteren op de betekenis van deze termen om relaties tussen school en praktijk te leggen.

Hoofdstuk 3 beschrijft hoe deze op theorie-gebaseerde ontwerpkenmerken gebruikt zijn om de huidige stagepraktijk in het groene vmbo te analyseren. Deze analyse had als doel mogelijkheden en beperkingen in kaart te brengen waarmee bij het ontwerpen van de

strategie rekening moet worden gehouden. De deelvraag van de studie die in dit hoofdstuk beschreven wordt, luidt:

In hoeverre zijn stages in het groene vmbo *in overeenstemming met de, op theorie gebaseerde, ontwerpkenmerken voor werkplek-gerelateerd leren en begeleiden?*

Selectie op basis van de relevantie van biologische kennis in het stagebedrijf heeft geleid tot negen casestudies uit de sector Landbouw. De casestudies bestonden uit interviews met studenten en stagebegeleiders van de werkplek. Daarnaast zijn 27 stageverslagen van vergelijkbare combinaties van leerlingen en stagebedrijven uit een schooljaar daarvoor geanalyseerd. De resultaten laten zien dat stages in het vmbo vooral gebruikt worden om leerlingen werkervaring op te laten doen en dat een deel van het leerpotentieel van de relatief korte stages onbenut blijft. Deze werkgerichtheid heeft onder andere tot gevolg dat veel theorie-gebaseerde kenmerken niet zijn aangetroffen. Hier volgen enkele voorbeelden. Leerlingen oriënteren zich niet op het bedrijf als geheel en stagebegeleiders kiezen er veelal voor om leerlingen vooral te laten participeren in dagelijkse werkzaamheden. Deze werkzaamheden komen op de onderzochte werkplekken niet overeen met werkzaamheden waarvan de samenhang met doelen van het bedrijf eenvoudig te achterhalen is. Tegelijkertijd geven stagebegeleiders aan dat participatie in dergelijke werkzaamheden wél mogelijk is. De werkgerichtheid of het gebrek aan leergerichtheid komt ook tot uitdrukking in de begeleiding en de manier waarop werkzaamheden besproken worden. In de discussie van dit hoofdstuk worden, naast een bespreking van de uitkomsten, suggesties gedaan voor ontwerpkenmerken van de beoogde strategie. Daarin wordt onder andere gesteld dat sommige stagebedrijven zich lenen voor het selecteren van verschillende, onderling samenhangende, werkzaamheden waarin leerlingen kunnen participeren en waarin biologische kennis over voortplanting functioneel is. Er zijn echter ook stagebedrijven die hieraan niet voldoen. Een belangrijke vraag bij een specifiek stagebedrijf lijkt dan ook: wat kan er in dit bedrijf geleerd worden?

Hoofdstuk 4 rapporteert over een onderzoek waarin het doel is om inzicht te krijgen in verbindingen tussen biologische kennis van voortplanting en werkzaamheden in paardenhouderijen en veehouderijen. Het gaat om verbindingen die door leerlingen gelegd zouden kunnen worden wanneer ze in deze praktijken participeren. Uit het onderzoek, gerapporteerd in het vorige hoofdstuk, is gebleken dat deze stagebedrijven geschikt lijken om over voortplanting bij dieren te leren en de functionaliteit van die kennis te ontdekken. Dit onderzoek geeft daarmee antwoord op de volgende vragen.

- *Welke relaties tussen biologische kennis en beroepskennis over voortplanting bij dieren worden geverbaliseerd in paardenhouderijen, veehouderijen en in het groene vmbo?*
- *Hoe worden biologische kennis en beroepskennis over voortplanting in het groene vmbo gerelateerd?*

Om deze relaties en hun aard te onderzoeken, zijn stagebegeleiders op de werkplek en biologieleraren geïnterviewd. Ook zijn educatieve materialen zoals schoolboeken en werkbladen geanalyseerd. Daarbij is er in de transcripten van de interviews en in de documenten onderscheid gemaakt tussen biologische kennis en beroepskennis. Vervolgens is gekeken of in samenhangende tekstfragmenten biologische kennis en beroepskennis beide vertegenwoordigd waren. Zo kon worden gezocht naar relaties tussen beroepskennis en biologische kennis die al geëxpliciteerd worden en naar de manier waarop deze worden geëxpliciteerd. Het resultaat is een overzicht van relaties tussen biologische kennis en werkzaamheden die geverbaliseerd kunnen worden in deze stagebedrijven. Het blijkt dat biologische kennis vooral geverbaliseerd wordt in beschrijvingen en verantwoordingen van interveniërende (bijvoorbeeld insemineren en hengstig spuiten) en monitorende werkzaamheden (bijvoorbeeld scannen, kalven). Het hoofdstuk eindigt met een discussie over functionaliteit van biologische kennis in deze laatstgenoemde werkzaamheden.

Hoofdstuk 5 beschrijft de eerste beproeving van een didactische strategie, ontwikkeld op basis van de hiervoor gerapporteerde deelonderzoeken. De strategie beschrijft en verantwoordt opeenvolgende en onderling samenhangende activiteiten van de student en de begeleider, alsmede de beoogde leereffecten. Het onderzoek in dit hoofdstuk geeft daarmee antwoord op de volgende vragen.

- *Hoe uitvoerbaar en effectief zijn de componenten van de leer- en begeleidingsstrategie op veehouderijen?*
- *Hoe zijn combinaties van componenten van de strategie gerelateerd aan de beoogde effecten?*

De test bestond uit zes casestudies van telkens een leerling en een stagebegeleider op een werkplek. De gegevens zijn op verschillende momenten tijdens de stageperiode verzameld, gebruik makend van methodische triangulatie. Resultaten zijn verkregen door het gemaakte werk van leerlingen, audio-opnames van begeleidingsgesprekken en interviews met leerlingen en stagebegeleiders te analyseren. De resultaten laten zien dat de strategie effectief is: studenten beschrijven biologische kennis van voortplanting en verbinden dit aan werkzaamheden in de veehouderijen. Het blijkt dat de bespreking van sommige werkzaamheden eerder tot het verbaliseren van biologische kennis leidt dan andere. Het begrip dat leerlingen van de werkplek hebben en van de werkzaamheden en daarmee samenhangende biologische kennis, laat een toename zien in de loop van de stage. Er blijken echter ook aanzienlijke verschillen tussen leerlingen te zijn. Zo gaan begeleiders van ervaren leerlingen en de leerlingen zelf anders om met de opdrachten dan leerlingen met weinig ervaring. Twee strategiecomponenten lijken niet uitvoerbaar te zijn. Instrumenten uit de praktijk (e.g. een vee-managementprogramma of een schriftje van de veehouder) lijken in deze stagebedrijven onvoldoende overzicht te bieden om ze goed te kunnen gebruiken. Daarnaast blijkt het bespreken van de betekenis van de gebruikte termen problematisch.

Begeleiders geven daarbij aan dat het hun misschien aan didactische vaardigheden ontbreekt om leerlingen daarin goed te begeleiden.
Het hoofdstuk eindigt met een reflectie op de resultaten van dit onderzoek en de, op theorie gebaseerde, ontwerpkenmerken die aan de strategie ten grondslag liggen. Daarnaast wordt in het laatste deel ingegaan op mogelijke verbeteringen van de strategie en dan met name op hoe bijeenkomsten op school de strategie kunnen verbeteren.

Hoofdstuk 6 beschrijft een empirisch onderzoek van de aangepaste en uitgebreide strategie waarin stage en school geïntegreerd zijn. Tijdens een stage worden leerlingen ook op school begeleid bij het maken en bespreken van opdrachten en het bespreken van de ervaringen op de stageplaats. Nadat de aanpassingen in de strategie zijn besproken, worden de volgende onderzoeksvragen gepresenteerd.

- *Hoe uitvoerbaar en effectief is de leer-, onderwijs- en begeleidingsstrategie waarin stage en lessen op school geïntegreerd zijn?*
- *Hoe ontwikkelt het begrip zich van leerlingen over de werkplek, biologische kennis over voortplanting en de relaties daartussen gedurende de strategie?*

Deze test van de strategie bestond uit vier casestudies. Ook nu zijn de gegevens op verschillende momenten tijdens de stageperiode verzameld, gebruik makend van methodische triangulatie. Resultaten zijn verkregen door het gemaakte werk van leerlingen, audio-opnames van begeleidingsgesprekken, video- en audio-opnames van lessen en interviews met leerlingen en stagebegeleiders te analyseren. De resultaten laten zien dat de strategie wederom voor het grootste gedeelte effectief is. Leerlingen gebruiken niet alleen meer biologische kennis; de antwoorden die leerlingen geven bij de opdrachten vertonen ook meer samenhang. In de strategie waarin stage en school geïntegreerd zijn, doen zich evenwel andere problemen voor. Deze komen onder andere tot uitdrukking bij het gebruiken van een zogenaamde koekalender als instrument voor het plannen van interveniërende en monitorende werkzaamheden. De resultaten van opdrachten met de koekalender laten zien dat deze opdrachten functioneren in de onderwijspraktijk. Leerlingen blijken geholpen bij het structureren van de werkzaamheden waardoor zij overzicht krijgen over de werkzaamheden die op het bedrijf worden uitgevoerd en een kader hebben voor het uitwerken van de andere opdrachten. Het laat echter ook zien dat het instrument niet altijd voldoende functioneert in de stagepraktijk omdat het als het een ouderwets instrument wordt beschouwd of omdat stagebegeleiders zelf niet met het instrumenten weten om te gaan. Daarnaast blijkt uit de resultaten dat het bespreken van termen van school en van de werkplek en het bespreken van hun betekenissen leerlingen helpt bij het verbinden van disciplinaire en beroepskennis. Het laat echter ook zien dat leerlingen soms met ‘de bril van school’ termen uit de verschillende contexten verbinden. De koe wordt in die gevallen bijvoorbeeld gezien als biologisch object in plaats van een werkplekobject. Het hoofdstuk eindigt met reflecties op de strategiecomponenten waarbij sterk gefocust wordt op de

relatie tussen componenten op school en op de werkplek. Daarbij wordt ingegaan op specifieke delen van de strategie zoals de mogelijkheden om de koekalender te laten functioneren in de school en op de werkplek en de mogelijkheden om het werplekperspectief vast te houden op school.

Hoofdstuk 7 bediscussieert de theoretische bijdrage van dit ontwerponderzoek. Als antwoord op de hoofdvraag worden de, op theorie gebaseerde, ontwerpkenmerken aangevuld. Als het doel is om leerlingen te laten ervaren dat biologische kennis over voortplanting functioneel is op de werkplek, is het naast de, in hoofdstuk 2 genoemde theorie-gebaseerde ontwerpkenmerken aan te raden om:

- leerlingen te laten participeren in een reeks van *controlerende* en *interveniërende* werkzaamheden waarvoor kennis over voortplanting nodig is;
- leerlingen te laten participeren in werkzaamheden die om overzicht van het bedrijf vragen en waarbij instrumenten gebruikt worden die vragen om begrip van de relaties tussen doelen, werkzaamheden en kennis over voortplanting;
- leerlingen te laten oriënteren op innovaties op de werkplek waarin kennis van voortplanting gebruikt wordt.

Vervolgens wordt in het hoofdstuk verkend hoe delen van de leer-, onderwijs-, en begeleidingsstrategie waarin deze ontwerpkenmerken ook zijn opgenomen, mogelijk toepasbaar zijn in andere contexten. Voor deze verkenning wordt bediscussieerd hoe de ontwerpkenmerken kunnen worden uitgewerkt voor andere stages waar disciplinaire kennis functioneel is. In dit geval een elektricien en een ouderenverzorger. De verkenning suggereert dat de meeste ontwerpkenmerken potentieel toepasbaar zijn. Echter, de toepasbaarheid kent waarschijnlijk ook beperkingen. Bijvoorbeeld het instrument dat vraagt om begrip van relaties tussen doel, werkzaamheden en kennis is waarschijnlijk niet eenvoudig te vinden in andere contexten. Het hoofdstuk vervolgt met het presenteren van de didactische structuur. Dit is een geabstraheerde versie van de strategie die gebaseerd is op de uitkomsten van het onderzoek en de genoemde verkenning. De didactische structuur kan worden gezien als een middel om over de bredere toepasbaarheid van de strategie en de onderliggende ontwerpkenmerken te communiceren en deze te bediscussiëren. Het hoofdstuk eindigt met implicaties voor het vmbo en de vragen voor vervolgonderzoek die deze oproepen. De implicaties richten zich vooral op integraties van leren op school en op de werkplek. Niet alleen de vraag hoe vakken op school kunnen voorbereiden op de stage wordt gesteld maar ook de vraag hoe de stage kan voorbereiden op de vakken op school. Het beeld wordt geschetst dat stages studenten gevoelig moeten maken voor kennis op de werkplek door de functionaliteit ervan te benadrukken. Ervaringen van leerlingen tijdens de stages kunnen vervolgens gebruikt worden in de beroepsgerichte en algemeen vormende vakken op school. Tot slot wordt ingegaan op de centrale rol van de beroepsgerichte vakken in de integratie van leren op school en op de werkplek en op de rol van de algemeen vormende vakken om onderwerpen van het vak die relevant zijn voor de beroepssector, te benadrukken.

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Na het afronden van de havo op de RSG Enkhuizen en na het afronden van een tweedegraads lerarenopleiding biologie in 1995 is Marco begonnen als leraar biologie, natuur- en scheikunde in het toenmalige individueel voorbereidend beroepsonderwijs ((i)vbo) op het Comenius college in Stadskanaal. Tijdens zijn eerstegraads lerarenopleiding biologie die hij in 2000 afrondde, werd Marco gevraagd om lessen te verzorgen op de lerarenopleiding van de Noordelijke Hogeschool Leeuwarden die later NHL Hogeschool is gaan heten. Van mei 1999 tot januari 2004 combineerde hij het lerarenopleiderschap met een baan op het voorbereidend middelbaar beroepsonderwijs (vmbo). Vanaf januari 2004 is hij volledig gaan werken als lerarenopleider in Leeuwarden waar hij zich naast enkele biologiemodulen vooral is gaan bezighouden met de modulen die voorbereiden op het leraarschap. In september 2007 startte hij met een promotieonderzoek op het Freudenthal Institute for science and mathematics education (FIsme). Dit onderzoek bood hem ook de mogelijkheid om aan te sluiten bij het lectoraat Werkplekleren en ICT van NHL Hogeschool waar hij tot op de dag van vandaag deel van uitmaakt als onderzoeker.

FIsme Scientific Library

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