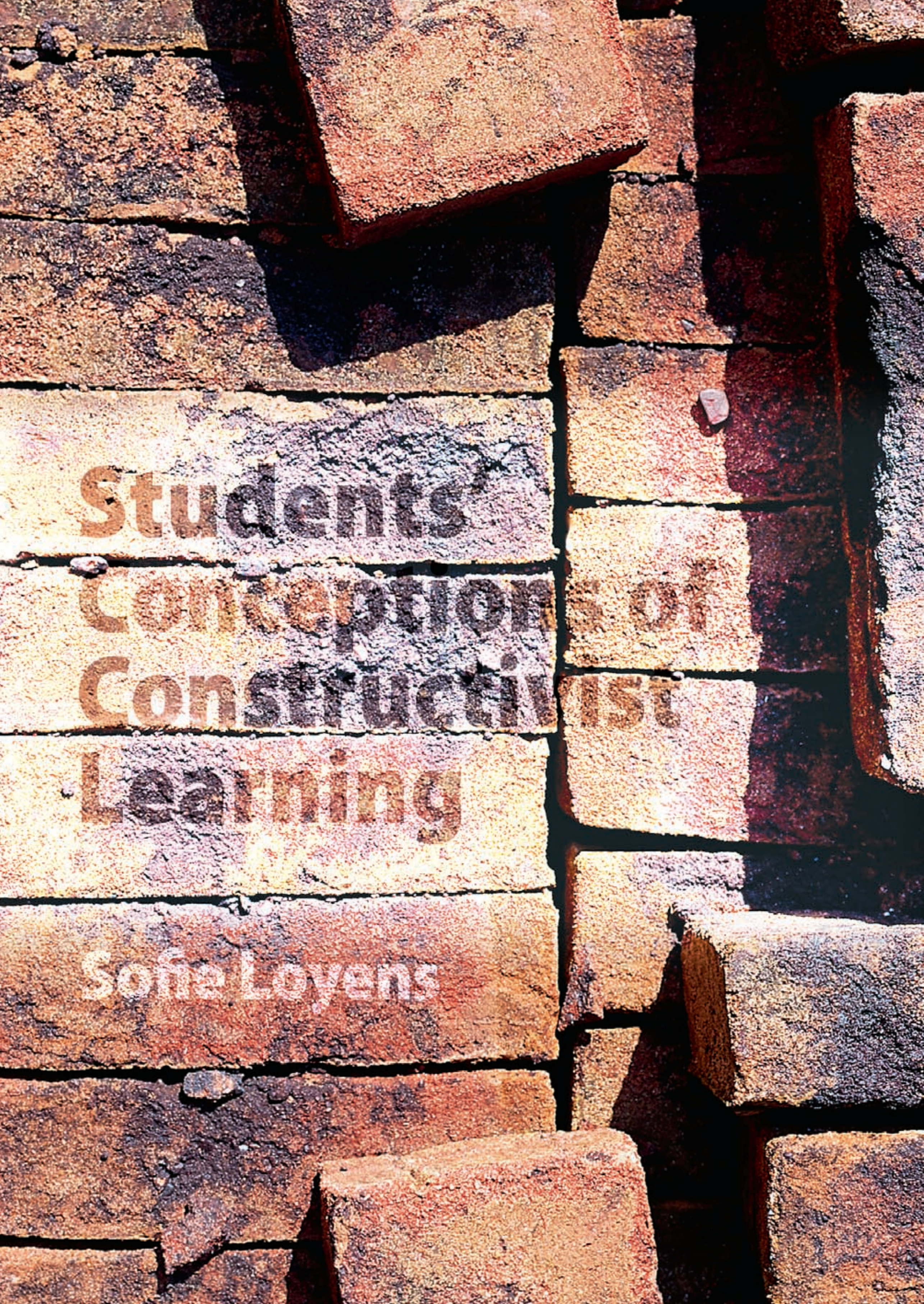

Students' Conceptions of Constructivist Learning

Sofie Loyens

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Concepties van studenten van constructivistisch leren

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	Prof.dr. P.A. Alexander
	Dr. S.E. Severiens

Voor mijn ouders,
van wie ik de meeste wijze lessen geleerd heb

CONTENTS

VOORWOORD

Voilà, het is zover, 'het boekje' is klaar en ik ben aanbeland bij het schrijven van het allerlaatste onderdeel: het voor- of dankwoord. Na lang, heel lang, staren naar een knipperende cursor, is het officieel: ik heb geen groter writer's block gekend dan bij het schrijven van dit voorwoord. En de druk is hoog, want inderdaad, het is het meest gelezen proefschriftonderdeel en in zekere zin ook het meest belangrijke onderdeel. Ook al hoop je stiekem dat "Bedankt allemaal" volstaat, tegelijkertijd besef je dat je dan heel veel mensen tekort zou doen. Vier jaar is immers een hele tijd waarin een heleboel mensen op veel verschillende manieren hebben bijgedragen aan de totstandkoming van dit proefschrift. Ik wil al deze mensen dan ook van harte bedanken en hoop dat ik er in hetgeen volgt de juiste woorden voor vind.

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Sofie
Rotterdam, januari 2007.

> "When you are a Bear of Very Little Brain, and you Think of Things, you sometimes find that a Thing which seemed very Thingish inside you is quite different when it gets out into the open and has other people looking at it."
>
> *A.A. Milne, The House at Pooh Corner, 1928.*

Chapter 1

Constructivism and conceptions of learning - An introduction

A group of first-year university students is studying in the library for the first term exams. During one of their breaks, they start a conversation about what would work best in order to become optimally prepared for the exams. One student says that he tries to memorise as much as possible. He reads the study material over and over again in until he can reel off everything. He knows his strategy is at odds with the study strategies that his professor always propagates: Rephrase information in your own words, elaborate, and try to understand what you read. By using his own method, however, he can be confident that he has fully covered the subject matter. Another student looks surprised and adds that she would mix up everything if she had to learn it by heart. She indicates that for her, learning implies discovering meaning. She always tries to derive coherent stories from the subject matter and every chapter in the study book adds something to this story. A third student brings in that she studies by discussing the subject matter with a fellow-student. They both prepare possible exam questions, which they pose to each other. By taking up each other's answers, they become familiar with the study material.

Three students with three different study strategies that are based on three different beliefs about learning. Students' beliefs or conceptions are not always in accordance with those of teachers, as the first student explained. Furthermore, while the second student puts emphasis on extracting meaning and making connections across chapters, the third student stresses learning in interaction with others.

This thesis tackles the issue of students' conceptions of learning. In particular, it focuses on students' conceptions of constructivism: A dominant view on learning in our society. Constructivist learning views consider certain assumptions that foster learning, which will be outlined below. Students' beliefs about these assumptions constitute the building blocks of this thesis.

This chapter will start with an outline of what constructivism is, a short historical overview, followed by several perspectives on and different types of constructivism that can be distinguished. In addition, the common ground in constructivist views of learning as well as applications of constructivism in education are highlighted. The remainder of this chapter will handle the topic of conceptions and the role they play in students' learning processes. Finally, an overview of the chapters will be presented.

1. WHAT IS CONSTRUCTIVISM?

Consider the following situation: A young child who has never been in the hospital is in her bed in the paediatric wing. The nurse at the station down the hall calls over the intercom above the bed, "Hi, Chelsea, how are you doing? Do you need anything?" The girl looks puzzled and does not answer. The nurse repeats the question with the same result. Finally, the nurse says emphatically, "Chelsea, are you there? Say something!" The little girl responds tentatively, "Hello wall, I'm here." Chelsea encountered a new situation; a talking wall. The wall is persistent. It sounds like a grown-up wall. She shouldn't talk to strangers, but she is not sure about walls. She uses what she knows and what the situation provides to *construct* meaning and to act (Woolfolk, 2004, p. 322).

How people try to make sense of situations such as the one described above or, in other words, how people create meaning is the main concern of *constructivist theories*. A clear, unequivocal definition of constructivism is, however, hard to find. Although this concept is currently influential in psychology and education, it is embodied in numerous ways and has a different meaning to several researchers. In essence, constructivism is a view of learning that considers the learner as a responsible, active agent in his/her knowledge acquisition process. Before definitions and different types of constructivism are discussed, a brief historical perspective on the background and origins of this concept will be given.

1.1 Brief historical perspective

Although constructivist theory has reached high popularity in recent years, its idea is not new. Educational methods that try to involve learners in their own learning processes can already be found in the early history of didactics. The ancient Greeks used the 'dialogos', the method of the dialogue, in their education. In essence, a teacher proposes a problem and helps the learner solving this problem by asking questions. This method can be found in the work of Plato (427-347 B.C.) where he describes how Socrates helps a slave solving Pythagoras' theorem (Plato, 1949). Furthermore, the works of Socrates, Plato, and Aristotle (ranging from 470-320 B.C.) all include ideas about epistemology; the branch of philosophy that studies the nature and scope of knowledge.

The epistemology of more recent philosophers such as Immanuel Kant (late 18th to early 19th centuries) can also be seen as constructivist. Kant mentions the 'faculty of knowledge' that people have, which refers to the influence of people's own minds in making sense of the environment around us. Therefore, he argues: "But though all our knowledge begins with experience, it does not follow that it all arises out of experience" (Kant, 1959, p. 25). Some form of mental activity is required from the one who experiences: People need to generate or construct knowledge on the basis of their individual experiences.

In the late 19th century, the American philosopher and educator John Dewey (1859 - 1952) reacted against the passive teaching in a rote manner, which was common practice in the late 19th to early 20th centuries. He believed that a child is an active learner who learns best by doing. He argued for constructive activities in the classroom that were meaningful and interesting (i.e., connecting with the child's social environment) for children. Education should not be about becoming narrowly educated in academic topics; it should be pragmatic and should teach children how to think and adapt to a world outside (Dewey, 1902, 1929).

A renowned constructivist in the 20th century is Jean Piaget (1896 - 1980). He is generally considered as the founding father of constructivism. His ideas will be discussed in more detail in the section about the different types of constructivism. First, several definitions of constructivism are addressed.

1.2 A theory of learning, a philosophical position, or a theory of instruction?

1.2.1 A theory of learning

In many handbooks on educational psychology (e.g., Parsons, Lewis Hinson, & Sardo-Brown, 2001; Woolfolk, 2004) constructivism is explained as a response to the information processing theories, or more broadly, cognitivism. Cognitivism is a theoretical approach to understanding the mind. This view argues that the teacher disseminates knowledge, which students absorb. The aim of instruction according to cognitivists is an increase of knowledge in students' memory systems. Constructivism reacted against 'the traditional classroom' that focused on the transmission of knowledge and in which meaning was conveyed by the teacher. Transferring knowledge from a knowledgeable person to someone who lacks specific knowledge, does not work according to a constructivist view of learning, since 'wisdom cannot be told' (Bransford, Franks, Vye, & Sherwood, 1989). When constructivism is explained in terms of a reaction against cognitivism, it is seen as a theory of learning, concentrating on the question 'How do learners acquire knowledge?' Slavin states in this respect that constructivism is a theory of learning that is student-centred. The emphasis is on students as active learners and "the teacher becomes the "guide at the side" rather than the "sage on the stage" (Slavin, 2006, p. 243). Although most cognitive views of learning agree with the concept of 'active learners', constructivism lays more emphasis on learners constructing their own understanding. In this respect, constructivism could also be considered a rising paradigm in the field of cognitive psychology instead of a reaction against it.

1.2.2 A philosophical position

Others see constructivism as a philosophical position, grounded in epistemology and focused on the discussion about what knowledge really is. Colliver, for example, prefers to see constructivism as "an insight into the nature of human knowledge" (Colliver, 2002, p. 51). Constructivism is not a theory of learning according to him, because regardless whether we think of knowledge as a construction process or a representation of reality, the principles of learning are the same in his opinion. Saunders states that "constructivism can be defined as that philosophical position which holds that any so-called reality is, in the most immediate and concrete sense, the mental construction of those who believe they have discovered and investigated it" (Saunders, 1992, p. 136).

1.2.3 A theory of instruction

A third perspective of constructivism is instructional, pedagogical. According to this view, constructivism is a theory of instruction that supplies educational tools for teaching in the classroom. In line with the previous perspectives, however, not everyone agrees on this view. Some argue that when instruction is described as 'constructivist' its theory is misapplied and a theory of knowing is confused with a theory of pedagogy (Eggen & Kauchak, 2006). In this respect, the question arises: What makes teaching methods constructivist? Some educators believe that knowledge construction can occur, irrespective of instructional methods. By listening to a lecture, one can be involved in active attempts to construct new knowledge (Bransford, Brown, & Cocking, 2000). von Glasersfeld (1993) argued that all mental activity is constructive because that is the way the mind operates. Even when learners are engaged in rote learning, they still are constructing knowledge. Therefore, all teaching can be considered constructivist (Windschitl, 2002). According to others, specific constructivist operationalizations can be identified in education and they are typically student-centred. An example of constructivist teaching will be given in the section about applications of constructivist perspectives below.

A question that comes to mind while discussing constructivism as a theory of instruction is: Does constructivism exclude all other forms of instruction? Harris and Alexander (1998) argue that the 'either/or' view regarding instruction versus knowledge construction is one of the challenges to the constructivist reaction to traditional teaching. In a broader perspective, the cognitivism versus constructivism controversy is still ongoing. Not everyone embraces a constructivist view of learning. Some educators believe that the teacher, and not the learner, should be in charge of students' learning process; (s)he should direct and control. These educators also believe that constructivists often do not focus sufficiently on basic academic tasks, whereas too much emphasis is laid on skills (Santrock, 2001). Others have even argued that constructivism is in conflict with human, cognitive architecture (Kirschner, Sweller, & Clark, 2006). However, these discussions are mainly problematic because the starting points are extremes, sometimes even caricatures of cognitivism and constructivism, which are inherently incompatible. Focusing on extreme views makes that one inevitably faces the shortcomings of either view, which sets in a movement to the other extreme (Elshout, 2000).

Therefore, a working definition of constructivism could be: A theory of how we learn and construct meaning, grounded in philosophy, which has led to the development of several educational applications. In the next section, we will discuss the various types of constructivism that can be found in the literature.

1.3 Different types of constructivism

Phillips (2000) has argued that distinguishing different types of constructivism is "a trip to a nightmarish landscape", since many different views and designations exist with several overlaps and points of divergence. Nevertheless, several constructivist views and their most important adherents, divided in three main categories, can be distinguished.

1.3.1 Cognitive constructivism

Cognitive constructivism, also called individual or psychological constructivism, is mainly concerned with how individuals build up their knowledge and beliefs. Within this framework, the most recent information processing theories can be labelled constructivist (Mayer, 1996). Information processing theories of learning use the computer metaphor for the human mind; it is a symbol processing system. Incoming information from the outside world is translated into symbols (i.e., schemas, images, propositions) and is then processed (e.g., connected with previously learned knowledge) in order to be stored in the human memory and retrieved when necessary. Knowledge is actively restructured in highly individual ways according to this type of constructivism. This led to the designation **weak or trivial constructivism** because the only constructive activity of the learner is "to build accurate representations of the outside world" (Woolfolk, 2004, p. 324).

Piaget's work is often seen as the impetus for constructivism. In contrast with the information processing approach, Piaget focused more on how individuals construct meaning and less on how individuals build accurate representations of the outside world. Individual learners need to organize their thoughts so that they make sense and they do this by refining and adapting their knowledge (Windschitl, 2002). When new ideas and experiences are encountered, they are added to existing schemas (i.e., assimilation). However, when new information is in conflict with existing knowledge, schemas are revised to fit new situations; this process is called accommodation (Slavin, 2006). The way in which individuals build 'universal' knowledge and meaning based on the processes of assimilation and accommodation, was crucial to Piaget. Although Piaget's constructivist view is labelled as individual, he did acknowledge the social environment as an important factor in the knowledge acquisition process, but social interactions serve primarily as stimulants for individual schema adjustments (Eggen & Kauchak, 1999). Piaget's constructivism is also called 'endogen constructivism' (Harris & Graham, 1994).

Within cognitive constructivism, at the extreme end, a type of constructivism known as **radical constructivism** can be found with von Glasersfeld (1998) as most important adherent. Radical constructivism is not only unconcerned with correct representations of the outside world, it states that there is no reality or truth. Reality is idiosyncratic, *cognitive* reality and is therefore dependent on the individual that perceives this reality. Formal knowledge receives a minor role in radical constructivism, because knowledge depends on individual perceptions. In this account, the role of instruction is not clear and sometimes even considered unnecessary. Only few radical constructivists, however, completely disregard formal knowledge (Richardson, 1997).

1.3.2 Social constructivism

Social constructivism considers learning as a social process that takes place in interaction with the social and cultural environment. The Russian educational psychologist Vygotsky (1978) is classified as a social constructivist. Since learning is social in nature according to this view, cultural tools, especially language, play a crucial role. A concept that clearly demonstrates the social constructivist view that knowledge acquisition is centred in the learner's interaction with the social world is Vygotsky's 'zone of proximal development'. The zone of proximal development refers to "the notion that developing mental functions must be fostered and assessed through collaborative activities in which learners participate in constructive tasks or problem solving, with the assistance of more knowledgeable others" (Windschitl, 2002, p. 141). Is the individual completely ignored in social constructivist views? No, but social constructivists depart from a *contextualized* individual. It assumes a more dynamic relation between individual and social environment. Social constructivism, as advocated by Vygotsky, is also known as 'dialectical constructivism' (Harris & Graham, 1994).

1.3.3 Sociological constructivism

While social constructivists are concerned with the influence of members of a group on the knowledge construction of an individual, sociological constructivists are concerned with the development of formal, public knowledge in disciplines (e.g., science, mathematics, economics) and the social processes that influence that development. In other words, sociological constructivism, alias socio-cultural constructivism or constructionism, is also concerned with the contextualized individual, but the context according to this view is a large sociological and historical context, not only the individual's immediate environment (Phillips, 1997). Individual knowledge is disregarded by constructionists; knowledge is not an individual's possession, but all knowledge is socially constructed and is therefore object of discussion and questioning. Power is an important concept in sociological constructivism because socio-political and cultural forces are determinative for the way in which things are constructed in society (Gergen, 1997).

In summary, three major types of constructivism can be distinguished. Each type puts a particular emphasis on learning and knowledge that makes the views different from each other. Even within the major types, several subtypes can have different views on certain aspects. An important difference of opinion pertains to the source of constructive change. According to trivial constructivists, knowledge is *re*constructed based on incoming information from the outside world. Piagetian constructivists, on the other hand, would argue that individual's knowledge construction is guided by internal conflict when new information is irreconcilable with existing knowledge, whereas social constructivists stress the interactions between individual and environment in learners' knowledge construction processes. Similarly, a second controversy among constructivist theories concerns the extent to which products of learning are transferable. Social constructivists highlight the social nature of learning; learning is embedded in a particular context. Consequently, knowledge that learners acquire is restricted to a specific context. This idea that knowledge is tied to the learning context implies that transfer to other situations will be very difficult. Individual constructivists, however, think of learning as a primarily individual process, which makes it possible that knowledge is transferred to situations other than the learning context (Eggen & Kauchak, 1999; Woolfolk, 2004).

Having outlined different perspectives and types of constructivism, we will now look into the common ground that constructivist views share.

1.4 Common ground in constructivist views of learning

Despite all different embodiments of constructivism, constructivist views also share important ideas. A number of shared assumptions that should be considered in learning can be deduced from the different views (e.g., Driscoll, 2005; Marshall, 1992; Slavin, 2006; Woolfolk, 2004). Four commonly shared constructivist assumptions for learning will be discussed next.

1.4.1 Knowledge construction

As mentioned earlier, the essence of constructivism is that students actively construct knowledge. In other words, the acquisition of knowledge is a process of knowledge construction (Cunningham, 1992). The core element of this assumption is that learners interpret new information using knowledge that they have acquired previously. Learners activate prior knowledge and try to relate new information to knowledge they already possess. By doing so, understanding subject matter is a function of knowledge construction and transformation, not merely information acquisition and accumulation (Blumenfeld, 1992). Wheatley refers to this process with the following quote: "Knowledge is always someone's knowledge" (Wheatley, 1991, p. 13). In addition, learning that builds upon what students already know leads to an increase in not only retention, but in interest and motivation as well (Forbes, Duke, & Prosser, 2001).

1.4.2 Cooperative learning

The importance of cooperative learning is a second assumption put forward by constructivist theorists. Social interactions with fellow-students, teachers, and others contribute to the construction of knowledge (Steffe & Gale, 1995). Although constructivists differ with regard to the extent that cooperation contributes to knowledge acquisition, they share the idea that social negotiation and interaction are important factors in this process (Greeno, Collins, & Resnick, 1996). Social interactions among students also facilitate communication of ideas about subject matter, because their level of understanding is more similar to each other as compared to the teacher's level (Slavin, 1996). Furthermore, cooperative learning provides opportunities for student discussions that can be used as an assessment of their prior knowledge. These discussions, in turn, provide students with both the direction and extent of study that needs to be undertaken to acquire a deep understanding of the subject matter to be studied.

1.4.3 Self-regulated learning

A third assumption put forward in constructivist theories is that students use their metacognitive skills to set academic learning goals or, in other words, that they are self-regulated learners (Paris & Paris, 2001; Zimmerman, 1989). Self-regulation is an umbrella term for various aspects such as goal setting, self-observation, self-assessment, and self-reinforcement, all of which are believed to influence learning. Although all learners are inevitably engaged in some form of self-regulation (i.e., they all plan, monitor, and evaluate their behaviour to some degree, Winne, 1995a), effective self-regulation requires having goals and the motivation to attain them. To be able to regulate your own learning is viewed as the key to successful learning in school and beyond (Boekaerts, 1999). Studies on self-regulation have demonstrated that effective learners possess and use a substantial knowledge base about learning that allows them to organise, plan, and monitor most aspects of learning tasks in a task-appropriate way (Cantwell & Moore, 1996). Furthermore, programs that promote self-regulated learning have been found to be beneficial for students' achievement (e.g., Mason, 2004).

1.4.4 Authentic, complex, ill-structured tasks

Finally, constructivists agree on the assumption that learning situations preferably have to resemble real-life or authentic situations. A way to accomplish this is by confronting students with complex, ill-structured problems; similar to the kinds of problems they will face in their future profession. These problems serve as a challenge to students' reasoning or problem-solving skills and as an organizer for their learning (Voss & Post, 1988; White & Frederiksen, 1998). Complex problems refer to problems that have many interacting elements and that can lead to multiple solutions; they are not simply difficult problems. By solving problems, learners develop understanding of subject matter: They apply and represent their ideas in a manner similar to the way in which experienced individuals in the field generate and use knowledge (Blumenfeld, 1992). This aspect of constructivist views is consistent with the notion of learning in a context, but as mentioned above, a controversy exists between 'knowledge tied to the learning context' versus 'knowledge learned in a context, but transferable to other contexts'.

These four assumptions will be the primary elements in the studies of this thesis, since they constitute the building blocks for a measurement instrument for students' conceptions of constructivist learning, discussed in Chapter 2. We will now focus on an application of constructivism in educational practice, namely problem-based learning, and we will describe how constructivist assumptions take shape in this approach.

1.5 Application of constructivist strategies

Probably the most well-known constructivist approach in education is *problem-based learning* (PBL). In PBL, small groups of students learn in the context of meaningful problems that describe observable phenomena or events (Schmidt, 1983). On some occasions (e.g., in medical education) these problems originate from professional practice, in other cases, they tackle problems or events typical for a particular domain of study (Barrett, 2005; Barrows, 1996; Norman & Schmidt, 1992; Schmidt, Loyens, Van Gog, & Paas, in press). In either case, the problems need to be understood in terms of their underlying theoretical explanations. Students can master understanding by discussing the problem with their fellow-students and proposing possible explanations or solutions, all based on students' prior knowledge. Since their prior knowledge of the problem-at-hand is limited, this discussion leads to the formulation of issues for further self-directed learning. Subsequently, students spend time studying literature relevant to the issues generated. After this period of self-study, students share and critically evaluate their findings, elaborate on knowledge acquired, and have an opportunity to correct misconceptions (Hmelo-Silver, 2004; Schmidt, 1983). The whole process takes place under guidance of a tutor who stimulates the discussion, provides students (if necessary) with just-in-time content information, evaluates the progress, and monitors the extent to which each group member contributes to the group's work (Schmidt et al., in press).

The four constructivist assumptions mentioned above clearly come to the fore in PBL. The starting point of the learning process in PBL is a complex, ill-structured problem. Students need to discuss these problems before they have received other curriculum inputs and therefore, they need to rely on their prior knowledge. The learning issues students formulate themselves constitute the basis of their self-regulated learning. Students need to select relevant literature about the topic to be studied, they need to plan their study activities in order to become optimally prepared for the next tutorial group meeting, they need to assess whether their self-study activities are sufficient to fully understand the subject matter introduced in the problem, etc. During self-study and also when students share and evaluate their findings after their self-study activities, they engage in knowledge construction. Prior knowledge was triggered during the initial discussion of the problem and new findings are interpreted in the light of this prior knowledge and, as mentioned above, possible misconceptions are resolved. Initial discussion of the problem-at-hand as well as evaluation of students' self-study findings always happen in a small group of students and therefore, they can be labelled as cooperative learning activities.

The studies in this thesis investigated constructivist learning assumptions in the context of problem-based learning. More specifically, students enrolled in a problem-based learning curriculum were questioned about their conceptions of these assumptions. Constructivist views of learning emphasize students' personal knowledge constructions and subjective beliefs. Therefore, we will now address the topic of conceptions and their role in learning.

2. WHAT ARE CONCEPTIONS?

2.1 Concepts and conceptions

As Entwistle and Peterson (2004) point out, a necessary staring point is to shed light on the definitions of 'concept' and 'conception'. Although the definition of the term 'concept' can vary along different disciplines (Ferrari & Elik, 2003), in psychology a concept refers to an internal representation, or simply stated, an idea about something (Sternberg, 1999). Concepts are learned through sensory experiences. We derive our ideas from specific instances (Thagard, 1996). For example, acquiring a concept such as 'apple' happens through encounters with several different apples by which we can derive a list of features of an apple (e.g., round, having a core, etc.). A concept has, in this sense, a shared meaning.

A conception, on the contrary, refers to "an individual's personal and therefore variable response to a concept" (Entwistle & Peterson, 2004, p. 408). Because of this individualized character, conceptions may contain erroneous (i.e., in conflict with commonly accepted scientific explanations) information. For example, a child might believe that the earth is flat or hollow. These incorrect conceptions or 'misconceptions' are explained in terms of attempts "to reconcile incompatible pieces of information, some of them stemming from everyday experience and some coming from the surrounding culture" (Vosniadou, 2003, p. 386).

Two main categories of conceptions can be distinguished: Conceptions of knowledge and conceptions of learning, which will be discussed in the next section.

2.2 Conceptions of knowledge

Conceptions of knowledge, or epistemologies, refer to what we believe about knowledge. These conceptions can address, for example, the structure, stability, and source of knowledge. With respect to the structure of knowledge, some might believe that knowledge consists of a collection of individual facts (i.e., isolated bits), while others see knowledge as a complex structure of interrelated and integrated concepts. Similarly, different views can be hold about the stability of knowledge (e.g., tentative or unchanging) and the source of knowledge. As mentioned above, radical constructivists view knowledge as idiosyncratic (i.e., the source of knowledge lies in oneself) and allocate a minor role to formal knowledge. Completely at odds with this view of radical constructivists is considering knowledge as being handed down by an authority. Furthermore, epistemological beliefs can also address the speed (i.e., quick versus gradual process) and control (i.e., innate ability or life-long improvement) of knowledge acquisition (Hofer, 2000; Schommer-Aikins, 2002).

Perry (1970) proposed a model for the development of conceptions of knowledge. He described four stages in the development of students' conceptions of knowledge. Perry argued that the patterns of students' beliefs about knowledge develop throughout their academic program from a dualistic view (i.e., knowledge is either right or wrong), to an understanding that one can approach a situation from different angles (i.e., multiplicity), to consciousness that objective information is interpreted and that these interpretations are the building blocks of certain views from which numerous possible conclusions can be drawn (i.e., relativism), to, finally, the development of a personal opinion of issues, acknowledging that all knowledge and ideas are relative.

2.3 Conceptions of learning

Similar to conceptions of knowledge, the way in which students understand the nature of learning, students' conceptions of learning, has also become an increasingly significant construct in recent research on effective learning.

Marton, Dall'Alba, and Beaty (1993), elaborating on the work of Säljö (1979), have categorised conceptions of learning in a qualitative way. Conceptions of learning that solely involve the increase of knowledge are considered as the starting point from which all other conceptions of learning develop, whereas conceptions of learning that imply changing as a person are viewed as the most advanced (i.e., highest level in the development) conceptions of learning. The in-between stages in students' development of conceptions of learning involve (2) memorising, (3) applying, (4) understanding, and (5) seeing something in a different way. Essentially, these conceptions depict learning as developing from reproduction (with an emphasis on what is learned) to transforming subject matter (with an emphasis on the learning process, how things are learned) (Boulton-Lewis, Wills, & Lewis, 2001).

Säljö, Marton and colleagues, often referred to as the Göteborg group, developed a specific method for investigating students' conceptions of learning; the phenomenographic approach. Within this approach, ideas about learning are systematized by means of interviews. More specifically, adults with varying educational experience were asked what learning meant to them. This method showed that individual conceptions of learning often fall into a small number of categories, which eventually have led to the different categories of conceptions of learning mentioned above (Entwistle, McCune, & Walker, 2001).

Morgan and Beaty (1997) investigated university students' conceptions of learning over a six-year period and found the same conceptions of learning as proposed by Säljö (1979). Even the sixth conception, 'changing as a person', was held by some students. Furthermore, students' conceptions progressed from acquiring knowledge to developing understanding and seeing something in a different way. They argued that changes in conceptions of learning could be ascribed to students' educational experiences, which acknowledges an important role for the learning environment students are enrolled in (Morgan & Beaty, 1997).

3. RESEARCH ON CONCEPTIONS AND LEARNING

An implication of constructivist views of learning is that these views have brought personal knowledge constructions and learners' subjective beliefs to the fore in educational research

(Wigfield, Eccles, & Pintrich, 1996). The result was a vast number of studies relating students' conceptions of knowledge and learning to other aspects of learning such as cognitive processing strategies, regulation strategies, motivation, learning orientations, approaches to learning, and learning outcomes. We will give a brief (but by no means exhaustive) overview of studies that have linked conceptions of knowledge and learning to these aspects of learning.

3.1 Research on conceptions of knowledge

With respect to conceptions of knowledge, Ryan (1984) categorized students as either dualists (i.e., seeing knowledge as an array of discrete and absolute truths) or relativists (i.e., seeing knowledge as interpreted and integrated positions). Students were then asked to indicate the criteria they used for determining whether they had comprehended a textbook chapter. Ryan found that dualists reported more use of fact-oriented factors such as recall, while relativists reported more use of context-oriented variables such as paraphrasing. Schommer (1990) investigated the predictive value of epistemologies on reported confidence in understanding a text passage, writing a conclusion for a text passage, and a test about this text passage. Students who believed that knowledge acquisition is a quick process (as opposed to a gradual process) were overconfident in their understanding, wrote oversimplified conclusions to the text passage, and performed poorly on the test. Furthermore, the more students believed in certain, unchanging knowledge, the more they wrote inappropriately absolute conclusions. Lonka and Lindblom-Ylänne (1996) related conceptions of knowledge to students' study strategies. They found that relativists reported more frequent use of elaborative study strategies, whereas dualists reported more frequent use of rehearsal strategies, which is in line with the results of Ryan (1984). Also, Dahl, Bals, and Turi (2005) reported similar relationships between students' conceptions of knowledge and learning strategies for studying course material.

3.2 Research on conceptions of learning

Van Rossum and Schenk (1984) studied the relationship between conceptions of learning, study strategies (also referred to as Student Approaches to Learning – SAL), and learning outcomes by letting participants study a text, followed by a questionnaire containing items about the text as well as items about their study strategy and conceptions of learning. High quality learning outcomes appeared particularly related to learning conceptions that emphasize the constructive character of learning as well as deep (i.e., seeking meaning of the subject matter by elaborating and transforming this subject matter) learning approaches. In a study of student's conceptions of mathematics, Crawford, Gordon, Nicholas, and Prosser (1994) found similar results. Their research identified a structural relationship between students' conceptions of mathematics and their approaches to learning this subject. Similarly, Dart and colleagues (2000) tested a structural model relating conceptions of learning and SAL and found that qualitative conceptions (i.e., learning is concerned with understanding and meaning by relating or connecting new material to prior knowledge) were linked with deep approaches to learning. Furthermore, more advanced conceptions of learning in which learning is seen as understanding instead of memorising, are found to be associated with a more frequent use of self-regulated learning strategies (Purdie, Hattie, & Douglas, 1998). McLean (2001) demonstrated that the academic ability of students was related to the conceptions of learning they hold, with more advanced, transformative conceptions (i.e., involving personal development) being identified by students with an excellent academic record.

In sum, conceptions students hold with respect to knowledge and learning have implications for students' learning processes. Relationships can be found between conceptions and several learning aspects as well as learning outcomes. Research findings in this area stress the importance of students' beliefs.

4. OVERVIEW OF THE STUDIES

4.1 Why studying conceptions of constructivist learning?

The studies presented in this thesis investigated students' conceptions of constructivist learning. As outlined above, constructivism is an influential view on learning and an important consequence of this learner-centred perspective is the emphasis on students' beliefs. Constructivist theory assumes several factors that should be considered while creating learning environments for students. Therefore, the central question of this thesis is: How do students conceptualize constructivist assumptions and how does this affect their learning? If students do not consider these factors important for their own learning, it is not likely they will engage in constructivist learning activities. In fact, various studies report discrepancies between educational intentions and students' beliefs about these intentions. Learning modalities such as lectures and laboratory sessions, for instance, are imposed in a curriculum to prepare students for practice. However, research demonstrates that students often perceive this differently (Forbes et al., 2001). Analogously, in a study on feedback in a problem-based curriculum, students never labelled the use of marks, grades, and written feedback as helpful feedback, while these forms of feedback are still frequently used (Parikh, McReelis, & Hodges, 2001).

Furthermore, as discussed earlier in this chapter, relationships between conceptions of learning and knowledge and students' learning processes and outcomes have been established in previous research, emphasizing their prominent role in learning. Given this impact of students' conceptions, they comprise an important area of investigation.

Finally, the issue of conceptions of *constructivist* learning in particular has not been addressed previously. Reckoning with the just-mentioned reasons, examining this issue can lead to new insights with respect to students' learning processes.

In summary, the studies described in this thesis were conducted with the purpose of unearthing the topic of conceptions of constructivist learning and elucidating the relationships of these conceptions with other aspects of students' learning.

4.2 The studies

Chapter 2 describes two studies about the development of a questionnaire to measure students' conceptions of constructivist learning. We acknowledge that different types of constructivism exist, but we would like to bring the common ground of these different views to the fore. To that end, a questionnaire was developed containing statements about the four assumptions that are shared among different constructivist perspectives: The importance of knowledge construction, cooperative learning, self-regulation, and the use of authentic problems. Two other factors were measured in the questionnaire: Students' conceptions of self-perceived inability to learn and motivation to learn. Self-perceived inability to learn refers to feelings of doubt students can have with respect to their own capacities, what to study, and main and side issues of the subject matter to be studied. This factor was incorporated because constructivist learning environments are demanding for students in terms of being socially apt, self-regulated knowledge constructors. Some learners may experience this as a challenge and as part of their learning process, but others may relapse into uncertainty, confusion, and even anxiety (Duke, Forbes, Hunter, & Prosser, 1998). Experiencing full responsibility for your own learning in a constructivist curriculum can be stressful for some students. Beside self-perceived inability to learn, motivation to learn was another factor of the questionnaire developed because of its ubiquitous role in students' learning.

In sum, the purpose of the studies described in Chapter 2 was to investigate students' conceptions of constructivist learning. Study 1 was designed to investigate the distinctiveness that students ascribe to knowledge construction, cooperative learning, self-regulation, and the use of authentic problems, as well as how students stand in relation to self-perceived inability to learn and motivation to learn. A model that contained these factors was tested. In Study 2, this procedure was replicated in a second, independent student population to cross-validate the proposed model. Finally, two alternative models were investigated in search for additional support for the questionnaire's underlying structure.

In Chapters 3 and 4, relationships between students' conceptions and learning aspects were investigated. Earlier in this chapter, research on conceptions of learning and knowledge and students' study activities was outlined. Chapters 3 and 4 are directed at scrutinizing whether these associations also count for conceptions of *constructivist* learning.

In **Chapter 3**, the influence of students' conceptions of constructivist learning activities on academic achievement and dropout was examined. This study was conducted in a constructivist, problem-based learning environment. Conceptions were measured at the beginning of the academic year and their predictive validity for students' grades at the end of the academic year and possible dropout was investigated. Academic achievement was measured by students' performance on all course tests of the academic year. The dropout-variable consisted of the number of course tests not taken anymore before final attrition. Self-study time and students' learning activities (as observed by students' tutors) were included as possible mediating variables to examine whether conceptions have a direct or mediated influence on students' academic success. Students' self-study time for each course was measured by asking students at the end of each course to estimate the mean number of hours spent on self-study per week. Observed study activities undertaken by each student were measured through a tutor rating scale in which the tutor evaluates the students on how well they had prepared themselves with respect to the subject matter, how active and motivated they participated in the group activities, and how well they fulfilled their roles as chair and scribe.

In **Chapter 4**, conceptions of constructivist learning were linked with regulation and processing strategies to appraise whether relationships between conceptions of learning and knowledge and study strategies found in earlier research could be generalized to conceptions of constructivist practices. Students' regulation and processing strategies were measured by corresponding items of Vermunt's ILS (Vermunt, 1992) and the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich & de Groot, 1990). A model incorporating conceptions, regulation, and processing strategies was proposed in which a three level-structure is assumed. The first level is the cognitive-symbolic or conceptual level consisting of students' conceptions. Furthermore, a controlling level can be distinguished that refers to regulation processes, whereas a third level, the operational-behavioural level, concerns the processing strategies. The controlling level tunes the conceptual level to the operational level (Vermetten, Lodewijks, & Vermunt, 1999). The study reported in Chapter 4 tested whether the structure of conceptual, controlling, and operational level is also valid for conceptions of constructivist learning.

While Chapters 3 and 4 address relationships between conceptions of constructivist learning and learning activities and outcomes, Chapters 5 and 6 are directed at comparing conceptions of constructivist learning between students in conventional and students in constructivist (i.e., problem-based learning) curricula. In **Chapter 5**, it was examined whether students who have chosen for a problem-based curriculum have different conceptions of constructivist assumptions compared to students who have chosen to be enrolled in a conventional, lecture-based curriculum when they enter university. Learners' preconceived conceptions of learning are advocated as an additional factor that should be considered in comparative educational research. Students bring along a variety of conceptions of learning when they enter university that they have inherited from their previous educational experiences (Marton et al., 1993). As mentioned earlier in this chapter and further investigated for conceptions of constructivist learning in Chapters 3 and 4, this pre-existing knowledge serves as a frame of reference from which students interpret and approach learning tasks. Therefore, this study explicitly focused on the conceptions that first-year students bring to the fore at the beginning of the academic year and tackled the question whether the choice of students to study in a specific curriculum (problem-based learning or conventional) reflects on their conceptions of constructive learning activities.

In line with Chapter 5, **Chapter 6** also takes a comparative point of view between a conventional and a constructivist learning environment. However, the study explained in Chapter 6 attempted to shed light on the *development* of students' conceptions of constructivist learning. Do students look at constructivist learning differently with greater experience in their academic program? Previous studies in the domain of epistemologies concluded that conceptions of knowledge develop progressively through educational experiences (Hofer & Pintrich, 1997; Perry, 1970). Similarly, as mentioned earlier in this chapter, Morgan and Beaty (1997) have argued that changes in conceptions of learning could be ascribed to students' educational experiences. In Chapter 6, it was examined whether these findings also count for conceptions of constructivist learning. In addition, this study addressed the question to what extent students' conceptions of constructivist learning develop differently in a conventional, lecture-based curriculum compared to a constructivist (i.e., problem-based learning) curriculum. Instruction that students receive, or more broadly, the learning environment in which students are enrolled, can affect students' conceptions (Vermunt & van Rijswijk, 1988; Tynjälä, 1997). Conceptions of constructivist learning of three student groups (i.e., first-year, second-year, and third-year students) in two different curricula (i.e., conventional, lecture-based and constructivist, problem-based) were compared.

Finally, **Chapter 7** provides a summary and general discussion of the findings reported in the studies of this thesis. It is discussed how higher education students conceptualize constructivist assumptions and how does this affect their learning.

Chapter 2

Students' conceptions of distinct constructivist assumptions

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ABSTRACT

The present studies were conducted to investigate students' conceptions of distinct constructivist assumptions. To that end, a questionnaire was developed containing statements about four constructivist assumptions: The importance of knowledge construction, cooperative learning, self-regulation, and the use of authentic problems. Furthermore, self-perceived inability to learn and motivation to learn were also examined. The studies demonstrate that the questionnaire was able to unearth students' conceptions of the distinctiveness of constructivist assumptions. Students were able to identify the six factors underlying the questionnaire, as indicated by the fit of the hypothesized model. The test for measurement invariance showed that factor loadings were equivalent across groups and that the questionnaire's underlying factor structure gave evidence of cross-validation. Testing alternative models with one and three latent factors resulted in poor model fits, supporting the questionnaire's latent factor structure. The questionnaire developed appeared an adequate instrument to investigate students' conceptions of constructivist assumptions of learning and students acknowledge the importance of these assumptions as distinct influences on their learning process.

1. INTRODUCTION

1.1 Constructivism

An important restriction of education is that teachers cannot simply transmit knowledge to students, but students need to actively construct knowledge in their own minds. That is, they discover and transform information, check new information against old, and revise rules when they do not longer apply. This constructivist view of learning considers the learner as an active agent in the process of knowledge acquisition.

Constructivist conceptions of learning have their historical roots in the work of Dewey (1929), Bruner (1961), Vygotsky (1962), and Piaget (1980). More recent views have been put forward by for instance Bednar, Cunningham, Duffy, and Perry (1992) and von Glasersfeld (1995). Bednar and colleagues (1992) have proposed several implications of constructivist theory for instructional developers stressing that learning outcomes should focus on the knowledge construction process and that learning goals should be determined from authentic tasks with specific objectives. Similarly, von Glasersfeld (1995) states that learning is not a stimulus-response phenomenon, but a process that requires self-regulation and the development of conceptual structures through reflection and abstraction. It is important to note, in this respect, that constructivism is embodied in numerous ways and that these different views share important overlaps, but also contain major differences (For a detailed discussion about the range of constructivist authors, see Phillips, 1995).

The purpose of this article is to highlight the common ground in the various views on constructivism, acknowledging that there are points of divergence. The views promoted by the authors above rest on a number of shared assumptions that should be considered in learning (Marshall, 1992; Woolfolk, 2004).

1.2 Constructivist assumptions for learning

First of all, they agree on the assumption that the acquisition of knowledge is a process of knowledge construction. That is, understanding subject matter is a function of knowledge construction and transformation, not merely information acquisition and accumulation (Blumenfeld, 1992). The core element of this conception is that learners interpret new information using knowledge that they have acquired previously. In other words, learners activate prior knowledge and try to relate new information to this existing knowledge (Kintsch, 1994). This process, which is called elaboration (Anderson & Reder, 1979), can be accomplished by discussions, asking critical questions, answering questions, creating analogies, and by giving explanations (Weinstein & Mayer, 1986). It has been shown that elaboration facilitates and enhances subsequent retrieval of information because multiple redundant retrieval paths are constructed (Chi, de Leeuw, Chiu, & LaVancher, 1994). Furthermore, if learning builds upon what students already know, not only retention, but also interest and motivation increase as well (Forbes, Duke, & Prosser, 2001).

The importance of cooperative learning is a second assumption put forward by constructivist theorists. Social interactions with fellow-students, teachers, and others contribute to the construction of knowledge (Steffe & Gale, 1995). Although constructivists differ with regard to the extent that cooperation contributes to knowledge acquisition, they share the idea that social negotiation and interaction is an important factor in this process (Greeno, Collins, & Resnick, 1996). Social interactions among students also facilitate communication of ideas about subject matter, because their level of understanding is more similar to each other's knowledge level compared to the teacher's (Slavin, 1996). Furthermore, cooperative learning provides opportunities for student discussions that can be used as an assessment of students' prior knowledge. These discussions, in turn, provide students with both the direction and extent of study that needs to be undertaken to acquire a deep understanding of the subject matter to be studied.

A third assumption of constructivism is that students use their meta-cognitive skills to set academic learning goals or, in other words, that they are self-regulated learners (Zimmerman, 1989). Self-regulation is viewed as the key to successful learning in school and beyond (Boekaerts, 1999). It presupposes various aspects such as goal setting, self-observation, self-assessment, and self-reinforcement, all of which are believed to influence learning. Effective self-regulation implies having goals and the motivation to attain them, which requires more from learners than just the planning, monitoring, and evaluation of their behaviour (Winne, 1995a). Regulating one's study actions is insufficient, the underlying cognitions, affects, beliefs, and intentions need to be regulated as well to have a positive influence on achievement (Schunk & Zimmerman, 1994). Studies on self-regulation have demonstrated that effective learners possess and use a substantial knowledge base about learning that allows them to organise, plan, and monitor most aspects of learning tasks in a task-appropriate way (Cantwell & Moore, 1996).

Finally, constructivists concur with the assumption that learning situations preferably have to resemble real-life or authentic situations. By confronting students with complex, ill-structured problems (i.e., similar to the kinds of problems they will face in their future profession), this resemblance can be attained. Ill-structured problems challenge students' reasoning or problem-solving skills and they can operate as organizers for students' learning (Voss & Post, 1988; White & Frederiksen, 1998). By solving problems, learners develop understanding of subject matter. They apply and represent their ideas in a manner similar to the way in which experienced individuals in the field generate and use knowledge (Blumenfeld, 1992). Skills to solve problems, encountered in learning situations, can be used in future professional problem-solving situations. The more similar learning and professional situations are, the more likely it is that transfer of knowledge will occur (e.g., Mayer & Wittrock, 1996).

An extensive body of research substantiates the idea that knowledge construction, cooperation, self-regulation, and transfer appropriate problems are important aspects of learning and promote achievement (Greeno et al., 1996; Pintrich, Smith, Garcia, & McKeachie, 1993; Schunk, 1996; Schunk & Zimmerman, 1994).

Although constructivists agree that these assumptions, at least to some extent, should be considered while creating learning environments for students, the assumptions carry a caveat with them. After all, a great deal of responsibility is required from learners in terms of being socially apt, self-regulated knowledge constructors. Some learners may experience this as a challenge and as part of their learning process, but others may relapse into uncertainty, confusion, and even anxiety (Duke, Forbes, Hunter, & Prosser, 1998). Experiencing full responsibility for your own learning in a constructivist curriculum can be stressful for some students. Therefore, self-perceived inability to learn was another factor that was examined in the present study. Self-perceived inability to learn refers to feelings of doubt concerning one's own learning capacities.

Another widely acknowledged factor influencing students' learning in constructivist, but also in conventional curricula, is motivation to learn. Motivation can affect what, when, and how students learn (Schunk, 1991). It can influence both new learning and the performance of previous learned skills, strategies, and behaviours (Pintrich & Schunk, 1996). Individual motivational orientations and beliefs about learning are relevant to cognitive engagement and performance (Ames & Archer, 1988; Pintrich & de Groot, 1990). Most contemporary views of motivation emphasize these individual orientations and focus on attributions, self-efficacy beliefs, mastery and performance goals, intrinsic and extrinsic motivation, and relationships among motivation and self-regulation, learning strategies, and academic performance (Ames & Archer, 1988; Blumenfeld, 1992; Pintrich, 1999, 2003). However, not only individual processes, but also social processes and relationships influence students' motivation to learn and to achieve (Ryan, 2000; Wentzel, 1999).

1.3 Why studying conceptions of constructivist learning?

In summary, the assumptions of knowledge construction, cooperation, self-regulation, and the use of authentic problems, as well as self-perceived inability to learn and motivation to learn are considered crucial aspects of students' knowledge acquisition processes. However, little is known about the students' perspective on these aspects of learning. Does the way students perceive these elements contribute to or obstruct their own learning? The study of students' conceptions of constructivist learning is important for two reasons. First, the research literature reports associations among students' conceptions of issues related to learning and education, and learning styles (Vermunt, 1992), approaches to learning (Crawford, Gordon, Nicholas, & Prosser, 1994), learning activities (Klatter, Lodewijks, & Aarnoutse, 2001), levels of processing (Säljö, 1979), social-communicative competence (Bakx, Vermetten, & Van der Sanden, 2003), learning outcomes (Van Rossum & Schenk, 1984), cognitive engagement and classroom performance (Ames & Archer, 1988), and academic achievement (Cantwell & Moore, 1996; McLean, 2001; Pintrich et al., 1993; Pintrich & de Groot, 1990). Also in the field of epistemological beliefs (i.e., students' conceptions of knowledge), numerous relations with the variables mentioned above have been established (e.g., Hofer & Pintrich, 2002).

Second, various studies report discrepancies between educational intentions and students' perceptions of these intentions. A study of Forbes et al. (2001), for example, demonstrated that students experienced learning modalities (e.g., lectures, laboratory sessions) in ways that were different from their purpose. The aim of each modality was to prepare students for practice, but only one modality actually did in the eyes of the students. Similarly, in their study on received feedback in a problem-based curriculum, Parikh, McReelis, and Hodges (2001) found that students never labelled the use of marks, grades, and written feedback as helpful feedback, although these forms of feedback are still frequently used as such. Furthermore, a study of Duke et al. (1998) on students' conceptions of problem-based learning showed that a number of students did not recognize the problem-based learning environment as one that would lead to the development of knowledge and skill. These students felt unsupported and isolated, and viewed learning as something they did on their own.

Moreover, a study of students' constructivist learning assumptions is new in the domain. The embodiment of constructivism is very different (e.g., Phillips, 1995) and the shared ideas among these different appearances of constructivism often fall into the background compared to their points of divergence. It is, however, insightful for learning processes to bring the core common assumptions to the fore and develop an instrument that is able to do so. To our knowledge, no research has yet tackled this issue. The present study is a first start to map students' conceptions of constructivist learning.

1.4 The present study

The purpose of the present study was to investigate students' conceptions of the constructivist assumptions of the role of knowledge construction, cooperative learning, self-regulation, and the use of authentic problems, as well as self-perceived inability to learn as an undesirable influence and motivation to learn as a positive influence in students' learning environments. Do students identify these principles as distinct aspects of their own learning process? To that end, two groups of university students were presented with a questionnaire containing statements about their learning. Students' responses were analyzed using confirmatory factor analysis techniques. Study 1 was designed to investigate the distinctiveness that students ascribe to knowledge construction, cooperative learning, self-regulation, and the use of authentic problems, as well as how students stand in relation to self-perceived inability to learn and motivation to learn. A model that contained these factors was tested. In Study 2, this procedure was replicated in a second, independent student population to cross-validate the proposed model. Finally, two alternative models were investigated in search for additional support for the questionnaire's underlying structure.

2. STUDY 1

2.1 Method

2.1.1 Participants

Participants were 209 students enrolled in the first-year psychology curriculum of Erasmus University Rotterdam, the Netherlands. 143 students were female, 66 were male. The mean age of the students was 20.01 ($SD = 2.94$).

2.1.2 Materials

A 95-item questionnaire was developed for this first study to measure four constructivist learning assumptions: Knowledge construction, cooperative learning, self-regulation, and use of transfer appropriate or authentic problems, as well as the constructs of self-perceived inability to learn and motivation to learn.

All 95 statements had to be rated on a Likert-scale ranging from -3 (entirely disagree) to +3 (entirely agree) with 0 reflecting a neutral opinion about a particular statement. The knowledge construction assumption was represented by statements such as "Trying to relate the subject-matter to what you have learned before will lead to a better understanding". An example of a statement reflecting the cooperative learning assumption was "Discussing subject-matter with fellow-students leads to a better understanding". The self-regulation assumption was measured by statements such as "When students have to deal with difficult subject matter, they have to take responsibility themselves to read a chapter or article once again, they should not wait for their teacher's explanations". Items such as "Above all, acquired knowledge has to be useful for practice situations" served as a measurement of the assumption of the use of authentic problems. Statements reflecting self-perceived inability to learn were for example "I feel often insecure about what exactly I have to study". Finally, the assumption about motivation to learn was represented by statements such as "I seldom feel like studying".

The questionnaire in its preliminary form had been pilot tested in December 2002 on 202 psychology students of Erasmus University Rotterdam. Their mean age was 20.8 ($SD = 2.86$) and 137 students were female, 65 were male. These students did not participate in Study 1 or Study 2. This test revealed in the first place that the questionnaire needed shortening, since a substantive number of students complained about the number of questions. Data from this pilot study were analyzed using a structural equation modelling approach. The results showed a poor fit between the six underlying constructs and the items: $\chi^2(4355, N = 202) = 8249$, $p < .001$, Tucker-Lewis index (TLI) = .44, comparative fit index (CFI) = .45 (explanation of these indices will be given in the Analysis section). Due to the need to shorten the questionnaire and due to the poor fit between the items and the underlying constructs, the questionnaire's model was modified by examination of the items' modification indices (Byrne, 2001). This exploratory analysis resulted in the elimination of 40 items with high modification index values. The deleted items often let room for multiple interpretations or were mere replications of other items. The remaining items were clustered in groups of three or four based on semantic overlap, a technique called item parcelling (Bandalos & Finney, 2001; Little, Cunningham, Shahar, & Widaman, 2002). Parcelling is a measurement practice that is particularly used with latent-variable analyses. A parcel can be defined as an aggregate-level indicator, comprised of the sum (or average) of two or more items (Little et al., 2002, p. 152). A detailed description of each of the 18 parcels, accompanied with item examples, is presented in Appendix A. The resulting model is presented in Figure 1. For simplicity, correlations among the six constructs were omitted in Figure 1.

2.1.3 Procedure

The questionnaire was administered to the participants of Study 1 at the start of the 2003-2004 academic year. The questionnaire could be filled out at home or at campus. The questionnaire's instruction stated that there were no right or wrong answers to the items, all answers were correct as long as they reflected students' personal opinions. No information was given about the constructs underlying the questionnaire. Filling in the questionnaire took approximately ten to fifteen minutes.

2.1.4 Analysis

Responses to negatively stated items (n = 23) were reversed so that for all items the highest response score was indicative of a positive rating of each of the six latent constructs.

Data were analyzed using a structural equation modelling approach to test whether the underlying structure fitted the assumptions. In other words, a confirmatory factor analysis was conducted on the model presented in Figure 1. Maximum likelihood estimations were used for the estimation of the model's parameters. For the evaluation of the model presented in this study, two groups of fit indices, absolute and incremental, were selected.

In the present study, χ^2, accompanied by degrees of freedom, sample size, and p-value, as well as the root mean square error of approximation (RMSEA, Steiger, 1990) were used as absolute fit indices. χ^2 has been the traditional statistic to test the closeness of fit between an observed and predicted covariance matrix. A small χ^2-value, relative to the degrees of freedom (i.e., ≤ 3) is an indication of good fit and vice versa (Kline, 1998; Byrne, 2001). RMSEA appears to be sensitive to model specification, minimally influenced by sample size, and not overly influenced by estimation method and was therefore included (Fan, Thomson, & Wang, 1999). The lower the value of RMSEA, the better the fit, with a cut-off value close to .06 (Hu & Bentler, 1999).

Two incremental fit indices were included: The Tucker-Lewis index (TLI, Tucker & Lewis, 1973) and the comparative fit index (CFI, Bentler, 1990). Both indices range from 0 to 1, with higher values indicating a better fit. Values greater than .90 are traditionally associated with well-fitting models (Bentler, 1990; Marsh et al., 1994), although more recently, cut-off values close to .95 or .96 are suggested (Byrne, 2001; Hu & Bentler, 1999).

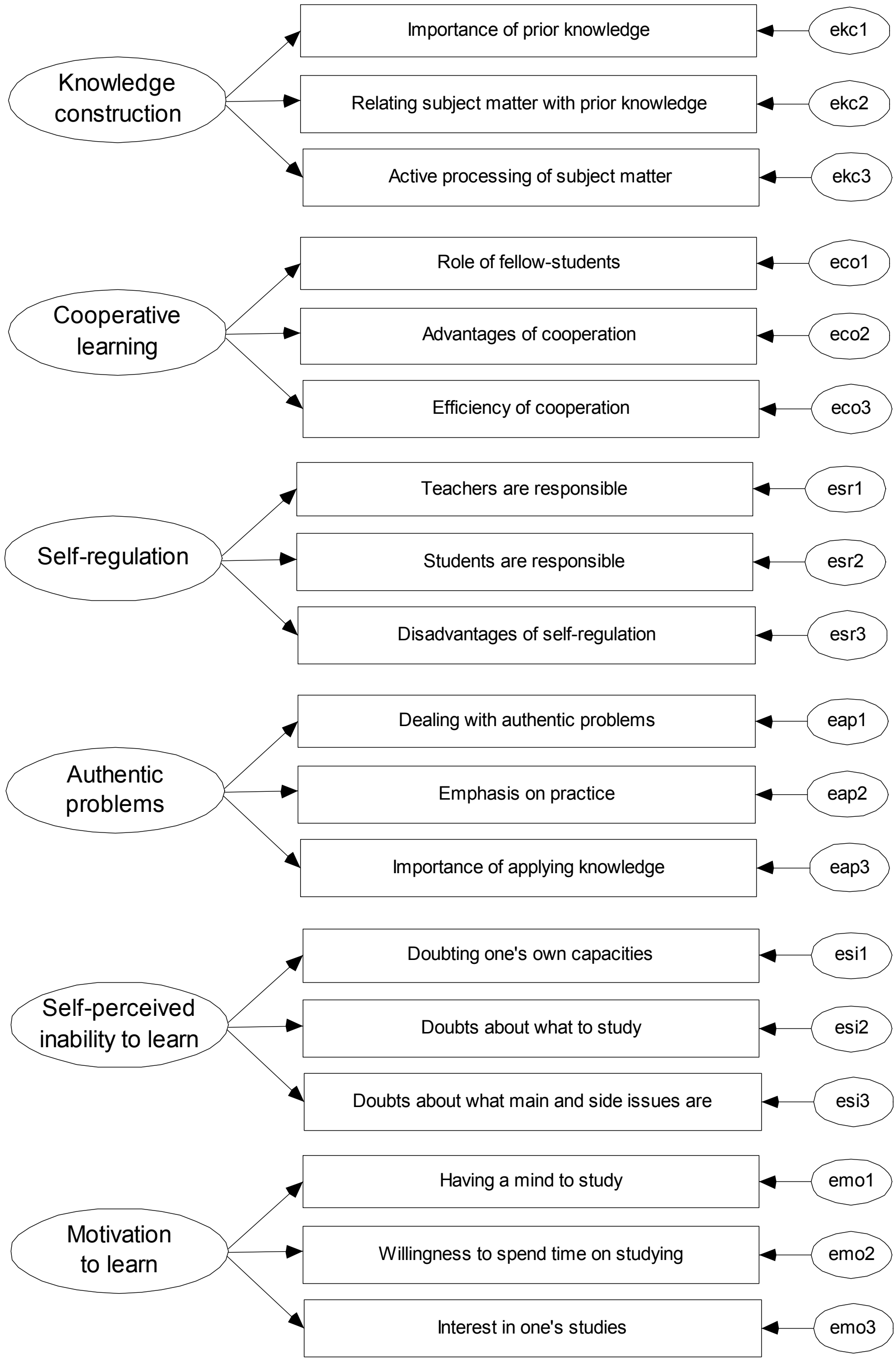

Figure 1: Model with the 6 underlying assumptions

Note: Each assumption consists of three item parcels and their associated error terms. For clarity, double arrows indicating correlations among the six latent variables were omitted.

Table 1: Standardized regression weights of the eighteen parcels in Study 1

		Knowledge construction	Cooperative learning	Self-regulation	Authentic problems	Self-perceived inability to learn	Motivation to learn
Knowledge construction	1. Importance of prior knowledge	.533					
	2. Relating subject matter	.645					
	3. Active processing of subject matter	.715					
Cooperative learning	4. Role of fellow-students		.760				
	5. Advantages of cooperation		.594				
	6. Efficiency of cooperation		.822				
Self-regulation	7. Teachers are responsible			.801			
	8. Students are responsible			.520			
	9. Disadvantages of self-regulation			.730			
Authentic problems	10. Dealing with authentic problems				.581		
	11. Emphasis on practice				.695		
	12. Importance of applying knowledge				.508		
Self-perceived inability to learn	13. Doubting one's own capacities					.683	
	14. Doubts about what to study					.881	
	15. Doubts about what main and side issues are					.509	
Motivation to learn	16. Having a mind to study						.814
	17. Willingness to spend time on studying						.723
	18. Interest in one's studies						.713

Note: All regression weights are significant at the .01 level

2.2 Results and Discussion

Data were analyzed initially to examine the descriptive statistics for each item and the composed parcels. No outliers were found. The total scores of each of the eighteen parcels described in Appendix A were distributed normally. Next, reliability analyses were carried out. The reliability of the six latent constructs was assessed using coefficient H (Hancock & Mueller, 2001), which captures the degree of replicability of a construct based on its measured indicators. In the current study the construct reliability values were .68, .80, .86. .64, .82, and .80 respectively, reflecting good construct reliability. Correlation and covariance matrices were computed for all the input variables. Covariance matrices were used to perform maximum likelihood linear structural relations analyses. For these analyses, Amos 5.0 (Arbuckle, 2003) was used.

The stability of the constructed model (see Figure 1) was tested into a new, independent sample. Analysis of the hypothesized structural model with the covariance matrix of the student population (*N* = 209) resulted in a CFI of .91, a TLI of .88, and a RMSEA of .06. These indices indicate a reasonable fit of the specified model with the data. χ^2 analysis, $\chi^2(120, N = 209) = 221.26, p < .001$, however, did not confirm that the specified model was satisfying. In this respect, it should be noted that the χ^2 test of statistical significance has several limitations. Not only is the test based on restrictive assumptions that are typically not met, but also the intent of a model is to provide an approximation to reality rather than to fully represent all the complexity in the observed data. Therefore, more emphasis should be placed on the other indices (Marsh et al., 1994).

Table 1 shows the regression weights of the eighteen parcels. All parcel loadings were significant, indicating that every parcel contributed significantly to its latent construct.

Correlations among the six latent variables are displayed in Table 2. Higher levels of belief in the importance of knowledge construction appeared to be associated with higher levels of cooperation, motivation to learn, authentic problems, and lower levels of self-perceived inability to learn. Furthermore, the more students agreed on the construct of self-regulation, the more they appeared motivated, but the less they were convinced of the use of authentic

Table 2: Factor correlations in Study 1

	1	2	3	4	5	6
1. Knowledge construction	---					
2. Cooperative learning	.574**	---				
3. Self-regulation	.084	.349**	---			
4. Authentic problems	.595**	.139	-.271*	---		
5. Self-perceived inability to learn	-.232*	-.271**	-.606**	.062	---	
6. Motivation to learn	.340**	.352**	.296**	.061	-.350**	---

Note: *Correlation is significant at the .05 level. ** Correlation is significant at the .01 level problems and the less uncertain they reported to be. Higher levels of motivation to learn were also associated with lower levels of self-perceived inability to learn. Significant correlations were found between cooperative learning and self-regulation, motivation to learn, and self-perceived inability to learn.

In summary, a hypothesized model consisting of the factors knowledge construction, cooperative learning, self-regulation, the use of authentic problems, self-perceived inability to learn, and motivation to learn, was tested. The results revealed a reasonable fit of the model with the data. This finding implies that students recognize the distinctiveness of the six latent factors.

3. STUDY 2

The second study was conducted to test measurement invariance across the student populations of Study 1 and Study 2. In seeking evidence of multi-group measurement invariance, the answers to two questions are particularly of interest. First, do the items comprising the questionnaire operate equivalently across different groups? In other words, is the model group-invariant and, hence, is there conceptual agreement with respect to the questionnaire items across groups? Second, does the factorial structure of the questionnaire replicate across different groups? This latter question addresses the issue of cross-validation (Byrne, 2001).

3.1 Method

3.1.1 Participants

Participants of the second study included 107 first-year psychology students of a different university, Utrecht University in the Netherlands. This university is not affiliated with Erasmus University Rotterdam. 87 students were female, 20 were male. Their mean age was 19.05 (*SD* = 2.73).

3.1.2 Materials

The same questionnaire as in Study 1 was used. Fifty-five statements had to be rated on a 7-point Likert-scale, ranging from –3 (entirely disagree) to +3 (entirely agree) with 0 reflecting a neutral opinion about a particular statement.

3.1.3 Procedure

Participants of Study 2 were also tested at the beginning of the 2003-2004 academic year. The same instructions were given as in Study 1.

3.1.4 Analysis

The same analyses as in Study 1 were applied to the data of the second study. The χ^2 statistic, together with the RMSEA, TLI, and CFI were used as fit indices. With respect to measurement invariance across both student populations it is commonly accepted that sufficient measurement invariance is established when the factor loadings are invariant across groups. If this is the case, conceptual agreement with regard to the importance attributed to items, is reached (Cheung & Rensvold, 1999; Marsh, 1994). Therefore, proceeding as Cheung and Rensvold (1999) and Byrne (2001) suggest, the model with no between-group invariance was tested first, followed by the testing of the equality of factor loadings across both student populations (i.e., multiple population analysis). Specifically, the test for the validity of the structure of the hypothesized model shown in Figure 1 was repeated, now across the two student populations simultaneously. The fit of this simultaneously estimated model provided the baseline value against which the subsequently specified model with fixed factor loadings was compared.

3.2 Results and Discussion

The descriptive statistics of each item and the resulting parcels revealed no outliers. Total scores of the eighteen parcels followed a normal distribution. Construct reliability values (coefficient H; Hancock & Mueller, 2001) for knowledge construction, cooperative learning, self-regulation, authentic problems, self-perceived inability to learn, and motivation to learn were .70, .76, .60, .63, .85, and .84 respectively. Similar to Study 1, maximum likelihood linear structural relations analyses were conducted. Results showed a CFI of .94, a TLI of .92, and a RMSEA of .05, indicating a fairly good fit. Results of the χ^2-analysis were: $\chi^2(120, N = 107) = 153.67$, $p < .05$. Standardized regression weights are shown in Table 3.

As in Study 1, every parcel contributed significantly to its latent construct. In general, factor correlations displayed in Table 4 showed the same pattern as in Study 1. Again, higher levels of knowledge construction appeared associated with higher levels of motivation to learn and the use of authentic problems. Self-regulation showed a significant, positive correlation with motivation to learn and negative associations with the use of authentic problems and self-perceived inability to learn. Higher levels of motivation to learn were associated with lower levels of self-perceived inability to learn. Contrary to Study 1, however, no significant correlations were found between cooperative learning and the five other latent constructs.

To measure conceptual agreement across both student groups concerning the questionnaire items, measurement invariance was examined. The test for the validity of factorial structure conducted across the two student populations simultaneously, resulted in a CFI of .92, a TLI of .89, and a RMSEA of .04. These values are indicative that the hypothesized model of Figure 1 is fairly well fitting the two student groups. The factor structure of the questionnaire repeats itself over different populations, giving evidence of cross-validation. The χ^2 value of

Table 3: Standardized regression weights of the eighteen parcels in Study 2

		Knowledge construction	Cooperative learning	Self-regulation	Authentic problems	Self-perceived inability to learn	Motivation to learn
Knowledge construction	1. Importance of prior knowledge	.542					
	2. Relating subject matter	.787					
	3. Active processing of subject matter	.475					
Cooperative learning	4. Role of fellow-students		.678				
	5. Advantages of cooperation		.707				
	6. Efficiency of cooperation		.762				
Self-regulation	7. Teachers should facilitate			.614			
	8. The student is responsible			.550			
	9. Disadvantages of self-regulation			.530			
Authentic problems	10. Dealing with authentic problems				.564		
	11. Emphasis on practice				.720		
	12. Importance of applying knowledge				.337		
Self-perceived inability to learn	13. Doubting one's own capacities					.864	
	14. Doubts about what to study					.827	
	15. Doubts about what main and side issues are					.632	
Motivation to learn	16. Having a mind to study						.734
	17. Willingness to spend time on studying						.676
	18. Interest in one's studies						.871

Note: All regression weights are significant at the .01 level

Table 4: Factor correlations in Study 2

	1	2	3	4	5	6
1. Knowledge construction	---					
2. Cooperative learning	.281	---				
3. Self-regulation	.059	-.142	---			
4. Authentic problems	.565*	.144	-.560*	---		
5. Self-perceived inability to learn	-.470**	-.019	-.351*	.107	---	
6. Motivation to learn	.539**	.028	.497**	-.037	-.666**	---

Note: * Correlation is significant at the .05 level. ** Correlation is significant at the .01 level

375.04 ($N = 316$, i.e., the two student populations together) with 240 degrees of freedom provided the baseline value against which the model with fixed factor loadings was compared. This fixed factor model generated a CFI of .91, a TLI of .89, and a RMSEA of .04.

Table 5 gives a summary of the χ^2 values and the χ^2 difference, compared with the unconstrained model. The χ^2 difference between the two models was not significant, indicating that the factor loadings were invariant across the two student populations. This result implies that the relations between the parcels and their latent constructs are equal across different groups.

Table 5: Summary of goodness-of-fit statistics for tests of invariance

Model description	χ^2	Df	$\Delta\chi^2$	Δ Df	Statistical significance
Hypothesized model (Figure 1)	375.04	240	---	---	---
Model with factor loadings constrained equal	393.72	252	18.68	12	NS

Note: χ^2 = Chi-square, $\Delta\chi^2$ = difference in chi-square values between models; Δ Df = difference in number of degrees of freedom between models; NS = not significant at the .05 level.

Study 2 was conducted to test measurement invariance. It was investigated if the response patterns to the items were equivalent across two student populations in order to conclude conceptual agreement across different groups with respect to these items. Furthermore, it was tested if the factor structure of the questionnaire's model could be replicated in a different student population. Results of Study 2 imply that the factor loadings were equivalent across groups and the factor structure gave evidence of cross-validation. These findings indicate that the questionnaire is an adequate instrument to measure students' conceptions of the latent constructs of knowledge construction, cooperative learning, self-regulation, the use of authentic problems, self-perceived inability to learn, and motivation to learn.

Table 6: Summary of goodness-of-fit statistics for both alternative models

Model description	χ^2	Df	p	CFI	TLI	RMSEA
Alternative model with one latent variable (Figure 2)						
- In Study 1 ($N = 209$)	775.05	135	< .01	.40	.32	.15
- In Study 2 ($N = 107$)	388.80	135	< .01	.51	.45	.13
Alternative model with three latent variables (Figure 3)						
- In Study 1 ($N = 209$)	534.08	132	< .01	.62	.56	.12
- In Study 2 ($N = 107$)	297.91	132	< .01	.68	.63	.11

Note: χ^2 = Chi-square, Df = degrees of freedom, p = significance level of the Chi-square test, CFI = comparative fit index, TLI = Tucker-Lewis index, and RMSEA = root mean square error of approximation.

4. TESTING ALTERNATIVE MODELS

Finally, two alternative (i.e., competing) models were tested in order to check whether the six-factor structure provided the most appropriate model in representing our data. Alternative models always need to be grounded in theory (Byrne, 2001). Therefore, the first competing model is a model with one latent factor, namely constructivism. As outlined in the Introduction, all six latent factors of Figure 1 could be captured under the umbrella 'constructivism'. This model is depicted in Figure 2.

Furthermore, a second alternative model is proposed with three latent factors. Since knowledge construction, cooperative learning, self-regulation, and the use of authentic problems are core constructivist assumptions, they could be summarized in a latent factor 'constructivism'. Self-perceived inability to learn and motivation to learn, although clearly related to constructivism, could be considered as two distinct factors included in our questionnaire. The resulting model is shown in Figure 3. Both alternative models were tested in the student populations of Study 1 and Study 2.

Table 6 shows the goodness-of-fit characteristics of the proposed alternative models. All fit measures give evidence of a poor model fit with the data in both student populations. The poor fit of both competing models gives additional support for the questionnaire's latent factor structure depicted in Figure 1.

5. GENERAL DISCUSSION

The present studies were conducted to shed light on students' conceptions of constructivist assumptions. Six factors that were demonstrated to be distinct influences on students' learning process in earlier research were identified and included in a questionnaire. In the first study, the questionnaire was given to a group of students to test the hypothesized structure underlying the questionnaire. In the second study, measurement invariance across

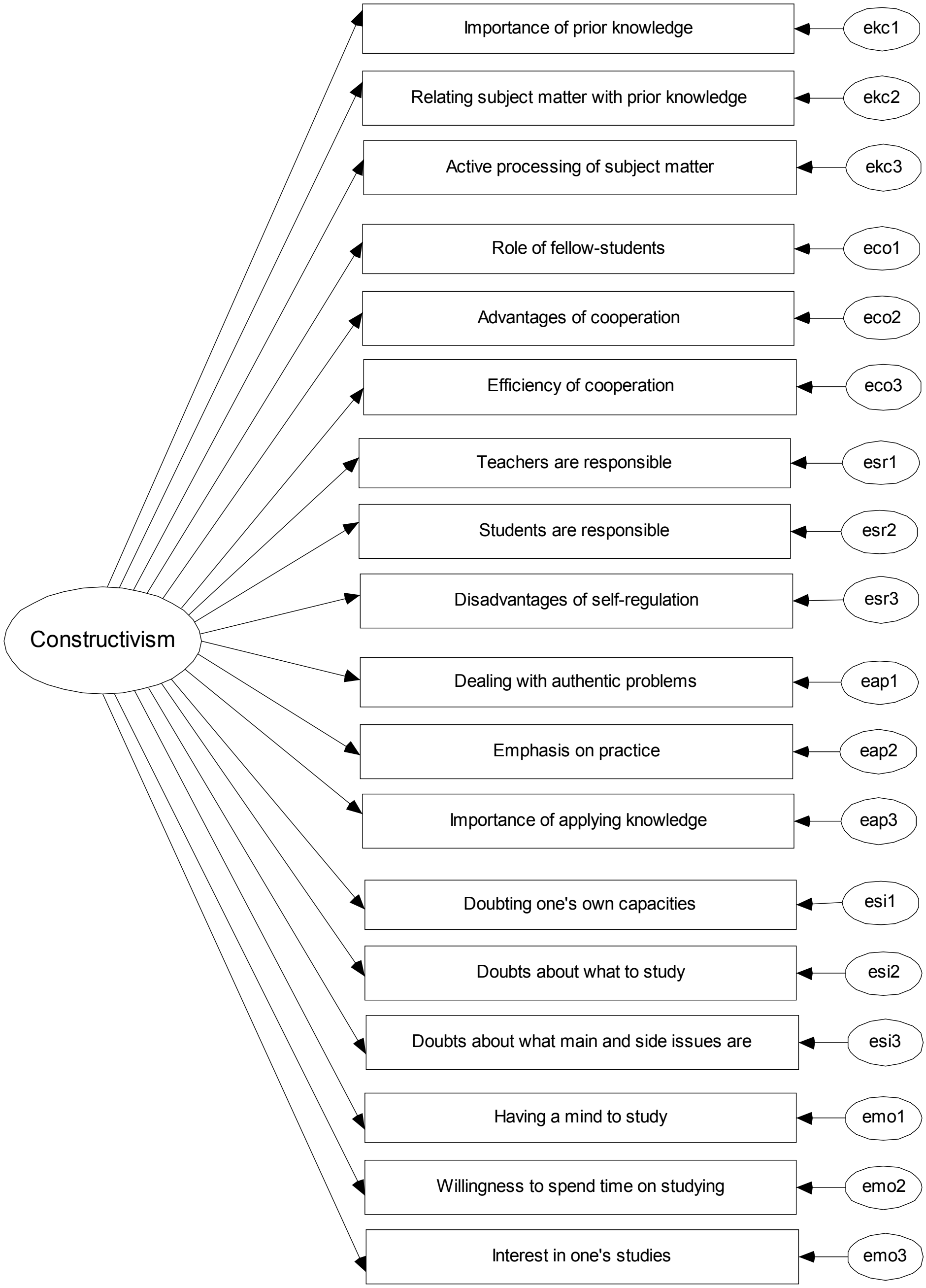

Figure 2: Alternative model with 1 latent factor 'constructivism'

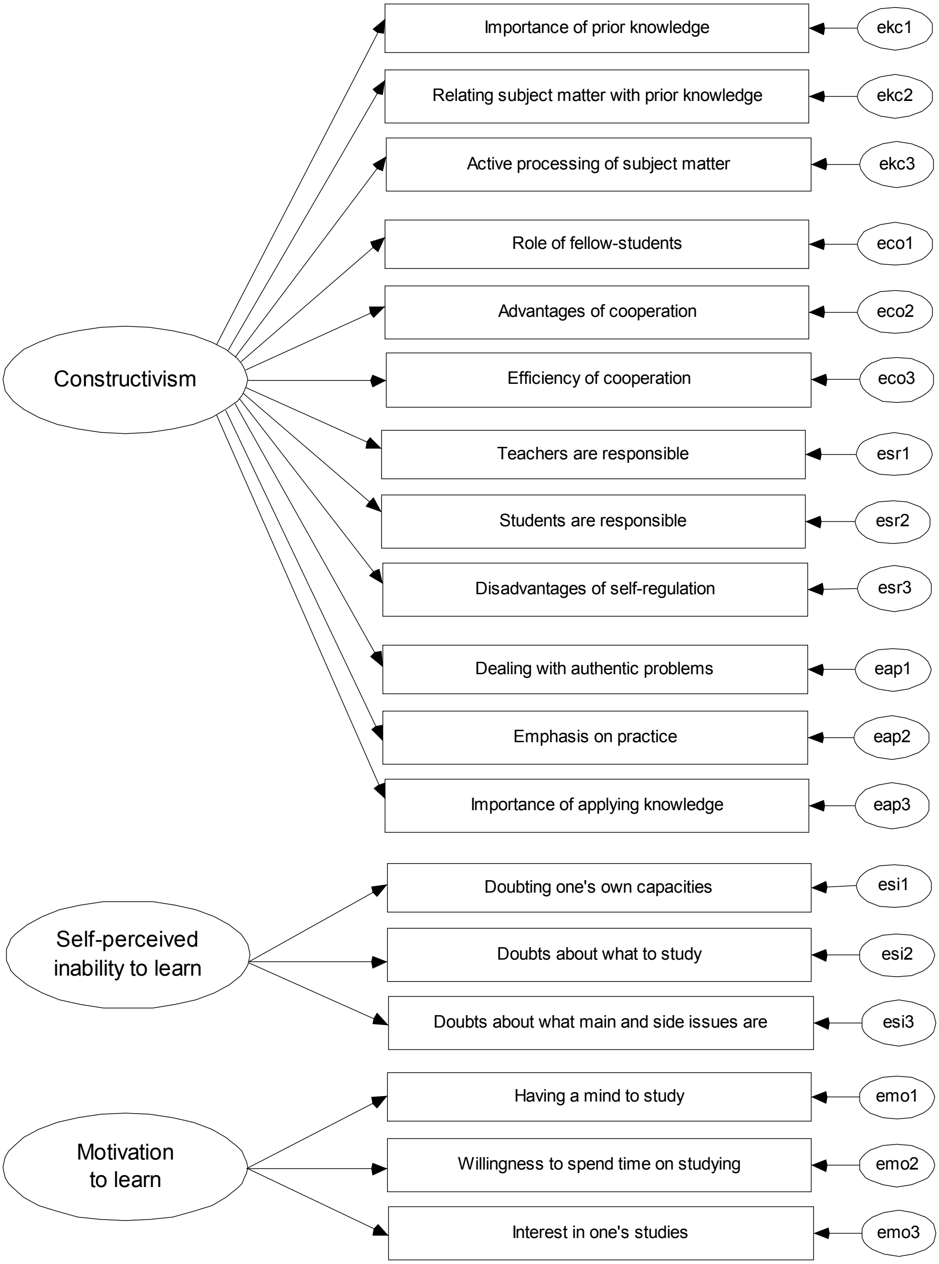

Figure 3: Alternative model with 3 latent factors

two student populations was tested to gain information about the equivalence of the items across different populations as well as about the cross-validation of the factor structure of the questionnaire. Finally, two alternative models were investigated to test the questionnaire's underlying structure.

5.1 Development of a questionnaire to measure students' conceptions of constructivist learning

The results of these studies indicate that the questionnaire was able to measure students' conceptions of the distinctiveness of constructivist assumptions. Students were able to identify the six factors underlying the questionnaire, as indicated by the fit of the hypothesized model. Data of two independent student populations fitted this model fairly well. These findings indicate that students acknowledge the distinctiveness of knowledge construction, cooperative learning, self-regulation, the use of authentic problems, self-perceived inability to learn, and motivation to learn as distinct influences on their learning process. Furthermore, construct reliability values of the six scales gave evidence of good reliability in terms of internal consistency. Results of the test for measurement invariance revealed that factor loadings were equivalent across groups. Therefore, it can be concluded that conceptual agreement about the items was established. The questionnaire's factor structure also stood up to cross-validation. Finally, two alternative models with a different latent factor structure were tested and demonstrated poor fit with the data. This test provided additional support for the questionnaire's structure with six latent factors. In summary, the questionnaire developed appeared an adequate instrument to measure students' conceptions of constructivist assumptions. The present studies confirmed that students recognize the distinctiveness of constructivist assumptions.

5.2 Correlations among the questionnaire's factors

Factor correlations showed that conceptions of self-perceived inability to learn could indeed be seen as an undesirable by-product with respect to students' learning process, as it has negative associations with conceptions of knowledge construction and self-regulation, as well as with motivation to learn in both student populations. This finding is in line with previous studies that have reported that many students experience considerable uncertainty and even anxiety about what and how much they should study (Duke et al., 1998). In the first study, self-perceived inability to learn had also significant negative associations with cooperative learning. However, it is argued that students' encounter with this uncertainty can be beneficial for their professional development. After all, students have to work hard to deal with this uncertainty and by doing so, they may come to a degree of acceptance or tolerance of uncertainty, which makes them less averse to it in other settings (Block, 1996). Furthermore, to become a self-regulated learner, one needs a certain degree of motivation to learn. Pintrich and colleagues (e.g., Pintrich, 1999; Pintrich & de Groot, 1990) have already frequently established the connection between self-regulation and motivation in previous studies. The present studies showed that this connection also appeared valid for students' *conceptions* of self-regulated learning and motivation to learn. The results of Study 1 showed that conceptions of self-regulation go hand in hand with conceptions of interactive behaviour, as is reflected by cooperative learning. Cooperative learning, in turn, requires a certain level of motivation, or the reverse, by having students work together towards a common goal, they may be motivated to express norms favouring academic achievement and to reinforce one another for academic efforts (Slavin, 1996). A rather new line of research in this area has demonstrated that social goals, such as making friends, play a crucial role in motivation (Wentzel, 1999). Peer students appear important elements for the shaping and development of motivation (Ryan, 2000). This association between conceptions of cooperative learning and motivation to learn, however, became only apparent in Study 1. Motivated and social-minded students will, furthermore, more easily agree on the fact that they have to be active learners. They are expected to use their prior knowledge and to engage in activities such as asking questions, creating analogies, and discussing the subject matter with fellow-students (Weinstein & Mayer, 1986). The more students are convinced of the importance of being active knowledge constructors, the more they agree on the benefit of authentic problems. Finally, the negative association between conceptions of authentic problems and conceptions of self-regulation is somewhat surprising. Authentic problems should challenge students and they should serve as an organizer and hence as a peg to hang students' self-regulated learning activities on. Unfortunately, this relation could not be established in the present study.

5.3 Limitation

There is a limitation to these findings, because the parcels included in the questionnaire, might not have been exhaustive. However, it should be noted that an unequivocal definition of constructivism, nor an instrument to measure constructivist concepts altogether, nor an instrument to measure students' conceptions of these constructivist concepts, do not exist. Therefore, we identified and included four latent factors in the questionnaire that are established concepts in constructivism, together with self-perceived inability to learn and motivation to learn. We selected certain aspects of every latent construct for use in the questionnaire. Students' conceptions of constructivist assumptions and inability and motivation to learn are pivotal in the studies that were conducted, not the measurement of the constructs themselves. Conclusions from this study are hence focused on students' conceptions of the selected six latent constructs and their aspects. Several researchers have proposed other subdivisions of constructs such as self-regulation (e.g., Boekaerts, 1999; Pintrich, 1999; Schunk & Zimmerman, 1994) and motivation (e.g., Pintrich & de Groot, 1990) and have developed instruments to measure them. Nevertheless, results showed that the created questionnaire was successful in mapping students' conceptions of the constructivist aspects included, as well as their conceptions of self-perceived inability to learn and motivation to learn.

5.4 Further research

Further research should investigate the predictive validity of the questionnaire with respect to academic performance. If beliefs such as the ones measured with the present questionnaire contribute to learning, then their influence should be reflected in student achievement. In addition, students enrolled in a constructivist curriculum might respond differently with respect to the dimensions unearthed in this study compared to students enrolled in a conventional curriculum. When students get more experience with certain constructivist assumptions, their points of view towards them might change, either in a positive or a negative direction. Furthermore, certain assumptions such as the use of authentic problems will become fully clear for students when they encounter real-life situations, for example during internships. The application of the acquired knowledge and skills is very important during this phase of students' academic program. Probably, students can judge the importance of the use of authentic problems at best at this point of their program. Notwithstanding, the present studies demonstrated that even first-year university students could already distinguish constructivist concepts as important for their learning.

Chapter 3

The impact of students' conceptions of constructivist assumptions on academic achievement and dropout

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The impact of students' conceptions of constructivist assumptions on academic achievement and dropout
Studies in Higher Education

ABSTRACT

This study investigated the impact of students' conceptions of constructivist learning activities on academic achievement and dropout. Although constructivism represents an influential view of learning, studies investigating how students conceptualize this perspective have not been conducted before. A structural equation modelling approach was adopted to test different models relating students' conceptions with their achievement in the university setting. Results suggested an indirect relationship between conceptions and achievement as well as dropout, mediated by actual learning activities. What students believe about the role of knowledge construction in learning predicts the actual learning activities they undertake. Conceptions of self-perceived inability to learn and motivation to learn predict students' study time.

1. INTRODUCTION

People's conceptions of learning and knowledge vary widely. They serve as a frame of reference for how people approach learning tasks. Theories of what knowledge consists of, and how it can be acquired, influence these learning tasks (Bereiter & Scardamalia, 1989). Similarly, students bring along a variety of conceptions of learning when they enter university that they may have inherited from their previous educational experiences (Marton, Dall'Alba, & Beaty, 1993). Therefore, conceptions of learning may play an important role in students' study processes.

Conceptions of learning have come to attention again due to the influence of new views on learning in which personal knowledge constructions and subjective beliefs of learners play a pivotal role (Wigfield, Eccles, & Pintrich, 1996). This constructivist perspective is embodied in numerous ways, but most constructivist theories share four core assumptions that should be considered while creating learning environments for students (Marshall, 1992; Woolfolk, 2004).

The first assumption concerns the way knowledge is acquired by the learner. It implies that deep understanding of subject matter is a result of knowledge construction and transformation, not merely information acquisition and accumulation (Blumenfeld, 1992; Lonka, Joram, & Bryson, 1996). The central idea behind knowledge construction is that learners interpret new information by using and relating it to knowledge that they have acquired previously. This process is called elaboration and it has been shown to produce significant learning gains (Pressley, McDaniel, Turnure, Wood, & Ahmad, 1987; Willoughby, Waller, Wood, & MacKinnon, 1993).

A second dimension of constructivism is cooperative learning (Ryan, 2000; Slavin, 1996). Social interactions with fellow-students, teachers, and others contribute to the construction of knowledge (Steffe & Gale, 1995). Although constructivist theoreticians differ with regard to the extent that cooperation contributes to knowledge acquisition, they share the idea that social negotiation and interaction is an important factor in this process (Greeno, Collins, & Resnick, 1996). In his review of research on cooperative learning, Slavin (1996) highlights the elements of cooperative learning that promote achievement. Cooperative learning leads to higher motivation, stronger social cohesion, and it enhances mental processing like cognitive elaboration. Each of these effects has been demonstrated to be beneficial for students' learning outcomes (Slavin, 1996).

A third key concept underlying the constructivist perspective is to set academic learning goals by using one's meta-cognitive skills. In other words, students need to be self-regulated learners (Zimmerman, 1989). Self-regulated learning implies having the knowledge of effective learning strategies and knowing how and when to use them (Schunk & Zimmerman, 1994; Winne, 1995b). To be able to regulate your own learning is viewed as the key to successful learning in school and beyond (Boekaerts, 1999). In a study of Pintrich and de Groot

(1990), self-regulation evolved as the best predictor of academic performance of all outcome measures studied. Also, high- and low-achieving students appear to differ on self-regulated strategy use with high achievers reporting a significant greater degree of engagement in such strategy use (Cantwell & Moore, 1996; VanZile-Tamsen & Livingston, 1999). Self-regulation has even a substantial additive value on top of intelligence in explaining academic performance (Minnaert & Janssen, 1999).

Finally, the usefulness of authentic, ill-structured problems for education is the fourth core assumption put forward by constructivists. Confronting students with complex problems similar to the kinds of problems they will face in their future profession, makes learning situations more similar to real-life, professional situations which, consequently, would promote transfer of knowledge (Mayer & Wittrock, 1996; White & Frederiksen, 1998). Ill-structured problems also serve as facilitators for processing new information since discussing these problems activates relevant prior knowledge to which new knowledge can be related (Hmelo-Silver, 2004; Schmidt, de Volder, de Grave, Moust, & Patel, 1989).

In sharp contrast to the abundance of studies demonstrating the effects of constructive activity on learning, is the scarcity of literature discussing the students' perspective on these aspects of learning. How do students conceptualize constructive learning activities? And how are these conceptions linked to their performance? In other words: Do students believe that rephrasing subject matter in one's own words improves learning? That discussing subject matter with peers helps? And do these beliefs actually influence learning?

The way in which students understand the nature of learning, that is students' conceptions of learning, has become an increasingly significant construct in recent research on effective learning. Similarly, conceptions of knowledge (i.e., epistemologies) have also come to the fore in educational research (e.g., Schommer-Aikins, 2002) although Hofer and Pintrich (1997) have argued that it is better from a theoretical point of view that conceptions of learning and epistemologies, albeit indisputably related to each other, are kept separate. With respect to conceptions of learning, Boyle, Duffy, and Dunleavy (2003) report these conceptions to be an important determinant of effective learning, together with deep learning and self-regulated learning. Conceptions of learning also have a central role in taxonomies such as Säljö's (Marton et al., 1993; Säljö, 1979). Furthermore, several studies have linked conceptions of learning with academic achievement (Crawford, Gordon, Nicholas, & Prosser, 1994; Dahlgren & Marton, 1978; Mclean, 2001; Van Rossum & Schenk, 1984). Therefore, a question that comes to mind is: To what extent do these findings generalise to student conceptions of *constructivist* practices? And if so: How are these constructivist conceptions related to actual learning? Is there a direct relationship between them and achievement? Or do they have solely an impact on achievement via mediating variables such as study strategies? The study reported here addresses these questions.

Students' conceptions of constructivism were measured through a questionnaire in which students' beliefs about the usefulness for their own learning of knowledge construction, cooperative learning, self-regulation, and the use of authentic problems were measured. In addition, conceptions of self-perceived inability to learn and motivation in learning were taken into account. Self-perceived inability to learn refers to feelings of doubt concerning one's own learning capacities. It has been observed that open, constructive learning environments require a great deal of responsibility from learners in terms of being socially apt, self-regulated knowledge constructors. Some learners may experience this as a positive challenge and as part of their learning process, but others may relapse into uncertainty, confusion, and even anxiety (Duke, Forbes, Hunter, & Prosser, 1998). Motivation to learn is a widely acknowledged factor influencing students' learning (e.g., Pintrich & Schunk, 1996; Schunk, 1991) and was therefore also included. Students' conceptions were measured at the beginning of the academic year and their predictive validity for students' grades at the end of the academic year and possible dropout was investigated. Self-study time and other students' learning activities (as observed by their tutors) were included as possible mediating variables.

It was hypothesized that students' conceptions have primarily an indirect influence on students' academic achievement, because we assumed that what students *believe* about learning has mainly an impact on what they *do*. The actual learning activities they undertake, in turn, would influence academic performance. A structural equation modelling approach was adopted to test different models concerning the impact of students' conceptions on academic success.

2. METHOD

2.1 Participants

Participants were 180 students enrolled in the first-year, problem-based learning psychology curriculum of Erasmus University Rotterdam, the Netherlands. 126 students were female and 54 were male. The mean age of the students was 19.94 and the response rate was 74.4% of the first-year student population.

2.2 The learning environment in which the study took place

The psychology curriculum in this study applies a problem-based learning approach. Problem-based learning has its roots in constructivist learning theories. Students work in small groups on authentic problems, under the guidance of a tutor (Barrows, 1996). First, students discuss a problem and possible explanations or solutions are proposed. Since their prior knowledge of the problem-at-hand is limited, this discussion leads to the formulation of issues for further self-directed learning. Subsequently, students spend time studying literature relevant to the issues generated. After this period of self-study, students share their findings, elaborate on knowledge acquired, and have an opportunity to correct misconceptions (Hmelo-Silver, 2004; Schmidt, 1983). The first-year curriculum studied here consists of eight consecutive courses of five weeks each.

2.3 Measurement of students' conceptions

Students' conceptions of constructivist assumptions were measured by means of a 55-item questionnaire (Loyens, Rikers, & Schmidt, in press-a). The constructs of self-perceived inability to learn and motivation to learn were also included in the questionnaire. All statements had to be rated on a 7-point Likert-scale ranging from -3 (entirely disagree) to +3 (entirely agree). Examples of items are shown in Table 1.

Table 1: Item examples of students' conceptions of constructivist learning activities

Concept	Item examples (translated from Dutch)
Knowledge construction (*n* = 10)	"Previous learned facts are the building blocks of new knowledge"
Cooperative learning (*n* = 9)	"Discussing subject matter with fellow-students leads to a better understanding"
Self-regulation (*n* = 9)	"Preparing a test is difficult when the teacher has not pointed out exactly what has to be studied" (reversed scoring)
Authentic problems (*n* = 7)	"Emphasis on practical abilities during the curriculum gives you a head start in your future job"
Self-perceived inability to learn (*n* = 12)	"I doubt if I can complete this study successfully"
Motivation to learn (*n* = 8)	"I easily find the motivation to study"

The questionnaire is influenced by research of self-regulated learning and motivation (Pintrich & de Groot, 1990), mental models (Vermunt, 1992), conceptions of learning (Marton et al., 1993), conceptions of knowledge (Schraw, Bendixen, & Dunkle, 2002), and constructivist literature (Eggen & Kauchak, 1999; Marshall, 1992; Woolfolk, 2004) with respect to its theoretical background. However, the questionnaire developed focuses explicitly on *conceptions* of *constructivist* learning activities and is therefore different from existing instruments. Confirmatory factor analysis has demonstrated that the questionnaire was able to measure students' conceptions in a reliable and valid fashion. Students were able to identify the six dimensions comprising the questionnaire, as indicated by the fit of the hypothesized model. The test for measurement invariance showed that factor loadings were equivalent across different groups of students and that the questionnaire's underlying factor structure gave evidence of cross-validation. The reliability of the six latent constructs was assessed using coefficient H (Hancock & Mueller, 2001) and ranged from .60 to .86 (Loyens et al., in press-a).

2.4 Measurement of study time and students' observed learning activities

Students' self-study time for each five-week course was measured by asking students at the end of each course to estimate the mean number of hours spent on self-study per week.

Observed study activities undertaken by each student were measured through a tutor rating scale. At the end of each course, the tutor evaluates each of his or her students based on a number of criteria. These include (1) how well they have prepared themselves with respect to the subject matter studied, (2) how active and motivated they participated in the group activities, and (3) how well they fulfilled their roles as chair and scribe. Tutors rated their students for each of these different dimensions on a scale ranging from 1 (student did not show these activities at all) to 5 (student showed these activities to a large extent). After completing this scale, an average rating of observed learning activities was computed resulting in a rating ranging from 2 to 10. The average of these ratings over all eight courses was used as a measure of the extent and quality of the learning activities undertaken. Reliability analysis of the three subscales (i.e., preparation, participation, and role as chair and scribe) gave evidence of good internal consistency with Cronbach's alpha values of .85, .89, and .86 respectively. The rating scale is shown in Appendix B.

2.5 Outcome measures

2.5.1 Academic achievement

At the end of each course, students took a course test. They received a grade (ranging from 0 to 10) for their performance on each of these tests. Hence, academic achievement was measured by students' performance on the eight course tests.

2.5.2 Dropout

The dropout-variable consisted of the number of course tests not taken anymore before final attrition. Hence, this variable ranged from 0 (took all course tests) till 7 (only took one course test before dropping out). Students who did not take any course tests at all were excluded from the analyses.

2.6 Procedure

The questionnaire was administered to the first-year psychology students at the beginning of the 2003-2004 academic year. The questionnaire's instruction stated that there were no right or wrong answers to the items, all answers were correct as long as they reflected students' personal opinions. No information was given about the constructs underlying the questionnaire. Filling in the questionnaire took approximately ten to fifteen minutes. The remaining measurements were collected throughout the academic year and compiled at the end of the year.

2.7 Statistical analysis

A descriptive analysis was initially conducted. Furthermore, data were subjected to structural equation modelling. Therefore, hypothesized structural relationships among the variables were established. A two-stage approach was followed in the analysis. The first stage involved the testing of the measurement model, and the second stage involved testing of the structural models, depicted in Figure 1 and Figure 2.

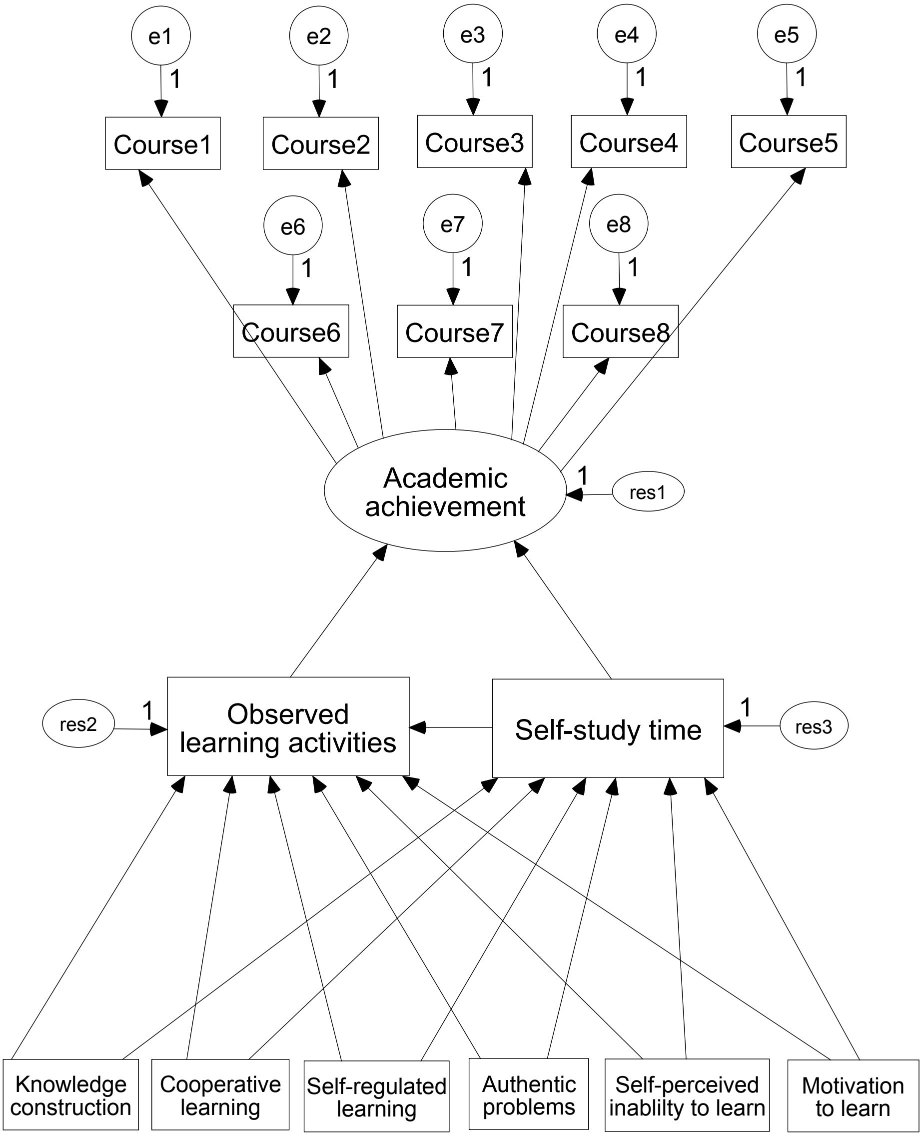

Figure 1: Hypothesized model with academic achievement as dependent variable

Note: For clarity, correlations among the four conceptions of constructivism as well as conceptions of inability and motivation to learn were omitted. e = error; measurement error of observed variables; res = residual; error in the prediction of endogenous factors from exogenous factors.

2.7.1 Measurement model

Academic achievement was modelled as a latent factor underlying measured variables (being the results of the eight course tests). Confirmatory factor analysis was conducted as a first step to determine the adequacy of factor loadings and model fit of the academic achievement variable using Amos 5.0 (Arbuckle, 2003).

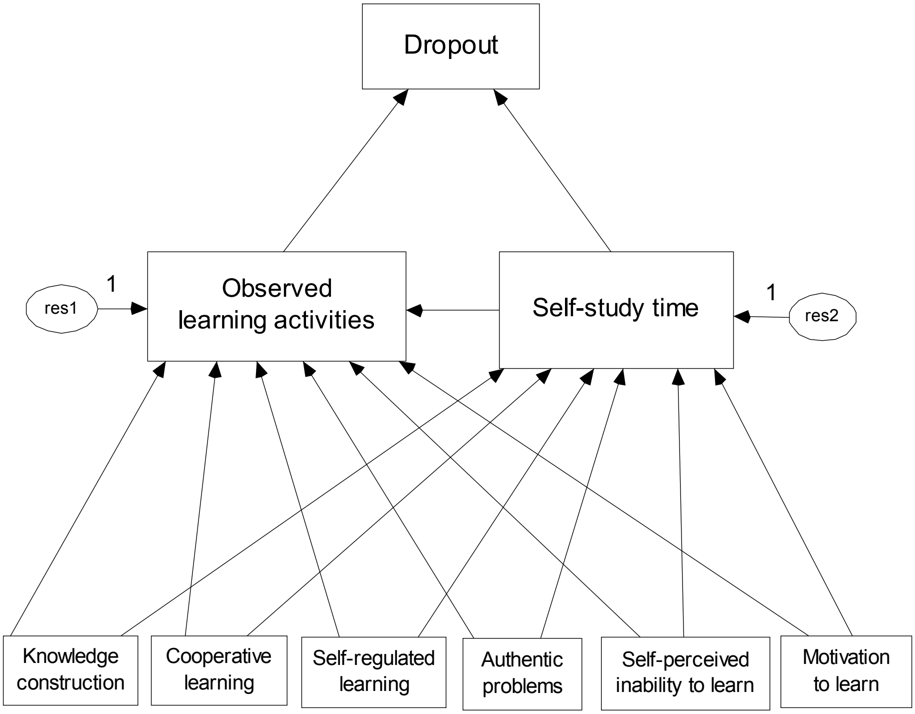

Figure 2: Hypothesized model with dropout as dependent variable
Note: For clarity, correlations among the four conceptions of constructivism as well as conceptions of inability and motivation to learn were omitted. e = error; measurement error of observed variables; res = residual; error in the prediction of endogenous factors from exogenous factors.

2.7.2 Structural models

The hypothesis that the associations between students' conceptions of constructivist assumptions and academic achievement would be mediated by students' observed learning activities and self-study time, was tested by the structural equation model (Figure 1). In this model, academic achievement is a latent variable specified by eight factors. Students' conceptions of knowledge construction, cooperative learning, self-regulated learning, authentic problems, as well as students' conceptions of inability to learn, and motivation to learn are observed variables. A measurement model of these six variables with their associated questionnaire items was tested in a previous study (Loyens et al., in press-a). For the model depicted in Figure 2, the same procedure was completed.

Maximum likelihood estimations were used for the estimation of the models' parameters. For the evaluation of the model presented in Figure 1 and Figure 2, two groups of fit indices, absolute and incremental, were selected.

In the present study, χ^2, accompanied by degrees of freedom, sample size, and p-value, as well as the root mean square error of approximation (RMSEA, Steiger, 1990) were used as absolute fit indices. χ^2 has been the traditional statistic to test the closeness of fit between an observed and predicted covariance matrix. A small χ^2 value, relative to the degrees of freedom is an indication of good fit and vice versa (Byrne, 2001). Although there is no clear-cut guideline about what value of χ^2 divided by the model's degrees of freedom is minimally acceptable, it is frequently suggested that this ratio should be less than three (Kline, 1998). RMSEA appears to be sensitive to model specification, minimally influenced by sample size, and not overly influenced by estimation method and was therefore included (Fan, Thompson, & Wang, 1999). The lower the value of RMSEA, the better the fit, with a cut-off value close to .06 (Hu & Bentler, 1999).

Two incremental fit indices were included: The Tucker-Lewis index (TLI, Tucker & Lewis, 1973) and the comparative fit index (CFI, Bentler, 1990). Both indices range from zero to 1, with higher values indicating a better fit. Values greater than .90 are traditionally associated with well-fitting models (Bentler, 1990) although more recently, cut-off values close to .95 or .96 are suggested (Byrne, 2001; Hu & Bentler, 1999).

With respect to the values of the standardized path coefficients, values less than .10 indicate a small effect, values around .30 a medium effect and values greater than .50 a large effect (Kline, 1998).

Finally, $\Delta\chi^2$ tests were used to evaluate the role of the mediating variables (i.e., self-study time and students' observed learning activities). Alternative hierarchical models of Figure 1 and Figure 2 were constructed with direct paths between the six conception-variables and academic achievement and dropout. Each $\Delta\chi^2$ statistic reflects the difference between the χ^2 values of the two hierarchical models, its degrees of freedom equals the difference in the two models' degrees of freedom. A nonsignificant value of $\Delta\chi^2$ suggests that the overall fits of the two models are similar (Kline, 1998). With respect to the mediating variables, this implies that the mediated relation between students' conceptions and academic achievement and dropout by self-study time and students' observed learning activities is supported.

3. RESULTS

3.1 Descriptive analysis

Table 2 reports the means, standard deviations, and correlations for each observed variable.

3.2 Analysis of the measurement model

The proposed measurement model showed a good fit of the model with the data. All eight factor loadings of the course tests were significant, indicating that every course test contributed significantly to the latent factor of academic achievement. The standardized regression coefficients of the eight course test-variables were respectively .73, .74, .72, .86, .89, .87, .79, and .78. The χ^2 analysis of the measurement model revealed the following pattern: $\chi^2(20, N = 180) = 36.72$, $p > .01$. The fit indices showed a CFI of .98, a TLI of .98, and a RMSEA of .07.

Table 2: Descriptive statistics and correlation matrix for the observed variables

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Course 1	6.60	1.43	---																
2. Course 2	6.03	1.57	.61**	---															
3. Course 3	4.87	1.74	.50**	.57**	---														
4. Course 4	4.95	1.71	.63**	.64**	.63**	---													
5. Course 5	5.76	1.88	.62**	.65**	.66**	.79**	---												
6. Course 6	5.60	1.85	.62**	.61**	.61**	.75**	.78**	---											
7. Course 7	5.52	1.95	.58**	.60**	.55**	.65**	.66**	.73**	---										
8. Course 8	5.28	1.54	.61**	.54**	.56**	.64**	.68**	.67**	.71**	---									
9. Observed learning activities	7.24	.57	.42**	.48**	.49**	.57**	.61**	.56**	.54**	.55**	---								
10. Self-study time	11.97	5.88	.02	.12	.15*	.18*	.24*	.16*	.20*	.03	.22**	---							
11. Dropout	.52	1.60	-.24**	-.31**	-.35**	-.49**	-.50**	-.42**	-.24**	-.20**	-.34**	-.29**	---						
12. Knowledge construction	1.46	.51	.05	.22**	.13	.09	.14	.13	.12	.05	.23**	.06	-.10	---					
13. Cooperative learning	.77	.72	-.07	.03	.07	.04	.07	-.05	-.03	-.02	.12	.15*	-.13	.35**	---				
14. Self-regulated learning	-.51	.70	.02	.05	-.09	.03	-.03	.01	-.01	.05	.09	.00	-.07	.12	.30**	---			
15. Authentic problems	.84	.71	-.08	.00	.08	.11	.10	.04	.09	-.05	-.02	.12	-.12	.27**	.04	-.23**	---		
16. Self-perceived inability to learn	-.44	.77	.15*	.12	.12	.07	.14	.17*	.11	.12	-.05	.16*	-.08	-.29**	-.21**	-.44**	.06	---	
17. Motivation to learn	.42	1.02	-.06	.07	.00	.07	.15*	.09	.14	.03	.15	.23**	-.05	.28**	.23**	.20**	.11	-.17*	---

Note: N = 180; ** Correlation is significant at the .01 level. * Correlation is significant at the .05 level.

These measures indicate that academic achievement was well defined by the eight course tests.

3.3 Analysis of the structural model with academic achievement as a dependent variable

Analysis of the hypothesized structural model depicted in Figure 1 (N = 180) revealed a CFI of .95, a TLI of .93, and a RMSEA of .06. These indices indicate an adequate fit of the model with the data. The χ^2 analysis, $\chi^2(82, N = 180) = 142.68$, $p < .001$, on the other hand, suggests that the hypothesized model does not fit the data very well. However, it should be noted that the χ^2 test of statistical significance has several limitations. The test is based on restrictive assumptions that are typically not met. In addition, the intention of a model is to provide an approximation to reality rather than to fully represent all the complexity in the observed data. Furthermore, the χ^2 statistic is quite sensitive to sample size. Therefore, other indices of fit are to be preferred when evaluating a particular model (Marsh et al., 1994).

Table 3 displays the estimates and standard errors of the structural parameters. The estimates displayed in Table 3 account for the hypothesized model that depict the influence of students' conceptions of constructivist learning through observed learning activities and self-study time on students' academic achievement. Five regression paths were significant. Students' observed learning activities appeared a very strong predictor of academic achievement. Surprisingly, self-study time did not significantly contribute to academic achievement, but it did show a significant relationship with observed learning activities. This suggests that the number of hours students spend on self-study is not directly linked with performance,

Table 3: Estimates and standard errors of structural parameters for academic achievement

Parameter	Unstandardized estimates	Standardized estimates	Standard Error
Observed learning activities → academic achievement	1.18**	.66	.14
Self-study time → academic achievement	.01	.04	.01
Self-study time → observed learning activities	.02**	.21	.01
Knowledge construction → observed learning activities	.27**	.24	.09
Cooperative learning → observed learning activities	-.01	-.01	.06
Self-regulated learning → observed learning activities	.03	.04	.07
Authentic problems → observed learning activities	-.08	-.10	.06
Self-perceived inability to learn → observed learning activities	.01	.02	.06
Motivation to learn → observed learning activities	.02	.04	.04
Knowledge construction → self-study time	-.20	-.02	.94
Cooperative learning → self-study time	1.18	.14	.64
Self-regulated learning → self-study time	.27	.03	.70
Authentic problems → self-study time	.73	.09	.63
Self-perceived inability to learn → self-study time	1.77**	.23	.62
Motivation to learn → self-study time	1.33**	.23	.43

Note: ** $p < .01$

but individual study hours do show off in students' activities as observed by their tutors. With respect to observed learning activities, knowledge construction appeared a significant predictor. This finding implies that students' beliefs about being the central agent for their own knowledge acquisition have consequences for the actual learning activities they undertake. No other conceptions of constructivist learning contributed significantly to observed learning activities. Conceptions of self-perceived inability to learn and motivation to learn had significant, positive path estimates leading to self-study time.

3.4 $\Delta\chi^2$ Test for the structural model with academic achievement as a dependent variable

Finally, a model assuming direct paths from students' conceptions to academic achievement was compared with the hypothesized model as suggested by Figure 1. This was done to examine whether the effect of students' conceptions on academic achievement is necessarily mediated by learning activities and self-study time. This alternative model was identical to the model in Figure 1, but it assumed additional paths from the conceptions directly to academic achievement. The χ^2 test that tested the difference between these two models was nonsignificant at the .05 level: $\Delta\chi^2$ (df = 6) = 11.20, indicating that direct relations between conceptions and achievement did not lead to a better explanation of the data. Therefore, any relations between conceptions and the endogenous factor (i.e., academic achievement) are entirely mediated by the two mediators.

3.5 Analysis of the structural model with dropout as a dependent variable

Testing the hypothesized structural model with dropout as dependent variable resulted in a CFI of 1.00 a TLI of .97, and a RMSEA of .03 indicating an excellent fit with the data. The χ^2 analysis, χ^2 (6, N = 180) = 6.97, p > .05, also supported excellent model fit.

Table 4 shows the estimates and standard errors of the structural parameters of the hypothesized model with dropout as dependent variable. The estimates shown in Table 4 revealed six significant path estimates. Similar to the model with academic achievement as dependent variable, observed learning activities emerged as a good predictor of dropout: The higher tutors rated students' learning activities, the lower the probability of dropout. Contrary to the analyses involving academic achievement, self-study time also emerged as an influence on dropout. The less time students spend on self-study, the higher the probability of premature dropout. Furthermore, self-study time entertained a significant relationship with observed learning activities. With respect to students' conceptions, a pattern emerged similar to the model with academic achievement as a dependent variable. Students' conceptions of knowledge construction as an activity that may or may not facilitate learning turned out to be the only significant predictor of observed learning activities. Conceptions regarding one's own learning ability and about the role of motivation to learn emerged as significant, positive paths to self-study time. Here again, doubts about one's learning abilities entertained a

Table 4: Estimates and standard errors of structural parameters for dropout

Parameter	Unstandardized estimates	Standardized estimates	Standard Error
Observed learning activities → dropout	-.81**	-.29	.20
Self-study time → dropout	-.06**	-.23	.02
Self-study time → observed learning activities	.02**	.21	.01
Knowledge construction → observed learning activities	.27**	.24	.09
Cooperative learning → observed learning activities	-.01	-.01	.06
Self-regulated learning → observed learning activities	.03	.04	.07
Authentic problems → observed learning activities	-.08	-.10	.06
Self-perceived inability to learn → observed learning activities	.01	.02	.06
Motivation to learn → observed learning activities	.02	.04	.04
Knowledge construction → self-study time	-.21	-.02	.94
Cooperative learning → self-study time	1.17	.14	.64
Self-regulated learning → self-study time	.24	.03	.70
Authentic problems → self-study time	.73	.09	.63
Self-perceived inability to learn → self-study time	1.76**	.23	.62
Motivation to learn → self-study time	1.35**	.23	.44

Note: ** $p < .01$

positive relation with self-study time, suggesting that self-perceived abilities in this domain stimulate rather than impede students' learning processes.

3.6 $\Delta\chi^2$ Test for the structural model with dropout as a dependent variable

Including direct paths from the learning conceptions to the dropout-variable resulted in a model with zero degrees of freedom (i.e., a just-identified or saturated model). Therefore, the χ^2 test of the model depicted in Figure 2 also serves as the $\Delta\chi^2$ test since the saturated model has, by default, a χ^2 of zero. The value of $\Delta\chi^2$ (df = 6) = 6.97 was nonsignificant at the .05 level, indicating that direct relations between conceptions and dropout did not lead to a better explanation of the data. Therefore, any relations between conceptions and dropout are entirely mediated by the two mediators.

4. DISCUSSION

4.1 Impact of conceptions of constructivism on achievement and dropout

The present study investigated the impact of students' conceptions of constructivist assumptions on academic achievement and student dropout. Upon entering university, students in a problem-based psychology curriculum were therefore questioned about their beliefs as to the utility of knowledge construction, cooperative learning, self-regulated learning, and the use of authentic problems for learning. In addition, their beliefs about their own (in)ability to learn and motivation were studied. Two hypothesized models were tested and a $\Delta\chi^2$ test was used to examine whether the influence of students' conceptions on achievement and dropout was mediated by self-study time and students' observed learning activities. Results revealed a good fit of the models with the data for the two structural models under study. These findings imply that similar to the previously found effects of students' conceptions on achievement (e.g., Crawford et al., 1994; McLean, 2001; Van Rossum & Schenk, 1984), mediated relations appear to exist between conceptions of constructivism and performance.

4.2 Mediated relationship between conceptions, achievement and dropout

The second part of our study addressed the question whether the influence of students' conceptions on academic achievement and dropout was mediated by actual learning activities. To that end, we measured learning activities by mapping students' self-study time and by having students' learning activities rated by their tutors. The nonsignificant $\Delta\chi^2$ tests implied that the relations between the conceptions and academic achievement and dropout were completely mediated by self-study time and other learning activities such as whether the student prepared him- or herself sufficiently and whether the student participated actively and enthusiastically in the group activities. What students believe concerning knowledge construction, self-perceived inability to learn, and motivation to learn has indeed an impact on what they do (i.e., in terms of self-study time, study preparation, active participation, etc.) and consequently students' activities influence academic performance and dropout.

4.3 Correlations between observed variables

The correlation matrix suggested a central role for students' observed learning activities. This variable appears associated with all performance measures (i.e., the course tests) as well as self-study time. In the curriculum under study, an independent tutor rated the students with respect to their learning activities. This assessment takes place at the end of every course and appears to be predictive of students' subsequent performance. Dropout was negatively correlated with all other observed variables, but correlations with the conception-variables were nonsignificant. The strongly negative correlations of dropout with the course tests showed the expected pattern: The higher students score on the course tests, the lower the probability of dropout. With respect to students' conceptions of constructivism, several conceptions appear interrelated which can be expected due to their common umbrella term 'constructivism'. Self-perceived inability to learn as a determinant of learning showed negative correlations with almost all other conceptions. This finding underlines its negative connotation in students' learning process. By contrast, conceptions of the role of motivation to learn had significant positive correlations with almost all other conceptions of constructivism, stressing its influential role in learning (Pintrich & Schunk, 1996).

4.4 The role of the mediating variables

A closer look at the mediating variables points out again the crucial role of observed learning activities. Observed learning activities showed a large effect on academic achievement and a medium effect on dropout. Tutors' judgements about how well students had prepared for the tutorial meetings and how active and motivated they participated in the group activities appeared good predictors for subsequent success or failure. In line with the correlation results, this finding underlines how crucial it is for students to engage in high-quality self-study activities, explain subject matter in their own words, read additional literature sources, take actively part in the group discussions, demonstrate interest and involvement, and to fulfil the roles of chair and scribe of the tutorial group well.

Self-study time, on the other hand, did not show a direct effect on academic achievement. It had a small average effect on performance, but only through the other learning activities. This finding is in line with a recent study by Plant, Ericsson, Hill, and Asberg (2005). In their research, self-study time only emerged as a significant predictor of performance (in their case cumulative GPA) when other variables as previously attained performance were taken into account. Similarly, a study on the relationship between self-study time and academic achievement demonstrated that time spent on individual study correlated poorly with students' performance on knowledge tests. The authors conclude that the relationship between study time and study success is complex and that qualitative factors about the way students learn need to be taken into account (van den Hurk, Wolfhagen, Dolmans, & van der Vleuten, 1998). In addition, students' ability level might also interfere the relationship between self-study time and performance. With respect to dropout, however, self-study time turned out to be a direct predictor: The higher the amount of study time, the lower the probability of attrition.

4.5 The pattern of path coefficients

With respect to the standardized path coefficients, the impact of students' conceptions of constructivism revealed the same significant effects for both hypothesized models (i.e., for academic achievement and dropout as dependent variables). Conceptions of knowledge construction significantly predicted observed learning activities and the conceptions of self-perceived inability to learn and motivation to learn had a significant positive effect on self-study time. The first finding implies that the more students agree with actively constructing their own knowledge and the beneficial effect of relating new knowledge to previously acquired knowledge, the higher the rates they receive from their tutors. The same implications hold for inability to learn and motivation: The more students agree on the importance of these concepts, the more hours they spend on self-study. For conceptions of self-perceived inability to learn, its positive effect on self-study time seems rather counterintuitive because it is a factor that is commonly referred to as a possible, negative by-product of constructivist learning environments (Duke et al., 1998). However, Block (1996) argued that students' encounter with their perceived inability can have beneficial effects. After all, students will work harder to manage this uncertainty and by doing so, they may come to a degree of acceptance or tolerance of uncertainty, which makes them less averse to it. Similarly, McInerney, McInerney, and Marsh (1997) concluded from their study on computer achievement and computer anxiety that anxiety experienced by their participants was not debilitating, but actually facilitating in terms of performance. Our finding concerning self-perceived inability to learn confirms that the more insecure students believe they are with respect to their learning process, the more they study. However, bearing in mind the study of van den Hurk and colleagues (1998), this finding does not shed light on the *quality* of students' study hours, only on the *quantity*. In sum, even though students in constructivist learning environments might experience feelings of inability, confusion or anxiety, these feelings do not appear detrimental in terms of study hours. With respect to the importance of motivation to learn, students' conceptions seem to be in line with numerous studies that actually demonstrate the positive impact of motivation on learning (Pintrich & Schunk, 1996).

Students' conceptions of cooperative learning, the usefulness of authentic problems, and self-regulated learning activities did not show significant effects on learning activities nor self-study time. The question is why this is the case. One could argue that cooperative learning and authentic problems differ from the other elements of constructive learning because they are describing the learning environment rather than behaviours of students. Both concepts refer to context factors and students possibly experience more difficulty in estimating the effects of these factors. Estimating the impact of concepts in which they themselves have a clearly defined role (e.g., relating subject matter to previously acquired knowledge or feeling doubts concerning which subject matter to study) may be easier. If this is true then it is puzzling why beliefs about the role of self-regulation did not have significant effects on the mediating variables. Self-regulation is a student-generated activity just like the construction of knowledge. A possible explanation could lie in the fact that the students involved in this study had just entered university and could only rely on their previous educational experiences in secondary school. Especially for self-regulated learning, this may have coloured their answers since secondary education is typically teacher-centred: The teacher indicates which book chapters are important, the teacher clarifies subject matter, and the teacher helps students preparing for the tests. Perhaps the participants involved could not foresee what it would mean to be responsible for one's own learning and to plan, monitor, and regulate one's own learning activities independently.

In summary, what students believe concerning knowledge construction predicts the learning activities they undertake and the importance they ascribe to their inability to learn and motivation can make predictions with respect to students' study time. All significant effects emerged in two different hypothesized models and were clearly predictive in nature since students' conceptions were measured at the very beginning of the academic year whereas all other data were collected throughout the academic year. Although not all conceptions showed effects on the mediating variables, the present findings demonstrate the relative importance of students' conceptions of constructivism for their learning.

4.6 Implications

The relationship we found between some conceptions of constructivist learning and study activities and consequently academic achievement points out that in order to improve academic achievement, changing study activities is not sufficient since these activities are to some extent dependent on students' conceptions. What students believe with respect to learning and constructivism in particular, plays therefore a role, though indirect, in students' learning outcomes. Traditionally, the teacher, instructional methods, learning materials, and study activities are considered as the elements of change in order to achieve the necessary knowledge reconstruction to promote performance (Sinatra & Pintrich, 2003). Our study suggests that the learner can and has to act as a controller. Students' conceptions should receive more attention in education and specific instruction and training programs could help students in this respect (Lonka et al., 1996).

4.7 Limitations

There is, however, a constraint to our findings that is inherent to working with structural models: The models that were tested are just two of the numerous possibilities of structural models that can be proposed concerning the relationship between conceptions of constructivist learning, learning activities, and performance measures. Several other variables could have been included in these models (e.g., context effects, students' ability level, actual self-regulation measures etc). However, we aimed for a general and simple structural model with conceptions of constructivist learning as the main component since those conceptions and their impact were the corner stones of the present study.

Another constraint is that the student population in this study was enrolled in a problem-based learning curriculum. To test generalization, the models should be tested in conventional, lecture-based curricula.

4.8 Future research

Future research should examine whether conceptions change throughout students' academic program. Participants in this study were all first-year students. Therefore, it would be informative to investigate whether changes take place, when they take place and how this reflects on students' learning activities and performance. A next step could be to investigate whether conceptions can be changed purposively and whether this would influence students' learning.

Chapter 4

Relationships between students' conceptions of constructivist learning and their regulation and processing strategies

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ABSTRACT

The present study investigated relationships between students' conceptions of constructivist learning on the one hand, and their regulation and processing strategies on the other hand. Students in a constructivist, problem-based learning curriculum were questioned about their conceptions of knowledge construction and self-regulated learning, as well as their beliefs regarding their own (in)ability to learn and motivation to learn. Two hypothesized models were tested: The first model implemented regulation and processing variables of the Inventory of Learning Styles (ILS; Vermunt, 1992), the second model of the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich & de Groot, 1990). Results showed that structural relations also exist between conceptions of constructivist learning and regulation and processing strategies. Furthermore, students who express doubt with regard to their own learning capacities are at risk for adopting an inadequate regulation strategy. Conceptions of self-regulated learning had positive relationships with actual reported self-regulation activities, stressing the central role of conceptions. A tripartite structure of conceptual, controlling, and operational level appeared valid for the MSLQ variables, but not entirely for those of the ILS.

1. INTRODUCTION

An important implication of modern constructivist views of learning is that they have brought personal knowledge constructions and learners' subjective beliefs to the fore in educational research. The result is a large number of studies relating students' conceptions of knowledge (i.e., epistemologies) and learning to other aspects of learning such as cognitive processing strategies (e.g., Vermunt, 1996), regulation strategies (e.g., Purdie, Hattie, & Douglas, 1998), motivation (e.g., Pintrich & Zusho, 2002), learning orientations (e.g., Beaty, Gibbs, & Morgan, 1997), approaches to learning (e.g., Dart et al., 2000), and learning outcomes (e.g., McLean, 2001). The present study sheds light on the relationship between students' conceptions of *constructivist* learning and their regulation and processing strategies. It is examined whether these relations exist and if so, to what extent. In order to evaluate these connections, we first discuss several studies on conceptions of learning and knowledge and certain aspects of students' learning processes.

Van Rossum and Schenk (1984) studied the relationship between conceptions of learning, study strategies (also referred to as Student Approaches to Learning – SAL), and learning outcomes by letting participants study a text, followed by a questionnaire containing items about the text as well as items about their study strategy and conceptions of learning. They found that high quality learning outcomes are particularly related to learning conceptions that emphasize the constructive character of learning as well as deep (i.e., seeking meaning of the subject matter by elaborating and transforming this subject matter) learning approaches. Crawford, Gordon, Nicholas, and Prosser (1994) came to the same conclusion in a study of student's conceptions of mathematics. Their research identified a structural relationship between students' conceptions of mathematics and their approaches to learning this subject. Similarly, Dart and colleagues (2000) tested a structural model relating conceptions of learning and SAL and found that qualitative conceptions (such as 'learning is concerned with understanding and meaning by relating or connecting new material to prior knowledge') were particularly linked with deep approaches to learning. Furthermore, more advanced conceptions in which learning is seen as understanding instead of memorising, are found to be associated with a more frequent use of self-regulated learning strategies (Purdie et al., 1998). Lonka and Lindblom-Ylänne (1996) found that conceptions of knowledge students hold were indicative for their study strategies with 'relativists' (i.e., those seeing knowledge as interpreted and integrated positions) reporting more frequent use of elaborative study strategies compared to 'dualists' (i.e., those seeing knowledge as an array of discrete and absolute truths). The latter reported more frequent use of rehearsal strategies. Dahl, Bals, and Turi (2005) reported similar relationships between students' conceptions of knowledge and learning strategies for studying course material.

In sum, several studies report relationships between conceptions and other aspects of students' learning processes such as approaches to learning, regulation, and processing strategies. Students' beliefs have received a more prominent role in research and studies often depart from a more integrative approach, focussing on different aspects of learning and including students' conceptions as an important factor.

This integration of conceptions in educational research on students' learning processes has led to the development of several models that combine student characteristics on different levels. Biggs (1993), for example, proposed the 3P-model (Presage, Process, and Product) of learning. Presage factors include student characteristics (e.g., conceptions of learning, prior knowledge, motivation, etc.) and aspects of the teaching context (e.g., conceptions of teaching, curriculum organization, assessment, etc.). Process factors refer to how students manage their learning tasks, and product factors concern learning outcomes. All factors are related to each other and changes on one level have repercussions on other levels (Biggs, 1993). A second approach comprising different learning variables are Individual Learning Theories (ILTs; van der Sanden, Terwel, & Vosniadou, 2000). ILTs summarize self-perceived competencies, individual goal orientations, conceptions of learning, preferred learning situations, and learning activities. As a whole, ILTs serve as individual frameworks with regard to learning and instruction.

Interestingly, measurement instruments of learning aspects also started to adopt this integrative approach. Perhaps the most obvious example in this respect is Vermunt's Inventory of Learning Styles (ILS; Vermunt, 1992, 1998). The ILS measures four aspects of students' learning: Processing strategies, regulation strategies, mental models of knowledge (which can be labelled as conceptions of knowledge), and learning orientations (i.e., personal goals, intentions, motives, expectations, concerns, and doubts with respect to learning). Relationships among these four aspects are assumed and from a theoretical perspective, these aspects can be categorised into three levels. The first level is the cognitive-symbolic or conceptual level consisting of students' ideas and beliefs. Mental models of knowledge and learning orientations fall into this category. Furthermore, a controlling level can be distinguished that refers to regulation processes, whereas a third level, the operational-behavioural level, concerns the processing strategies. The controlling level tunes the conceptual level to the operational level (Vermetten, Lodewijks, & Vermunt, 1999).

The present study also assumes an integrative approach and aims to investigate whether a relationship can be found between students' conceptions of *constructivist* learning on one hand, and regulation and processing strategies on the other hand. As mentioned above, students' conceptions of knowledge and learning have been linked to other aspects of learning in earlier research. Those studies, however, took existing taxonomies of conceptions of learning (e.g., qualitative categorisation by Marton, Dall'Alba, and Beaty, 1993) or knowledge (e.g., developmental pattern by Perry, 1970) as a starting point. Although these taxonomies carry constructivist elements in them such as the construction of knowledge, they do not specifically focus on constructivist learning. Therefore, this study examines whether relationships also apply to conceptions of *constructivist* learning and regulation and processing strategies.

In other words, it is appraised whether relationships between conceptions of learning and knowledge and study strategies found in earlier research can be generalized to conceptions of *constructivist* practices? Furthermore, it is investigated which aspects are related as well as how significant connections are. Finally, this study tested whether the structure of conceptual, controlling, and operational level is also valid for conceptions of constructivist learning. In line with previous research with conceptions of learning and knowledge, we hypothesized that relationships also exist between conceptions of *constructivist* learning and regulation and processing strategies. We expected that students' beliefs about constructivist learning have an impact on their learning activities (Loyens, Rikers, & Schmidt, in press-b).

2. METHOD

2.1 Participants

Participants were 76 third-year and fourth-year psychology students (62 female, 14 male; mean age = 22.41, *SD* = 3.67) enrolled in a problem-based learning (PBL) curriculum at Erasmus University Rotterdam, the Netherlands.

2.2 Measurement of students' conceptions

Students' conceptions of constructivist activities were measured by means of a 55-item questionnaire (Loyens, Rikers, & Schmidt, in press-a). The statements needed to be rated on a 7-point Likert-scale ranging from -3 (entirely disagree) to +3 (entirely agree). Although constructivism is embodied in numerous ways (e.g., Windschitl, 2002), most views share four core assumptions that should be considered while creating learning environments for students. These assumptions can be labelled as (1) knowledge construction, (2) cooperative learning, (3) self-regulation, and (4) use of ill-structured, authentic problems (e.g., Marshall, 1992; Woolfolk, 2004). Students' conceptions of two of these four constructs were measured by the aforementioned questionnaire. We focused on knowledge construction and self-regulated learning, since these assumptions reflect students' individual learning activities. Cooperative learning and the use of authentic problems on the other hand, are curriculum characteristics, which imply that students are automatically confronted with these activities in a constructivist learning environment. Therefore, we chose to zoom in on the conceptions of constructivist learning activities students can deliberately undertake.

In addition, students' conceptions of self-perceived inability to learn and motivation to learn were taken into account. Self-perceived inability to learn refers to feelings of doubt concerning one's own learning capacities. It has been observed that open, constructive learning environments require a great deal of responsibility from learners in terms of being socially apt, self-regulated knowledge constructors. Some learners may experience this as a positive challenge and as part of their learning process, but others may relapse into uncertainty,

Table 1: Item examples of students' conceptions of constructivist learning activities

Concept	Item examples (translated from Dutch)
Knowledge construction (*n* = 10)	"Previous learned facts are the building blocks of new knowledge"
Self-regulation (*n* = 9)	"Preparing a test is difficult when the teacher has not pointed out exactly what has to be studied" (reversed scoring)
Self-perceived inability to learn (*n* = 12)	"I doubt if I can complete this study successfully"
Motivation to learn (*n* = 8)	"I easily find the motivation to study"

confusion, and even anxiety (Duke, Forbes, Hunter, & Prosser, 1998). Motivation to learn is a widely acknowledged factor influencing students' learning (e.g., Pintrich & Schunk, 1996; Schunk, 1991).

The questionnaire used was influenced by research on self-regulated learning and motivation (Pintrich & de Groot, 1990), mental models (Vermunt, 1992), conceptions of learning (Marton et al., 1993), conceptions of knowledge (Schraw, Bendixen, & Dunkle, 2002), and constructivist literature (e.g., Marshall, 1992; Steffe & Gale, 1995; Tenenbaum et al., 2001) with respect to its theoretical background. However, our questionnaire focuses explicitly on *conceptions* of *constructivist* learning activities and is therefore different from existing instruments. Examples of items are shown in Table 1.

Confirmatory factor analysis has demonstrated that the questionnaire was able to measure students' conceptions in a reliable and valid fashion. Students were able to identify the six dimensions comprising the questionnaire (of which four are used in this study), as indicated by the fit measures of the hypothesized model. The test for measurement invariance showed that factor loadings were equivalent across different groups of students and that the questionnaire's underlying factor structure gave evidence of cross-validation. The reliability of the six latent constructs was assessed using coefficient H (Hancock & Mueller, 2001) and ranged from .60 to .86 (Loyens et al., in press-a).

2.3 Measurement of students' processing and regulation strategies

Students' regulation and processing strategies were measured by Part A 'Study strategies' of Vermunt's ILS (Vermunt, 1992). Three processing strategies are part of the ILS: Deep processing (characterized by relating and structuring and critical processing, *n* = 11 items), stepwise processing (characterized by memorising and rehearsing and analysing, *n* = 11 items), and concrete processing (*n* = 5 items). Furthermore, three regulation strategies are measured by this questionnaire: Self-regulation (both of learning process / results and learning content, *n* = 11 items), external regulation (both of learning process and learning results, *n* = 11 items), and lack of regulation (*n* = 6 items). For each item, participants had to indicate on a 5-point Likert-scale to what extent the statement applied to them (1 = I do this seldom or never, 5 = I do this almost always). Because we were particularly interested in the relationship of study strategies and students' conceptions of *constructivist* learning, part B of the ILS, 'Study motives and study views' (i.e., mental models of knowledge and learning orientations) was not considered in our study.

As a second measure of regulation and processing strategies, corresponding items of the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich & de Groot, 1990) were selected. Items of the MSLQ-subscales 'Cognitive strategy use' and 'Self-regulation' were included. However, because the MSLQ was designed for high-school education, two items of the cognitive strategy use subscale, stressing homework (item 31) and mentioning the teacher (item 36) were deleted for our study with higher-education students. A total of 20 items of the MSLQ (11 items of the cognitive strategy subscale and 9 items of the self-regulation subscale) were used and had to be rated on a 7-point Likert-scale ranging from 1 (= not at all true for me) to 7 (= very true for me). The MSLQ-part measuring motivational beliefs was not administered because of the focus on students' conceptions of constructivist learning.

2.4 Procedure

All three questionnaires were electronically administered to the students at the beginning of the academic year. The questionnaires' instructions stated that there were no right or wrong answers to the items, all answers were correct as long as they reflected students' personal opinions.

2.5 Statistical analysis

Responses to negatively stated items were reversed so that for all items the highest response score was indicative of a positive rating of each construct. Descriptive statistics were calculated for all subscales.

A structural equation modelling approach was adopted to test different models concerning the relationship between students' conceptions of constructivist learning and regulation and processing strategies. Hypothesized structural relationships among the variables were established and the structural models, depicted in Figure 1 and Figure 2, were tested. In these models, students' conceptions of knowledge construction, self-regulated learning, self-perceived inability to learn, and motivation to learn are observed variables at the conceptual level. A measurement model of these variables with their associated questionnaire items was tested in a previous study (Loyens et al., in press-a). In Figure 1, regulation processes of the ILS (self-regulation, external regulation, and lack of regulation) are modelled on the controlling level and the ILS-processing strategies (deep, stepwise, and concrete processing) on the operational level.

For the model depicted in Figure 2, the same three levels were modelled using the regulation and processing subscales of the MSLQ (Pintrich & de Groot, 1990).

Maximum likelihood estimations were used for the estimation of the models' parameters. For the evaluation of the models presented in Figure 1 and Figure 2, two groups of fit indices, absolute and incremental, were selected.

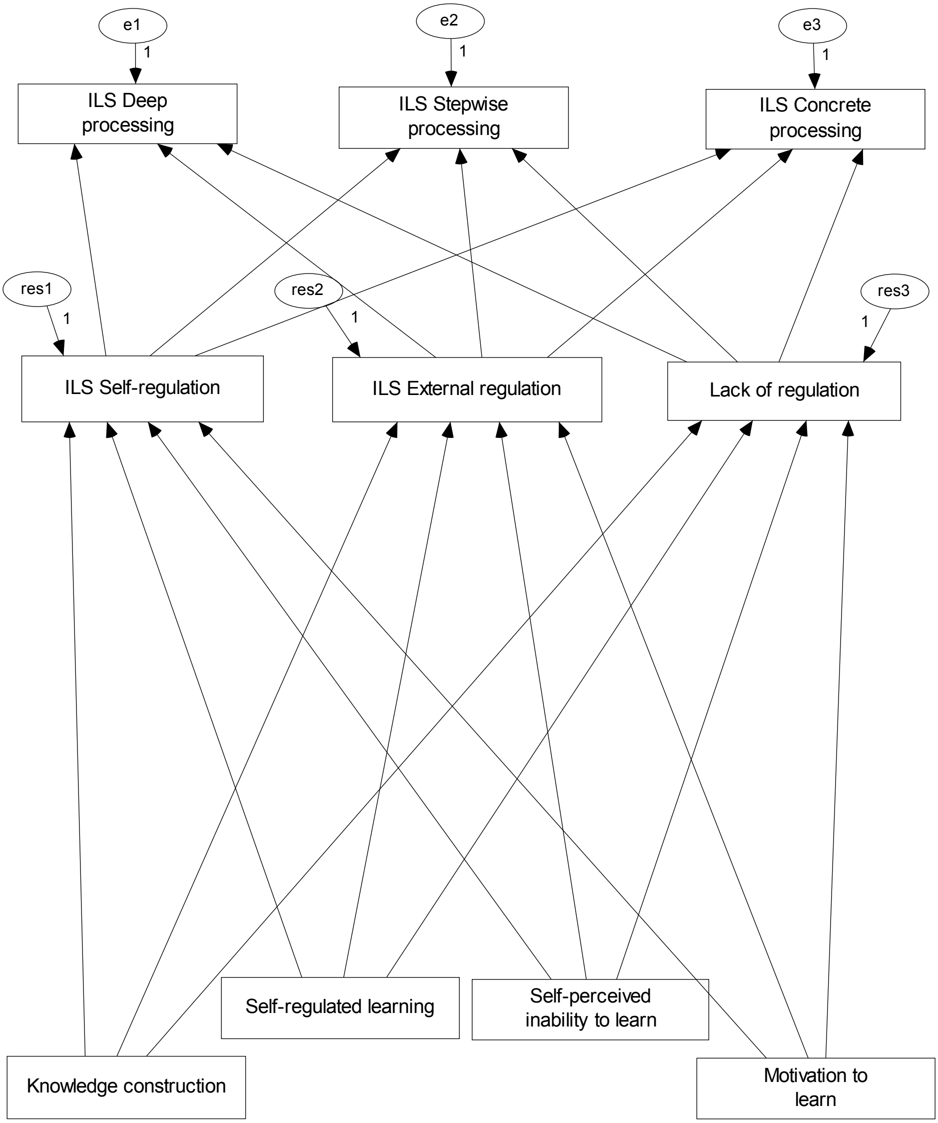

Figure 1: Hypothesized model with ILS regulation and processing variables
Note: For clarity, correlations among the four conceptions, among the residuals, and among the error terms were omitted.

In the present study, χ^2, accompanied by degrees of freedom, sample size, and p-value, as well as the root mean square error of approximation (RMSEA, Steiger, 1990) were used as absolute fit indices. χ^2 has been the traditional statistic to test the closeness of fit between an observed and predicted covariance matrix. A small χ^2 value, relative to the degrees of freedom, is an indication of good fit and vice versa (Byrne, 2001). Although there is no clear-cut guideline about what value of χ^2 divided by the model's degrees of freedom is minimally acceptable, it is frequently suggested that this ratio should be less than three (Kline, 1998).

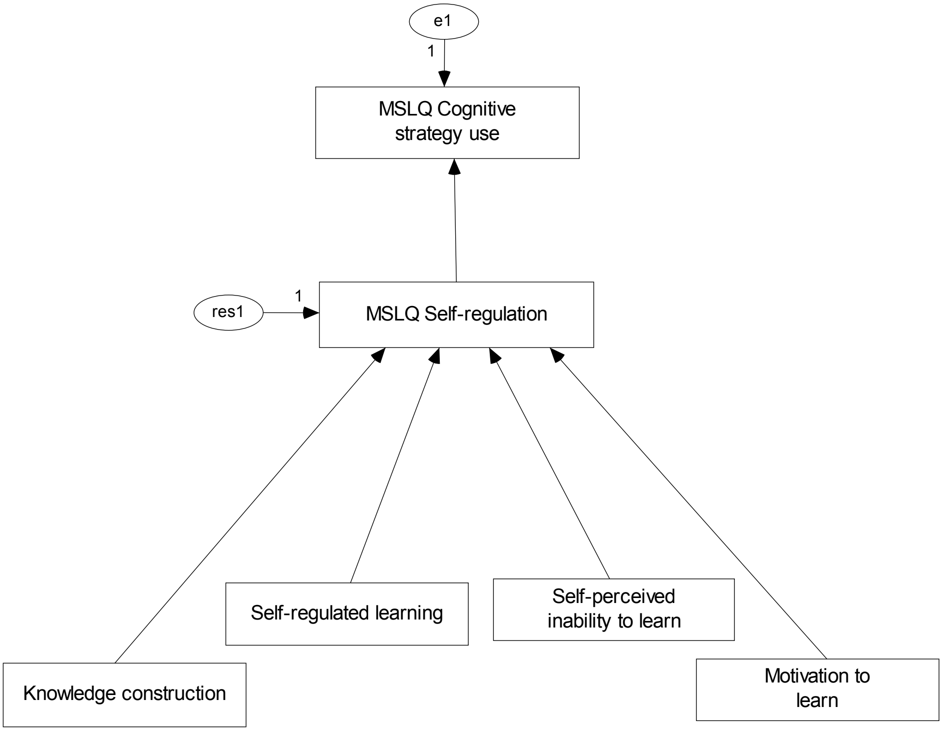

Figure 2: Hypothesized model with MSLQ regulation and processing variables
Note: For clarity, correlations among the four conceptions of constructivist learning were omitted.

RMSEA appears to be sensitive to model specification, minimally influenced by sample size, and not overly influenced by estimation method and was therefore included (Fan, Thompson, & Wang, 1999). The lower the value of RMSEA, the better the fit, with a cut-off value close to .06 (Hu & Bentler, 1999).

Two incremental fit indices were included: The Tucker-Lewis index (TLI, Tucker & Lewis, 1973) and the comparative fit index (CFI, Bentler, 1990). Both indices range from zero to 1, with higher values indicating a better fit. Values greater than .90 are traditionally associated with well-fitting models (Bentler, 1990) although more recently, cut-off values close to .95 or .96 are suggested (Byrne, 2001; Hu & Bentler, 1999).

With respect to the values of the standardized path coefficients, values less than .10 indicate a small effect, values around .30 a medium effect, and values greater than .50 a large effect (Kline, 1998).

Finally, $\Delta\chi^2$ tests were used to evaluate the three-level structure (i.e., the mediating role of the controlling level). Alternative hierarchical models of Figure 1 and Figure 2 were constructed with direct paths between the conception-variables and the processing strategies. Each $\Delta\chi^2$ statistic reflects the difference between the χ^2 values of the two hierarchical models, its degrees of freedom equals the difference in the two models' degrees of freedom.

A nonsignificant value of $\Delta\chi^2$ suggests that the overall fits of the two models are similar. With respect to the mediating, regulation variables, this implies that a completely mediated relation between students' conceptions and processing strategies by regulation activities is supported. A significant value of $\Delta\chi^2$ supports retention of the added paths and therefore implies a partially mediated relationship between the conceptual and operational level by the controlling level (Kline, 1998).

Data were analyzed using Amos 6.0 (Arbuckle, 2005).

3. RESULTS

3.1 Descriptive analysis

Table 2 reports the means, standard deviations, and correlations for each observed variable.

With respect to conceptions of constructivist learning, highest scores (i.e., factors on which students agreed the most) were obtained for conceptions of knowledge construction. For conceptions of self-regulated learning and self-perceived inability to learn, mean scores were negative implying that students disagree with statements about self-regulated learning (although the negative score is close to zero) and that they do not report feelings of doubt concerning their learning processes. Students' mean scores on the six subscales of the ILS were all average compared to the ILS norm group of higher education students.

Correlations among the four variables on the conceptual level were all significant and, as expected, self-perceived inability to learn showed negative relationships with all other variables, except with external regulation and lack of regulation. Similarly, lack of regulation showed negative correlations with all other variables, except for self-perceived inability to learn and external regulation.

Conceptions were significantly correlated with constructivist learning activities like self-regulation (of both ILS and MSLQ) and deep processing. However, for concrete processing and cognitive strategy use, not all relationships with the conceptual variables were significant.

Concerning the ILS variables, self-regulation showed positive correlations with deep and concrete processing. This finding is in line with the defined learning styles of the ILS where self-regulation, deep, and concrete processing are all part of the meaning-directed learning style. Self-regulation also had a positive relationship with stepwise processing, but this correlation was less high compared to deep and concrete processing. External regulation on the other hand, showed a positive correlation with stepwise processing, which is in line with the reproduction-directed learning style that consists of both variables.

The self-regulation subscale of the MSLQ showed the same pattern of correlations compared to the ILS self-regulation variable. The MSLQ cognitive strategy use variable, finally, showed positive correlations with self-regulation (of both ILS and MSLQ), external regulation, and all ILS processing variables as well as a negative correlation with lack of regulation.

Table 2: Descriptive statistics and correlation matrix for the observed variables

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11
1. Knowledge construction	1.73	.50	---										
2. Self-regulated learning	-.18	.77	.32**	---									
3. Self-perceived inability	-.87	.92	-.45**	-.42**	---								
4. Motivation to learn	.57	1.12	.44**	.42**	-.29*	---							
5. ILS Self-regulation	29.51	7.49	.38**	.46**	-.39**	.41**	---						
6. ILS External regulation	31.66	6.32	-.15	-.24*	.12	.20	.15	---					
7. ILS Lack of regulation	13.67	4.67	-.47**	-.42**	.65**	-.47	-.28*	.15	---				
8. ILS Deep processing	36.84	7.98	.41**	.43**	-.57**	.39**	.71**	.03	-.31**	---			
9. ILS Stepwise processing	30.29	7.88	.12	.15	-.08	.37**	.36**	.44**	-.15	.22	---		
10. ILS Concrete processing	15.45	3.46	.13	.22	-.29*	.12	.54**	.11	-.22	.51**	.11	---	
11. MSLQ Self-regulation	55.18	7.26	.42**	.48**	-.38**	.69**	.61**	.19	-.49**	.49**	.46**	.54**	---
12. MSLQ Cognitive strategy use	42.09	7.01	.34**	.17	-.21	.44**	.50**	.37**	-.27*	.45**	.55**	.30**	.53**

Note: N = 76; ** Correlation is significant at the .01 level. * Correlation is significant at the .05 level

3.2 Analysis of the structural model with regulation and processing variables of the ILS

Analysis of the hypothesized structural model depicted in Figure 1 (N = 76) revealed a CFI of .94 a TLI of .78, and a RMSEA of .13. These indices indicate a moderate fit of the model with the data. The χ^2 analysis, $\chi^2(12, N = 76) = 27.41, p < .01$, suggests that the hypothesized model does not fit the data well. However, it should be noted that the χ^2 test of statistical significance has several limitations. The test is based on restrictive assumptions that are typically not met. In addition, the intention of a model is to provide an approximation to reality rather than to fully represent all the complexity in the observed data. Furthermore, the χ^2 statistic is quite sensitive to sample size. Therefore, other indices of fit are to be preferred when evaluating a particular model (Marsh et al., 1994). χ^2 divided by the degrees of freedom of the hypothesized structural model depicted in Figure 1 was less than three.

Table 3 displays estimates and standard errors of the structural parameters. Estimates displayed in Table 3 account for the hypothesized model that depict the relationships among students' conceptions of constructivist learning, regulation strategies, and students' processing strategies. In total, nine regression paths were significant. With respect to students'

Table 3: Estimates and standard errors of structural parameters for ILS variables

Parameter	Unstandardized estimates	Standardized estimates	Standard Error
Knowledge construction → ILS Self-regulation	2.05	.14	1.72
Self-regulated learning → ILS Self-regulation	2.56*	.27	1.10
Self-perceived inability to learn → ILS Self-regulation	-1.29	-.16	.93
Motivation to learn → ILS Self-regulation	1.27	.19	.76
Knowledge construction → ILS External regulation	-2.88	-.23	1.56
Self-regulated learning → ILS External regulation	-2.84**	-.35	.99
Self-perceived inability to learn → ILS External regulation	.04	.01	.84
Motivation to learn → ILS External regulation	2.51**	.44	.68
Knowledge construction → ILS Lack of regulation	-1.10	-.12	.90
Self-regulated learning → ILS Lack of regulation	-.41	-.07	.57
Self-perceived inability to learn → ILS Lack of regulation	2.52**	.50	.48
Motivation to learn → ILS Lack of regulation	-1.01*	-.24	.39
ILS Self-regulation → ILS Deep processing	.74**	.69	.09
ILS Self-regulation → ILS Stepwise processing	.27*	.26	.11
ILS Self-regulation → ILS Concrete processing	.24**	.51	.05
ILS External regulation → ILS Deep processing	-.07	-.06	.10
ILS External regulation → ILS Stepwise processing	.53**	.42	.12
ILS External regulation → ILS Concrete processing	.03	.05	.06
ILS Lack of regulation → ILS Deep processing	-.18	-.10	.15
ILS Lack of regulation → ILS Stepwise processing	-.23	-.14	.17
ILS Lack of regulation → ILS Concrete processing	-.06	-.08	.08

Note: * $p < .05$; ** $p < .01$

conceptions of constructivist learning, conceptions of self-regulated learning, self-perceived inability to learn, and motivation to learn contributed significantly to the controlling level. Conceptions of self-regulated learning maintain a positive relationship with self-regulation and a negative relationship with external regulation. Conceptions of self-perceived inability to learn had a large positive effect on lack of regulation. This implies that students who express high levels of doubt with regard to their learning process are at risk for adopting an inadequate regulation strategy. Conceptions of motivation to learn had a negative relationship with lack of regulation and a fairly large positive effect on external regulation. Conceptions of knowledge construction did not show any significant relationships with students' reported regulation strategies.

Furthermore, several path coefficients from the controlling to the operational level were significant. Self-regulation had a very large effect on deep processing, a large effect on concrete processing, and a medium effect on stepwise processing. External regulation had a fairly large relationship with stepwise processing and no significant relationships with deep and concrete processing. Lack of regulation, finally, did not show significant path estimates with the operational level variables.

3.3 $\Delta\chi^2$ Test for the structural model with regulation and processing variables of the ILS

Finally, a model assuming direct paths from students' conceptions to processing strategies was compared with the hypothesized model as suggested by Figure 1. This was done to examine whether relations between students' conceptions and the operational level are completely mediated by students' regulation strategies. This alternative model was identical to the model in Figure 1, but it assumed additional paths from the conceptions directly to all three processing variables. This alternative model resulted in a saturated model with 0 degrees of freedom. Therefore, the χ^2 test of the model depicted in Figure 1 also serves as the $\Delta\chi^2$ test since the saturated model has, by default, a χ^2 of zero. The value of $\Delta\chi^2$ ($df = 12$) = 27.41, was significant at the 0.5 level, assuming partial mediation. In other words, adding direct relations between conceptions and processing variables lead to a better explanation of the data compared to complete mediation.

Therefore, relations between conceptions and the endogenous factors at the operational level are only partially mediated by students' reported regulation strategies. The regression coefficients of the alternative model showed a significant ($p < .001$), negative relationship between self-perceived inability to learn and deep processing (unstandardized regression weight = -3.72; standardized regression weight = -.43; standard error = .86). No other variables at the conceptual level showed significant, direct connections with the operational level. When the model depicted in Figure 1 was rerun with a direct path from self-perceived inability to deep processing, the following fit measures were obtained: $\chi^2(11, N = 76) = 11.19$, $p > .10$, CFI = 1.00, TLI = 1.00, RMSEA = .02. It should be noted, however, that in order to draw reliable conclusions, this renewed model should be tested in a new, independent sample.

3.4 Analysis of the structural model regulation and processing variables of the MSLQ

Testing the hypothesized structural model with the regulation and processing variables of the MSLQ resulted in a CFI of 1.00 a TLI of 1.00, and a RMSEA < .001 indicating an excellent fit with the data. The χ^2 analysis, χ^2 (4, N = 76) = 3.95, p > .10, also supported excellent model fit.

Table 4 shows the estimates and standard errors of the structural parameters of the hypothesized model with the MSLQ-variables.

Table 4: Estimates and standard errors of structural parameters for MSLQ variables

Parameter	Unstandardized estimates	Standardized estimates	Standard Error
Knowledge construction → MSLQ Self-regulation	.96	.07	1.32
Self-regulated learning → MSLQ Self-regulation	1.61	.18	.84
Self-perceived inability to learn → MSLQ Self-regulation	-.86	-.11	.71
Motivation to learn → MSLQ Self-regulation	3.47**	.55	.58
MSLQ Self-regulation → MSLQ Cognitive strategy use	.55**	.53	.10

Note: * p < .05; ** p < .01

The estimates shown in Table 4 revealed two significant path estimates. On the conceptual level, motivation to learn had a strong effect on self-regulation. The path coefficient from conceptions of self-regulated learning to reported self-regulation on the controlling level was significant on a .10 level, but not on the .05 level. No other conceptions of constructivist learning had significant relationships with self-regulation.

Self-regulation strategies had a strong effect on cognitive strategy use, in line with the data of the ILS variables.

3.5 $\Delta\chi^2$ Test for the structural model with regulation and processing variables of the MSLQ

Again, including direct paths from the conceptions to the processing-variable resulted in a just-identified or saturated model with zero degrees of freedom. Therefore, the value of the χ^2 test of the model depicted in Figure 2 is also the value of the $\Delta\chi^2$ test; $\Delta\chi^2$ (df = 4) = 3.95. This result is nonsignificant at the .05 level, indicating that direct relations between conceptions and cognitive strategy use did not lead to a better explanation of the data. Therefore, any relations between conceptions and the endogenous factor (i.e., cognitive strategy use) are entirely mediated by self-regulation. In line with this finding is that no direct path estimates between students' conceptions of constructivist learning and cognitive strategy use were significant.

4. DISCUSSION

4.1 Relationships between conceptions of constructivism and regulation and processing strategies

The present study investigated relationships between students' conceptions of constructivist learning on the one hand, and their regulation and processing strategies on the other hand. Students in a constructivist, problem-based learning curriculum were questioned about their beliefs about the utility of knowledge construction and self-regulated learning. In addition, their beliefs about their own (in)ability to learn and motivation to learn were studied. Two hypothesized models were tested and a $\Delta\chi^2$ test was used to examine whether relationships between students' conceptions and processing strategies were mediated by students' self-regulated learning activities. The first model implemented regulation and processing variables of the ILS, the second model of the MSLQ. Results revealed a moderate fit of the ILS model with the data. Previous studies have shown mixed results with regard to model fit of all ILS variables tested in a hypothesized structural model (e.g., Vermetten et al., 1999; Boyle, Duffy, & Dunleavy, 2003). An explanation could lie in the partially mediated relationships, which will be discussed later on. Testing the second hypothesized model with regulation and processing variables of the MSLQ resulted in an excellent fit. Altogether, these findings imply that, similar to previously found effects of students' conceptions on regulation and processing strategies (e.g., Lonka & Lindblom-Ylänne, 1996; Dahl et al., 2005), structural relations also exist between conceptions of *constructivist* learning and regulation and processing strategies.

4.2 The pattern of path coefficients

Students' conceptions of self-perceived inability to learn had a large effect on lack of regulation. This implies that students who report feelings of doubt with regard to their learning process are at risk for adopting an inadequate regulation strategy. Earlier research has demonstrated that conceptions of self-perceived inability to learn had a positive effect on students' self-study time (Loyens et al., in press-b). It has been argued that students' encounter with their perceived inability is not necessarily harmful for their learning processes. Possibly, they will work harder to manage this uncertainty and by doing so, they may come to a degree of acceptance or tolerance of uncertainty, which makes them less averse to it (Block, 1996). However, the present findings indicate that extra study hours of these students do not necessarily lead to more effective study strategies. On the contrary, these students are likely to adopt an undirected regulation strategy. Because an undirected learning style (which consist of a lack of regulation) has been proven to be consistently and negatively related to all types of exam results (Vermunt & Vermetten, 2004), students' expressing self-perceived inability to learn are highly at risk.

The negative relationship between conceptions of motivation to learn and lack of regulation could be expected. Students who indicate to agree with statements such as "I can easily find the motivation to study" are not likely to adopt an undirected regulation strategy. More striking is the fairly large effect of conceptions of motivation on external regulation, while their effect on the ILS self-regulation variable is not significant. Nevertheless, conceptions of motivation to learn had a large effect on the MSLQ self-regulation variable. The issue that comes to mind in this respect is the dichotomy intrinsic versus extrinsic motivation. However, this dichotomy was not as such integrated in the factor structure of the motivation to learn-variable, meaning that motivational aspects such as study goals (i.e., learning versus performance goals) were not explicitly questioned. It could be argued that some students can obtain high scores on statements such as "I can easily find the motivation to study" because they have high grades in mind (performance goals) and not because they are intrinsically motivated in the subject matter (learning goals). Using a more specific measure of motivation could shed light on this issue in future research.

Conceptions of self-regulated learning had positive relationships with actual reported self-regulation activities. This finding brings the central role of conceptions to the fore. If students believe that self-regulation is beneficial for their learning processes, they are more likely to engage in self-regulated behaviour. Consequently, these students do not believe that external regulation is of use for their learning. In terms of implications, more attention should be given to those students who do not believe that aspects of self-regulation such as goal setting, self-observation, self-assessment, and self-reinforcement can be helpful for their learning process, because differences in self-regulated strategy use reflect on academic achievement (e.g., Cantwell & Moore, 1996; VanZile-Tamsen & Livingston, 1999).

In both hypothesized models, conceptions of knowledge construction did not show significant relationships with regulation strategies, while these conceptions significantly predict students' learning activities as observed by their tutors in earlier research (Loyens et al., in press-b). One could argue that these conceptions would primarily have relationships with cognitive processing strategies, since the knowledge construction variable consists of processing concepts such as elaboration and an active processing of the subject matter. However, direct paths from the knowledge construction-variable to the operational level were not significant either.

Path coefficients between the controlling and operational level were in line with previous findings. For the model depicted in Figure 1, results were in line with defined learning styles as outlined in the Results-section. However, self-regulation showed a medium effect on stepwise processing, while the latter is part of a reproduction-oriented learning style. The combination of self-regulation with stepwise processing has been shown to lead to low performances of students (Beishuizen, Stoutjesdijk, & van Putten, 1994). On the other hand, deep processing does not completely exclude stepwise processing. Entwistle and Peterson (2004) state that memorisation may be acquired at some stage of the learning process, for certain purposes or in certain subject areas. Memorisation can precede understanding. Our results do confirm that self-regulation leads to deep and concrete processing, but it can, although to a smaller degree, also lead to stepwise processing.

4.3 Mediated relationship between conceptual and operational level

The $\Delta\chi^2$ tests showed different results for both hypothesized models. For the ILS, partial mediation is supported. A strong, negative effect of self-perceived inability to learn on deep processing could be derived from the saturated model, although the reliability of this finding needs to be explored in new, independent sample. The result is in line with earlier findings of Vermetten and colleagues (1999). They concluded that regulation strategies do function on a controlling level, but these strategies are not strict mediators. The present results seem to confirm this role of regulation strategies for the ILS model.

With respect to the MSLQ variables, complete mediation of self-regulation was found, implying that the influence of the conceptual level on the operational level is completely controlled by self-regulation. To our knowledge, no previous studies have tested this three-level structure on the MSLQ. We were able to show the important, controlling role of self-regulation for this instrument. It would be interesting to investigate whether the model depicted in Figure 2 also holds with the conceptual variables of the MSLQ (i.e., motivational beliefs subscale).

4.4 Limitations

There is a constraint to our findings. The sample size used in this study ($N = 76$) is rather small. However, the hypothesized models tested in our study are rather simple (i.e., do not consist of a large number of parameters) which is another important consideration that needs to be taken into account (Kline, 1998).

Another constraint is the fact that self-regulation and processing strategies were self-report measures. Although self-report measures are frequently used in educational research studies, there is a need for more behavioural measures.

Chapter 5

Students' conceptions of constructivist learning: A comparison between a conventional and a problem-based learning curriculum

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Students' conceptions of constructivist learning: A comparison between a traditional and a problem-based learning curriculum
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ABSTRACT

This study investigated students' conceptions of constructivist learning activities in a problem-based learning (PBL) and a conventional curriculum. We examined whether students who have chosen for a problem-based curriculum have different conceptions of constructivist assumptions compared to students who have chosen to be enrolled in a conventional, lecture-based curriculum when they enter university. Although constructivism represents an influential view of learning, studies investigating how students conceptualize this perspective have not been conducted before. A structural equation modelling approach was adopted to test the hypothesized model in both student populations and to calculate latent means. Results suggested that students in the PBL environment agree more on constructivist assumptions of cooperative learning and the use of authentic problems, while students in the conventional curriculum acknowledge the importance of motivation to learn more. It is discussed that conceptions of constructivist learning activities can act as an important moderator of PBL effects and should be considered in examining the effect of PBL and probably in all comparative education research.

1. INTRODUCTION

Problem-based learning (PBL) has its roots in constructivist learning theories and was developed in the mid-sixties as a useful instructional alternative to conventional teaching. PBL environments are designed to help students construct an extensive and flexible knowledge base, become effective collaborators, develop self-directed learning skills, develop effective problem-solving skills, and become intrinsically motivated to learn (Hmelo-Silver, 2004).

Studies have revealed a robust positive effect from constructivist curricula such as PBL on students' skills but not on measures of factual knowledge (e.g., Vernon & Blake, 1993), while others have questioned the superiority of PBL due to its costs (e.g., Albanese & Mitchell, 1993) and stressfulness (Berkson, 1993). Possible explanations have been proposed to explain why PBL does not always appear to fulfill its promise (Delva et al., 2000). A first reason concerns the measures deployed for assessment (e.g., multiple-choice exams) that are not in line with the aspects of performance that PBL tends to capture (e.g., the application of knowledge in real-life settings). The central role of assessment is underlined in a recent meta-analysis on PBL by Gijbels, Dochy, Van den Bossche, and Segers (2005). This study demonstrated that effects of PBL differed according to the levels of the knowledge structure that were measured with various types of exams measuring different types of knowledge structure levels. A second possible reason for the failure to demonstrate positive PBL effects concerns the field where PBL aims to establish changes. In order to enhance learning, changing the way students initially encounter information is insufficient, but changes with respect to what students do when they learn this information are crucial (Delva et al., 2000). Therefore, learning activities and learning styles and strategies in particular, have become more and more the object of investigation in PBL studies. With respect to learning strategies, it was found that for PBL sessions, students used more library resources and general reference texts compared to lecture sessions. However, this pattern was not stable over time and other factors, such as content overload and assessment systems, may be put forward as more important drivers of students' learning strategies (Delva et al., 2000). A recent study by McParland, Noble, and Livingston (2004) found no differences in learning styles between a group of students in a conventional versus a PBL curriculum. The PBL group, however, obtained better examination performances. In a commentary to this study, the important role of assessment is stressed and it is argued that students differentially use learning styles. Nevertheless, focus on relationships between different variables that influence student learning in a PBL environment is recommended (Dolmans & Wolfhagen, 2004). In sum, these explanations for why PBL does not always appear to fulfill its promise, show that studies on the effects of constructivist learning environments like PBL, do not have to exclusively focus on curriculum features, solely examining if instructional goals have been met. Instead, research should take stock of a broader range of variables influencing the learning process. In other words, while traditionally the teacher, instructional methods, and learning materials were considered as the elements of change in order to establish the necessary knowledge construction to promote performance, the learner himself now receives a more controlling role (Sinatra & Pintrich, 2003).

In this line of reasoning, a third reason could be added, namely the 'ignorance' of the preconceived conceptions of learning that learners have. Students bring along a variety of conceptions of learning when they enter university that they have inherited from their previous educational experiences (Marton, Dall'Alba, & Beaty, 1993). This pre-existing knowledge serves as a frame of reference from which students interpret and approach learning tasks and might therefore play an important role in students' learning processes. The way in which students understand the nature of learning, that is, students' conceptions of learning, has indeed become an increasingly significant construct in research on effective learning. It has been demonstrated, for example, that students conceptualize information differently. Hence, individual conceptions represent differences in the way students understand or misunderstand the same information. These differences can be seen as responsible for differences in students' learning outcomes (Dahlgren & Marton, 1978). Using Säljö's taxonomy (Säljö, 1979), Van Rossum and Schenk (1984) studied the relationship between conceptions of learning, study strategies, and learning outcomes by letting participants study a text, followed by a questionnaire containing items about the text as well as items about their study strategy and conceptions of learning. They found that high quality learning outcomes are particularly related to learning conceptions that emphasize the constructive character of learning. Therefore, ideas that students have about learning, the learning strategy employed in studying a text, and the quality of the learning outcomes seem intertwined. The same findings have been found with respect to students' conceptions of mathematics. A structural relationship between students' conceptions of mathematics and their approaches to learning this subject can be identified (Crawford, Gordon, Nicholas, & Prosser, 1994). Similarly, McLean (2001) demonstrated that the academic ability of students was related to the conceptions of learning they hold, with more advanced, transformative conceptions (i.e., in these conceptions, by developing insight into a certain phenomenon, one creates new ways of seeing the world, which involves personal development) being identified by students with an excellent academic record. In sum, empirical literature reports associations between conceptions of learning and approaches to learning and both appear crucial determinants of the quality of learning outcomes.

However, to our knowledge, no research has yet investigated students' conceptions of constructivist learning like PBL. As a result, little is known about students' conceptions of constructivist learning principles implemented in a PBL curriculum. Do students acknowledge constructivist concepts such as knowledge construction, cooperation, self-regulated learning, and the use of authentic problems as important factors of their learning processes? Furthermore, do first-year students who have chosen for a constructivist problem-based curriculum have different conceptions of constructivism compared to students who have chosen to study in a conventional, lecture-based curriculum?

Conceptions of constructive learning activities of students in a PBL curriculum were compared with those of students in a lecture-based program. More specifically, we examined whether students who have chosen for a problem-based curriculum have different conceptions of constructivist assumptions compared to students who have chosen to be enrolled in a conventional, lecture-based curriculum when they enter university. We focused explicitly on the conceptions that first-year students bring to the fore at the beginning of the academic year, since we were particularly interested in students' preconceived notions. In other words, does the choice of students to study in a specific curriculum (PBL or conventional) reflect on their conceptions of constructive learning activities? As outlined above, students bring along a variety of conceptions of learning when they enter university that may be determinants for students' learning processes. It was hypothesized that conceptions of constructive learning between both student groups were similar, because students were tested on the first day of the academic year. Therefore, both groups rely on their educational experiences from similar secondary education and have not yet experienced influences from the learning environment in which they are enrolled.

2. METHOD

2.1 Participants

Participants were 186 first-year students enrolled in a PBL psychology curriculum and 107 first-year psychology students of a lecture-based curriculum. In the problem-based learning group, 130 participants were female and 56 were male. The mean age of this group of students was 19.94 (SD = 2.99) and the response rate was 74.4% of all first-year students. Eighty-eight participants of the lecture-based learning group were female and 19 were male. The mean age of this group was 19.02 (SD = 3.39) and the response rate was 49.6% of the first-year student population.

2.2. Learning environments

The PBL curriculum in this study was structured as follows. Students work in small groups (maximum 12 students) on authentic problems, under the guidance of a tutor (Barrows, 1996). First, students discuss a problem and possible explanations or solutions are proposed. Since their prior knowledge of the problem-at-hand is limited, this discussion leads to the formulation of issues for further self-directed learning. Subsequently, students spend time studying literature relevant to the issues generated. After this period of self-study, students share their findings, elaborate on knowledge acquired, and have an opportunity to correct misconceptions (Hmelo-Silver, 2004; Schmidt, 1983). The first-year PBL curriculum in this study consists of eight courses of five weeks each. At the end of each course, a course test is administered.

The conventional, lecture-based curriculum consists of two semesters of 22 weeks each. Each semester is divided in two periods of 10 weeks, followed by an examination week. Students attend lectures of two hours each, twice a week. For some courses (e.g., statistics), students need to attend additional two-hour practical sessions as well.

2.3 Measurement of students' conceptions

Students' conceptions of constructivist assumptions were measured by means of a 55-item questionnaire. The statements needed to be rated on a Likert-scale ranging from -3 (entirely disagree) to +3 (entirely agree) (Loyens, Rikers, & Schmidt, in press-a). Although constructivism is embodied in numerous ways (e.g., Windschitl, 2002), most views share important overlaps. Most constructivist theories share four core assumptions that should be considered while creating learning environments for students. These assumptions can be labelled (1) knowledge construction, (2) cooperative learning, (3) self-regulation, and (4) use of ill-structured, authentic problems (Marshall, 1992; Woolfolk, 2004). Students' conceptions of these four constructs were measured by the aforementioned questionnaire. In addition, students' conceptions of self-perceived inability to learn and motivation to learn were taken into account. Self-perceived inability to learn refers to feelings of doubt concerning one's own learning capacities. It has been observed that open, constructive learning environments require a great deal of responsibility from learners in terms of being socially apt, self-regulated knowledge constructors. Some learners may experience this as a positive challenge and as part of their learning process, but others may relapse into uncertainty, confusion, and even anxiety (Duke, Forbes, Hunter, & Prosser, 1998). Motivation to learn is a widely acknowledged factor influencing students' learning (e.g., Pintrich & Schunk, 1996; Schunk, 1991). Examples of items are shown in Table 1.

Items were clustered based on semantic overlap, a technique called item parceling (Bandalos & Finney, 2001; Little, Cunningham, Shahar, & Widaman, 2002). The six constructs underlying the questionnaire accompanied by their item parcels are depicted in Figure 1. Confirmatory factor analysis has demonstrated that the questionnaire was able to measure

Table 1: Item examples of students' conceptions of constructivist learning activities

Concept	Item examples (translated from Dutch)
Knowledge construction (*n* = 10)	"Previous learned facts are the building blocks of new knowledge"
Cooperative learning (*n* = 9)	"Discussing subject matter with fellow-students leads to a better understanding"
Self-regulation (*n* = 9)	"Preparing a test is difficult when the teacher has not pointed out exactly what has to be studied" (reversed scoring)
Authentic problems (*n* = 7)	"Emphasis on practical abilities during the curriculum gives you a head start in your future job"
Self-perceived inability to learn (*n* = 12)	"I doubt if I can complete this study successfully"
Motivation to learn (*n* = 8)	"I easily find the motivation to study"

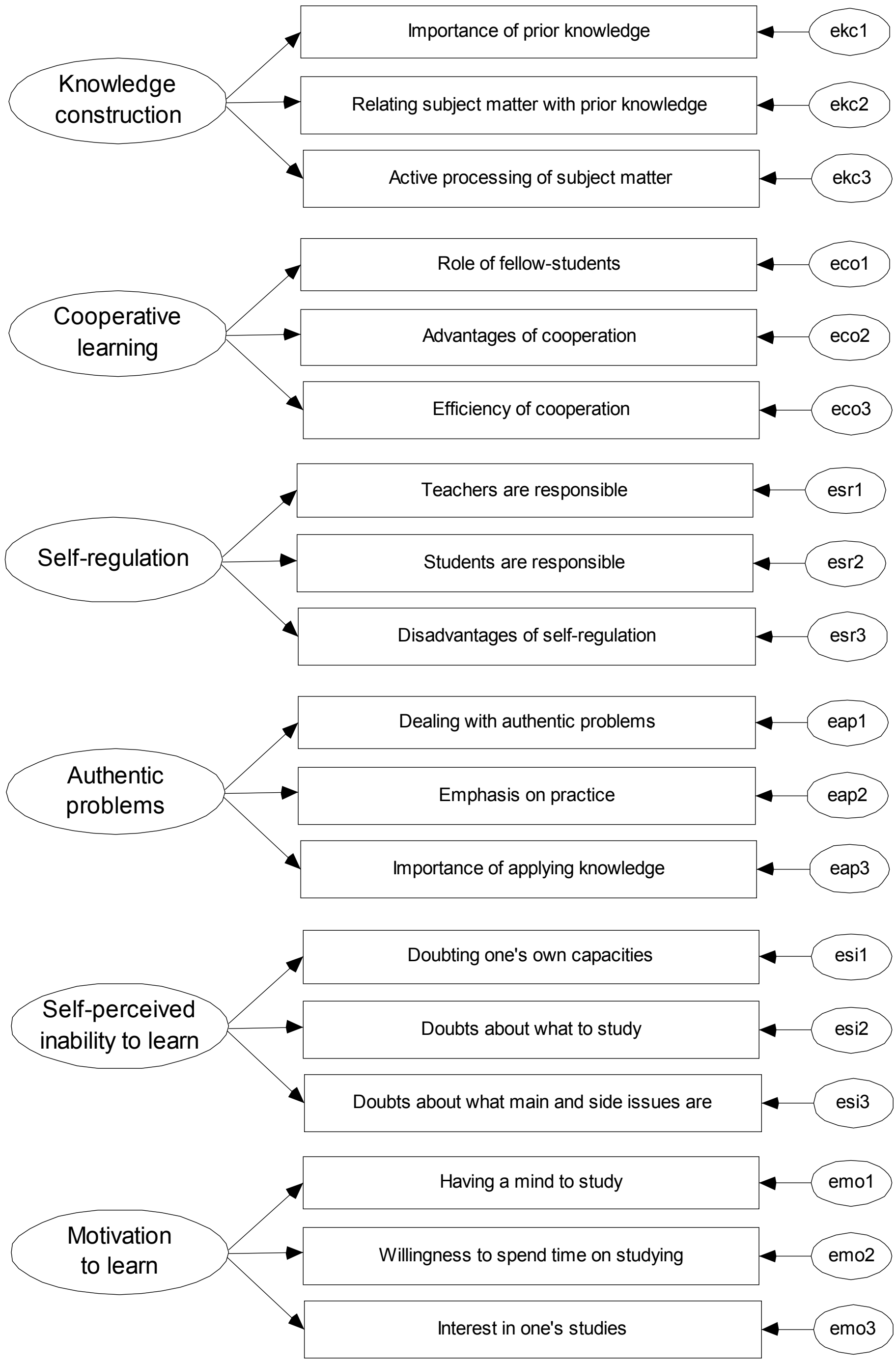

Figure 1: Model with the 6 underlying assumptions

Note: Each assumption consists of three item parcels and their associated error terms. For clarity, double arrows indicating correlations among the six latent variables were omitted.

students' conceptions in a reliable and valid fashion. Students were able to identify the six dimensions comprising the questionnaire, as indicated by the fit of the hypothesized model. The reliability of the six latent constructs was assessed using coefficient H (Hancock & Mueller, 2001) and ranged from .60 to .86 (Loyens et al., in press-a).

2.4 Procedure

The questionnaire was administered to both groups on the first day of the academic year. Students in the PBL-curriculum receive a PBL training to become familiar with the PBL-process in the first week of the academic year. In order to rule out any possible influences of this training on students' answers, all students were tested on the first day of the academic year. The questionnaire's instruction stated that there were no right or wrong answers to the items, all answers were correct as long as they reflected students' personal opinions. No information was given about the constructs underlying the questionnaire. Filling in the questionnaire took approximately ten to fifteen minutes.

2.5 Statistical analysis

Data were analyzed using a structural equation modelling approach. Amos 5.0 was used as software program (Arbuckle, 2003).

Maximum likelihood estimations were used for the estimation of the model's parameters. For the evaluation of the model presented in Figure 1, two groups of fit indices, absolute and incremental, were selected. In the present study, χ^2, accompanied by degrees of freedom, sample size, and p-value, as well as the root mean square error of approximation (RMSEA, Steiger, 1990) were used as absolute fit indices. The χ^2 measure has been the traditional statistic to test the closeness of fit between an observed and predicted covariance matrix. A small χ^2 value, relative to the degrees of freedom, is an indication of good fit and vice versa (Byrne, 2001). Although there is no clear-cut guideline about what value of χ^2 divided by the model's degrees of freedom is minimally acceptable, it is frequently suggested that this ratio should be less than three (Kline, 1998).

RMSEA appears to be sensitive to model specification, minimally influenced by sample size, and not overly influenced by estimation method and was therefore included (Fan, Thompson, & Wang, 1999). The lower the value of RMSEA, the better the fit, with a cut-off value close to .06 (Hu & Bentler, 1999).

Furthermore, two incremental fit indices were included: The Tucker-Lewis index (TLI, Tucker & Lewis, 1973) and the comparative fit index (CFI, Bentler, 1990). Both indices range from zero to 1, with higher values indicating a better fit. Values greater than .90 are traditionally associated with well-fitting models (Bentler, 1990) although more recently, cut-off values close to .95 or .96 are suggested (Byrne, 2001; Hu & Bentler, 1999).

To measure latent mean differences between both student populations, measurement invariance across both populations was investigated first. It is commonly accepted that sufficient measurement invariance is established when the factor loading matrix is invariant across groups, meaning that conceptual agreement with regard to the importance attributed to the questionnaire items, is reached (Cheung & Rensvold, 1999; Marsh et al., 1994). Therefore, proceeding as Cheung and Rensvold (1999) and Byrne (2001) suggest, the measurement model with no between-group invariance (depicted in Figure 1) was tested first, followed by the testing of the equality of factor loadings across both groups. A $\Delta\chi^2$ test was used to evaluate the difference between these two models. A nonsignificant value of $\Delta\chi^2$ suggests factorial invariance (Kline, 1998).

3. RESULTS

Analysis of the hypothesized model with the covariance matrix of the PBL student population resulted in a CFI of .90, a TLI of .87, and a RMSEA of .06. These indices indicated a reasonable fit of the specified model with the data. The χ^2 analysis, χ^2 (120, N = 186) = 211.69, $p < .001$, on the other hand, suggested that the hypothesized model does not fit the data very well. However, it should be noted that the χ^2 test of statistical significance has several limitations. The test is based on restrictive assumptions that are typically not met. In addition, the intention of a model is to provide an approximation to reality rather than to fully represent all the complexity in the observed data. Therefore, other indices of fit are to be preferred when evaluating a particular model (Marsh et al., 1994). Furthermore, the ratio of χ^2 divided by the model's degrees of freedom was less than two.

For the student population enrolled in the conventional curriculum, analysis of the hypothesized model depicted in Figure 1 revealed a CFI of .94, a TLI of .92, and a RMSEA of .05, indicating a fairly good fit of the specified model with the data. The χ^2 analysis, χ^2 (120, N = 107) = 153.66, $p < .05$, was not significant, while the ratio of χ^2 divided by the model's degrees of freedom was less than two.

In order to examine whether first-year students who chose for a PBL curriculum had different conceptions of the six investigated factors compared to students who chose to study in a lecture-based curriculum, measurement invariance across both populations had to be evaluated first. The test for the validity of factorial structure conducted across the two student populations simultaneously, resulted in a CFI of .91, a TLI of .89, and a RMSEA of .04. These values are indicative that the hypothesized model of Figure 1 is fairly well fitting both student groups. The factor structure of the questionnaire repeats itself over different populations, giving evidence of cross-validation. The χ^2 value of 365.43 (N = 293, i.e., both student populations together) with 240 degrees of freedom provided the baseline value against which the model with fixed factor loadings was compared. This latter model generated a CFI of .91, a TLI of .89, and a RMSEA of .04. Table 2 summarizes the χ^2 values and the $\Delta\chi^2$, compared with the unconstrained model.

Table 2: Summary of goodness-of-fit statistics for tests of invariance

Model description	χ^2	Df	$\Delta\chi^2$	Δ Df	Statistical significance
Hypothesized model (Figure 1)	365.43	240	---	---	---
Model with factor loadings constrained equal	379.00	252	13.60	12	NS

Note: $\Delta\chi^2$, difference in χ^2 values between models; Δ Df, difference in number of degrees of freedom between models; NS, not significant at the .05 level.

The nonsignificant $\Delta\chi^2$ between the two models indicates that the factor loadings were invariant across both populations. This implies that the relations between the items and their latent constructs are equal across different groups. In other words, conceptual agreement can be concluded with respect to the questionnaire's items. Due to this equality in factor loadings, latent means could be computed that are displayed in Table 3.

Table 3: Latent mean differences between the problem-based learning and lecture-based learning student populations

	Estimate	SE	p
Knowledge construction	.104	.063	.100
Cooperative learning	-.154	.076	.041
Self-regulation	.032	.093	.729
Authentic problems	-1.601	.114	.000
Self-perceived inability to learn	-.142	.118	.230
Motivation to learn	.381	.114	.000

Significant differences can be noticed on the latent factors of cooperative learning, authentic problems, and motivation to learn. The latent means were estimated for the lecture-based learning group, indicating that this student population scores significantly lower on the latent constructs of cooperative learning and authentic problems, but significantly higher on motivation to learn, compared to the PBL-group. This implies that the PBL-group agrees more on items concerning cooperative learning and the use of authentic problems than the lecture-based group. On the other hand, the lecture-based group agreed more on motivation to learn.

4. DISCUSSION

The present study investigated students' conceptions of constructivist learning activities in two independent student groups who had just started their first year at university. The aim of this study was to investigate whether students who have chosen for a problem-based curriculum have different conceptions of constructivist assumptions compared to students who have chosen to be enrolled in a conventional, lecture-based curriculum when they enter university.

4.1 The hypothesized model

The goodness-of-fit indices of the hypothesized model showed that both student groups acknowledge the importance of the constructivist concepts of knowledge construction, cooperative learning, self-regulation, and the use of authentic problems, as well as self-perceived inability to learn and motivation to learn. Consequently, the questionnaire appeared an adequate instrument to measure students' conceptions of constructivism, which is in line with previous findings (Loyens et al., in press-a). Moreover, the test for measurement invariance showed that factor loadings were equivalent across both groups of students and that the questionnaire's underlying factor structure gave evidence of cross-validation. Although constructivism is an influential view of learning nowadays, studies investigating students' conceptions of this view on learning have, to our knowledge, not been conducted before. Given the impact that preconceived notions can have on learning activities and learning outcomes (e.g., McLean, 2001), it is insightful for students' learning activities to investigate students' conceptions of constructivist learning activities. The present study tackled this issue and was able to chart conceptions of constructivism.

4.2 Differences between students enrolled in a constructivist, problem-based learning environment and a conventional, lecture-based curriculum

Furthermore, it was investigated whether differences in conceptions of constructivism could be detected between students in a PBL and a conventional curriculum when they enter their first year of university. Although no differences between both groups were expected, students who have chosen for a constructivist learning environment like PBL, appear to agree more on the constructivist constructs of cooperative learning and the practical application of knowledge, represented by authentic problems. Cooperative learning and the use of authentic problems are inherent to a constructivist learning environment. They could be considered as PBL context factors. The other two constructivist assumptions (i.e., knowledge construction and self-regulation) on the other hand, rely more on individual actions with respect to learning. It is an interesting finding that even PBL students, who have just entered university, already lay this emphasis and importance on the cooperation process and the use of authentic problems, while students in conventional education do not. Cooperative learning is indeed a key feature of PBL (e.g., Slavin, 1996) as well as working with authentic problems, which are the driving force behind students' independent study in constructivist learning environments (Dolmans, Snellen-Balendong, Wolfhagen, & van der Vleuten, 1997).

The difference between the two student groups on motivation -with PBL students reporting less agreement on the importance of motivation- is somewhat surprising, since making students intrinsically motivated to learn is one of the assumptions of constructivist learning. However, there is little research that bears directly on this issue. Most research has instead investigated student satisfaction or confidence (Hmelo-Silver, 2004). There have been proposed some reasons why learning formats like PBL can possibly fail to motivate students.

Although these learning formats can lead to effective solutions, it is usually unsystematic. This implies that when the problem solving process fails, learners tend to ascribe this to their ability, rather than to their technique, which is detrimental to their motivation (Zimmerman & Campillo, 2003). However, the question remains whether starting first-year students are already conscious of this caveat.

No differences in self-perceived inability to learn were found between the two student populations, while this factor is often mentioned as a possible 'danger' for students in a constructivist learning environment (Duke et al., 1998). The responsibility that learning environments like PBL expect from learners can be a stressful experience (Albanese & Mitchell, 1993). However, based on the present findings, this responsibility does not appear to discourage students who are about to start their program.

In conclusion, the findings of this study imply that starting first-year students come to university with pronounced conceptions of constructivist learning issues. PBL students already acknowledge the importance of several constructivist learning principles more than students in a conventional curriculum. Therefore, studies on the comparison of conventional and PBL curricula should take these initial differences into consideration, because students' conceptions of learning can influence other aspects of learning. Most studies comparing constructivist with conventional programs solely highlight differences that evolve due to the curriculum, while this study was able to show that with respect to conceptions, 'different' students enter different programs. Hence, conceptions of constructivist learning activities can act as an important moderator of PBL effects and should be considered in examining the effect of PBL and probably in all comparative education research.

4.3 Further research

Future research should examine whether conceptions change throughout students' academic program. Participants in this study were all first-year students who appear to bring along different conceptions of constructive learning activities. It would be informative to investigate whether changes take place, when they take place and how this reflects on students' learning activities and performance. A next step could be to investigate whether conceptions can be changed purposively and whether this would influence students' learning.

Chapter 6

Changes in students' conceptions of constructivist learning and the influence of the learning environment

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ABSTRACT

Constructivist views of learning have brought conceptions of learning to attention again, which are considered important determinants of effective learning. Conceptions are liable to change. They develop progressively through educational experiences. The present study investigated the development of students' conceptions of constructivist learning. Do students agree on constructivist learning to a larger extent with greater experience in their academic program? In addition, to what extent develop conceptions of constructivist learning differently in a conventional, lecture-based curriculum compared to a constructivist, problem-based learning curriculum. Three groups (i.e., first-year, second-year, and third-year students) in two different curricula (i.e., conventional, lecture-based and constructivist, problem-based) were tested. A cross-sectional design was used. Students' conceptions of constructivist activities (i.e., knowledge construction, cooperative learning, self-regulation, use of authentic problems, self-perceived inability to learn, and motivation to learn) were measured by a questionnaire. Data were analyzed using a two-way multivariate analysis of variance (MANOVA). A significant increase of the questionnaire's scores between year 1 and year 2 (but not between year 2 and 3) was found with respect to conceptions of knowledge construction, self-regulation, and the use of authentic problems, but not for cooperative learning and motivation to learn. For self-perceived inability, an interaction effect was found. Furthermore, results showed significant differences between the two curriculum groups on all dependent measures. Changes in conceptions due to a new learning program (i.e., higher education) happen in the first year. After this year, conceptions seem to consolidate. Furthermore, this study provides unequivocal evidence for the influence of the learning environment on students' conceptions of constructivist learning activities.

1. INTRODUCTION

Constructivist views of learning have brought conceptions of learning to attention again because personal knowledge constructions and learners' subjective beliefs play such a crucial role in these views (Wigfield, Eccles, & Pintrich, 1996). Students' conceptions of learning have become an increasingly significant construct in research on effective learning. The role of these conceptions as important determinants of effective learning (e.g., Boyle, Duffy, & Dunleavy, 2003), study strategies (e.g., Van Rossum & Schenk, 1984), approaches to learning (e.g., Crawford, Gordon, Nicholas, & Prosser, 1994), and academic achievement (e.g., McLean, 2001) has been frequently investigated.

Similarly, conceptions of knowledge (i.e., epistemologies) have also come to the fore (e.g., Schommer-Aikins, 2002), although Hofer and Pintrich (1997) have argued that it is better from a theoretical point of view that conceptions of learning and epistemologies, albeit indisputably related to each other, are kept separate. Despite this dichotomy in the theoretical field, educational researchers agree that both students' conceptions of knowledge as well as their conceptions of learning develop progressively through educational experiences.

Perry (1970) identified four stages in the development of students' conceptions of knowledge. He argued that the patterns of students' beliefs about knowledge develop throughout their academic program from a dualistic view (i.e., knowledge is either right or wrong), to an understanding that one can approach a situation from different angles (i.e., multiplicity), to consciousness that objective information is interpreted and that these interpretations are the building blocks of certain views from which numerous possible conclusions can be drawn (i.e., relativism), to, finally, the development of a personal opinion, acknowledging that all knowledge and ideas are relative. Similarly, Marton and colleagues, elaborating on the work of Säljö (1979), have categorised conceptions of learning in a qualitative way (Marton, Dall'Alba, & Beaty, 1993). Conceptions of learning that solely involve the increase of knowledge are considered as the starting point from which all other conceptions of learning develop, whereas conceptions of learning that imply changing as a person are viewed as the most advanced (i.e., highest level in the development) conceptions of learning. The in-between stages in students' development of conceptions of learning involve (2) memorising, (3) applying, (4) understanding, and (5) seeing something in a different way. Essentially, these conceptions depict learning as developing from reproduction to transforming subject matter (Boulton-Lewis, Wills, & Lewis, 2001). While these studies explicitly focused on constructing a theoretical overview of conceptions of knowledge and learning, other studies have focused on the application of these theoretical models and have investigated the kinds of conceptions of learning that are present within student groups. For example, Morgan and Beaty (1997) investigated university students' conceptions of learning over a six-year period and found the same conceptions of learning as proposed by Säljö (1979). Even the sixth conception, 'changing as a person', was held by some students. Furthermore, students' conceptions progressed from acquiring knowledge to developing understanding and seeing something in a different way. They argued that changes in conceptions of learning could be ascribed to students' educational experiences (Morgan & Beaty, 1997). In sum, conceptions of learning and knowledge are liable to change and need to be considered as process variables.

The present study investigated the development of students' conceptions of *constructivist* learning. Do students concur with constructivist learning to a greater extent with greater experience in their academic program? In addition, it was examined to what extent students' conceptions of constructivist learning develop differently in a conventional, lecture-based curriculum compared to a constructivist (i.e., problem-based learning) curriculum. Instruction that students receive, or more broadly, the learning environment in which students are enrolled, can affect students' conceptions (Vermunt & van Rijswijk, 1988; Tynjälä, 1997).

Constructivism can be defined by four characteristics. A first characteristic is knowledge construction: Students build their own knowledge structures by discovering and transforming information, checking new information against old, and by revising rules when they no longer apply. Students' prior knowledge plays a key role in the development of new conceptual understandings, or in other words, in their knowledge construction process (Taylor, Fraser, & Fisher, 1997). A second aspect of constructivist learning is cooperative learning. According to a constructivist view of learning, knowledge construction can be fostered through interaction of the learner with others (e.g., fellow-students and teachers) (Tenenbaum, Naidu, Jegede, & Austin, 2001). Although constructivists differ with regard to the extent that cooperation contributes to knowledge acquisition, they share the idea that social negotiation and interaction is an important factor in this process (Greeno, Collins, & Resnick, 1996). The role of metacognition in learning has been stressed as a third important factor (Heikkilä & Lonka, 2006). New information is preferably acquired through self-regulated learning, which implies goal setting, self-observation, self-assessment, and self-reinforcement. Research has shown that students benefit from a learning environment that allows them to exercise control over their learning experiences and that requires them to be responsible for their own learning performances (Tenenbaum et al., 2001). Fourth, most constructivists agree that meaningful learning is encouraged by authentic learning tasks. Encountering situations and solving problems that are similar to the kinds of situations and problems learners will face in their future profession provide students with practice in thinking in realistic, lifelike situations (Needels & Knapp, 1994).

Three student groups (i.e., first-year, second-year, and third-year students) in two different curricula (i.e., conventional, lecture-based and constructivist, problem-based) were tested. It is hypothesized that students' conceptions of constructivist learning develop through educational experience, in line with previous research on the development of conceptions of learning and knowledge (e.g., Boulton-Lewis et al., 2001; Morgan & Beaty, 1997). This is expected because in the course of their academic program, students are supposed to experience the beneficial effects of constructivist activities such as knowledge construction, cooperative learning, self-regulation, and working on authentic problems on their learning processes. Furthermore, it is hypothesized that students enrolled in a constructivist learning environment should agree on constructivist learning assumptions to a greater extent, since such a learning environment is based on these constructs.

2. METHOD

2.1 Participants

Participants were 212 first-year (146 female, 66 male; mean age = 20.02, *SD* = 2.95) 155 second-year (112 female, 43 male; mean age = 20.01, *SD* = 1.83), and 57 third-year (46 female, 11 male; mean age = 22.01, *SD* = 4.05) students enrolled in a problem-based learning (PBL) psychology curriculum.

In addition, 378 first-year (307 female, 71 male; mean age = 19.05, *SD* = 2.73), 187 second-year (161 female, 26 male; mean age = 20.82, *SD* = 3.81), and 36 third-year (29 female, 7 male; mean age = 21.33, *SD* = .99) students took part. They were enrolled in a conventional, psychology curriculum.

2.2 Learning environments

The PBL curriculum involved in this study was structured as follows. Students work in small groups (maximum 11 students) on authentic problems under the guidance of a tutor (Barrows, 1996). These problems consist of a description of observable phenomena or events that are to be explained in terms of their underlying theoretical explanation. First, students discuss these problems and possible explanations or solutions are proposed. Since their prior knowledge of the problem-at-hand is limited, questions will come up and dilemmas will arise that are used as learning issues for subsequent, individual learning. Subsequently, students spend time studying literature relevant to the issues generated. After this period of self-study, students share their findings, elaborate on knowledge acquired, and have an opportunity to correct misconceptions (Hmelo-Silver, 2004; Norman & Schmidt, 1992). Tutorial sessions last three hours each and are held twice a week. Each year of the PBL curriculum in this study consists of eight courses of five weeks each. At the end of each course, a test is administered.

The conventional, lecture-based curriculum consists of two semesters of 22 weeks each. Each semester is divided in two periods of 10 weeks, followed by an examination week. Students attend lectures of two hours each, twice a week. For some courses (e.g., statistics), students need to attend additional two-hour practical sessions as well.

2.3 Measurement of students' conceptions

Students' conceptions of constructivist activities were measured by means of a 55-item questionnaire (Loyens, Rikers, & Schmidt, in press-a). The statements needed to be rated on a 7-point Likert-scale ranging from -3 (entirely disagree) to +3 (entirely agree). Although constructivism is embodied in numerous ways (e.g., Windschitl, 2002), most views share important ideas. Most constructivist theories share four core assumptions that should be considered while creating learning environments for students. These assumptions can be labelled (1) knowledge construction, (2) cooperative learning, (3) self-regulation, and (4) use of ill-structured, authentic problems (e.g., Marshall, 1992; Woolfolk, 2004). Students' conceptions of these four constructs were measured by the aforementioned questionnaire. In addition, students' conceptions of self-perceived inability to learn and motivation to learn were taken into account. Self-perceived inability to learn refers to feelings of doubt concerning one's own learning capacities. It has been observed that open, constructive learning environments require a great deal of responsibility from learners in terms of being socially apt, self-regulated knowledge constructors. Some learners may experience this as a positive challenge and as part of their learning process, but others may relapse into uncertainty, confusion, and even anxiety (Duke, Forbes, Hunter, & Prosser, 1998). Motivation to learn is a widely acknowledged factor influencing students' learning (e.g., Pintrich & Schunk, 1996; Schunk, 1991).

The questionnaire is influenced by research on self-regulated learning and motivation (Pintrich & de Groot, 1990), mental models (Vermunt, 1992), conceptions of learning (Marton et al., 1993), conceptions of knowledge (Schraw, Bendixen, & Dunkle, 2002), and constructivist literature (e.g., Marshall, 1992; Steffe & Gale, 1995; Tenenbaum et al., 2001) with respect to its theoretical background. However, the questionnaire developed focuses explicitly on *conceptions* of *constructivist* learning activities and is therefore different from existing instruments. Examples of items are shown in Table 1.

Confirmatory factor analysis has demonstrated that the questionnaire was able to measure students' conceptions in a reliable and valid fashion. Students were able to identify the six dimensions comprising the questionnaire. Testing for measurement invariance

Table 1: Item examples of students' conceptions of constructivist learning activities

Concept	Item examples (translated from Dutch)
Knowledge construction ($n = 10$)	"Previous learned facts are the building blocks of new knowledge"
Cooperative learning ($n = 9$)	"Discussing subject matter with fellow-students leads to a better understanding"
Self-regulation ($n = 9$)	"Preparing a test is difficult when the teacher has not pointed out exactly what has to be studied" (reversed scoring)
Authentic problems ($n = 7$)	"Emphasis on practical abilities during the curriculum gives you a head start in your future job"
Self-perceived inability to learn ($n = 12$)	"I doubt if I can complete this study successfully"
Motivation to learn ($n = 8$)	"I easily find the motivation to study"

showed that factor loadings were equivalent across different groups of students and that the questionnaire's underlying factor structure gave evidence of cross-validation. The reliability of the six latent constructs was assessed using coefficient H (Hancock & Mueller, 2001) and ranged from .60 to .86 (Loyens et al., in press-a).

2.4 Procedure

A cross-sectional design was used to test the three student groups of both (i.e., lecture-based and problem-based learning) curricula. The questionnaire was administered to all students at the beginning of the academic year. The questionnaire's instruction stated that there were no right or wrong answers to the items, all answers were correct as long as they reflected students' personal opinions. No information was given about the constructs underlying the questionnaire. Filling in the questionnaire took approximately ten to fifteen minutes.

2.5 Statistical analysis

Responses to negatively stated items (n = 23) were reversed so that for all items the highest response score was indicative for a positive rating of each of the six latent constructs. Descriptive statistics were calculated for students' conceptions of the four constructivist learning assumptions together with self-perceived inability to learn and motivation to learn in the two curricula and three program years.

Data were analyzed using a two-way multivariate analysis of variance (MANOVA) with program years (first, second, and third year) and learning environment (conventional, lecture-based and constructivist, problem-based) as between-subject factors and the six conception-measures as dependent variables. Post-hoc multiple comparisons were performed for the year-of-program-variable.

3. RESULTS

Table 2 reports means and standard deviations of students' conceptions of the four constructivist learning assumptions together with self-perceived inability to learn and motivation to learn in the two curricula and the three program years. In our sample, scores were highest (i.e., students agreed the most) for conceptions of knowledge construction and the lowest for conceptions of self-perceived inability to learn. This implies that students acknowledge the importance of previous learned knowledge and actively constructing new knowledge for their learning processes the most. On the other hand, students do not have strong doubts concerning their own capabilities to learn. Furthermore, all self-regulated learning scores for both student groups were negative, indicating that students disagree with the importance of self-regulated learning activities for their learning processes.

Table 2: Means and standard deviations of the six dependent variables in the two curricula and three program years

	Conventional, lecture-based curriculum						Constructivist, problem-based learning curriculum					
	1		2		3		1		2		3	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Knowledge construction	1.31	.45	1.64	.52	1.45	.50	1.51	.50	1.72	.57	1.68	.51
Cooperative learning	.53	.83	.36	.78	.41	.86	.90	.69	.82	.71	.73	.73
Self-regulated learning	-.66	.72	-.49	.71	-.39	.69	-.49	.78	-.30	.84	-.21	.72
Authentic problems	.03	.78	.27	.86	.35	.67	.66	.77	.82	.80	.71	.72
Self-perceived inability	-.34	.89	-.79	.96	-1.20	.62	-.56	.85	-.55	1.01	-.67	.78
Motivation to learn	.56	.96	.56	1.09	.72	.90	.51	1.00	.34	1.03	.43	1.11

Preliminary analysis of the data involved inspection of the assumptions of independent observations, normality, and homogeneity of the covariances. The assumption of independent observations was met because students filled in the questionnaire independently of each other. All dependent measures met the normality criterion. Box's test of equality of covariance matrices was significant (Box's M = 194.66, $p < .001$), implying that the assumption of equal covariances was not met. However, further analysis showed that the smallest (co)variances were found in the smallest subsamples (i.e., third-year students). According to Tabachnick and Fidell (1996), the *F*-statistic is conservative in that case, meaning that the actual α is lower than the usual 5%.

Results of the MANOVA showed significant differences on all dependent measures between both learning environments [Hotelling's $T^2 = .13$, $F(6, 1014) = 21.21$, $p < .01$] as well as among the different years of both programs [Wilks's $\Lambda = .87$, $F(12, 2028) = 12.02$, $p < .01$][1]. Furthermore, a significant interaction effect was observed between different program years and both curricula [Wilks's $\Lambda = .97$, $F(12, 2028) = 2.93$, $p < .01$]. Univariate results showed significant differences between the two curriculum groups on all dependent measures. The problem-based learning group agreed more on knowledge construction, cooperative learning, self-regulated learning, and the use of authentic problems and agreed less on statements about motivation to learn, which is in line with a previous study (Loyens, Rikers, & Schmidt, 2006).

The interaction effect appeared only significant for self-perceived inability to learn [$F(2,1019) = 10.75$, $p < .01$, $\eta^2 = .02$][2]. While students in a conventional curriculum agreed significantly less on statements concerning self-perceived inability to learn in the course of their academic program, conceptions of students enrolled in a constructivist curriculum with respect to this factor do not differ significantly over the years.

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[1] Note that for a between-subject factor with more than two groups Wilks's Λ is used (Stevens, 1996).

[2] Following Stevens (1996, p. 177; based on Cohen, 1977, pp. 284-288), partial $\eta^2 = 0.01$ was interpreted as small, partial $\eta^2 = 0.06$ as medium, and partial $\eta^2 = 0.14$ as large.

To examine differences in students' conceptions in the course of their program, collapsed over both curricula, post-hoc multiple comparisons were conducted, using the Bonferroni method. No significant differences were found between the three program years on conceptions of cooperative learning (*MD* year 1 – year 2 = .09, $p = .26$; *MD* year 1 – year 3 = .05, $p > .99$; *MD* year 2 – year 3 = -.04, $p > .99$) and motivation to learn (*MD* year 1 – year 2 = .09, $p = .58$; *MD* year 1 – year 3 = 0, $p > .99$; *MD* year 2 – year 3 = -.09, $p > .99$). Significant differences were found between the first-year and the second-year students and between the first-year and the third-year students with respect to conceptions of knowledge construction (*MD* year 1 – year 2 = -.30, $p < .001$; *MD* year 1 – year 3 = -.21, $p < .001$), self-regulation (*MD* year 1 – year 2 = -.20, $p < .001$; *MD* year 1 – year 3 = -.32, $p < .001$), and the use of authentic problems (*MD* year 1 – year 2 = -.26, $p < .001$; *MD* year 1 – year 3 = -.31, $p < .001$). All differences showed an increase of the questionnaire's scores between year 1 and year 2. However, these conceptions did not seem to differ between the second and the third year of the academic program (knowledge construction; *MD* year 2 – year 3 = .09, $p = .40$; self-regulation; *MD* year 2 – year 3 = -.12, $p = .49$; authentic problems; *MD* year 2 – year 3 = -.05, $p > .99$). For self-perceived inability to learn, there was a significant decrease of the scores between year 1 and 2 (*MD* = .27, $p < .001$) and between year 1 and 3 (*MD* = .46, $p < .001$), and a nonsignificant decrease between year 2 and 3 (*MD* = .19, $p = .20$). However, as mentioned above, there was an interaction effect for this variable.

4. DISCUSSION

The present study investigated students' conceptions of constructivist learning activities. More specifically, it was examined (1) whether students' conceptions change as their exposure to university education increases and (2) whether the change of constructivist conceptions evolves differently in a conventional, lecture-based curriculum compared to a constructivist, problem-based curriculum. In other words, does learning environment affect (the development of) students' conceptions of constructivist learning activities?

4.1 Development of students' conceptions of constructivist learning activities

In general, students' conceptions of constructivist learning activities do change in the course of their academic program, but differences can only be found between the first and the second year. This was the case for conceptions of knowledge construction, self-regulation, and the use of authentic tasks. Second-year students agreed significantly more on the utility of these constructs, compared to first-year students. With greater experience in their program, students become more convinced of the impact of constructivist activities on their learning processes. This could be because they have experienced the beneficial and motivating effects of relating new subject matter with previous learned knowledge, self-regulated activities such as goal setting, self-assessment, and self-reinforcement, and the encounters with authentic learning tasks. Why no significant development took place concerning students' conceptions of cooperative learning and motivation to learn is puzzling, since one would expect that students also encounter positive effects of social interaction and motivation to learn. For conceptions of self-perceived inability to learn, an interaction effect was found: Students in a conventional curriculum agreed less on self-perceived inability throughout the years, while this factor remained at the same level for the constructivist learning population. This finding reflects the fact that open, constructivist learning environments require more responsibility from learners which can lead to a certain level of uncertainty and self-perceived incapability. Comparison of both students groups indicated that students in constructivist learning environments have more feelings of doubt (although those feelings are not very strong) concerning one's own learning capacities. While with greater academic experience, students' beliefs of self-perceived inability seem to diminish within students enrolled in a conventional curriculum, students in a constructivist learning environment maintain these beliefs. Previous research has demonstrated that these conceptions can make students work harder in terms of study hours to overcome their self-perceived inability (Block, 1996; Loyens, Rikers, & Schmidt, in press-b). However, as described in Chapter 4, conceptions of self-perceived inability are related to undesirable regulation strategies. Mean scores of conceptions of self-perceived inability to learn demonstrate that students tend to disagree with this construct, which will be explained in the next section.

4.2 Differences between the constructivist and conventional curriculum

Results indicated that students enrolled in a constructivist learning environment agree more on several constructivist learning assumptions (i.e., knowledge construction, cooperative learning, and the use of authentic tasks) compared to a conventional curriculum group. Being enrolled in a constructivist learning environment and experiencing effects of such an environment clearly reflects on students' conceptions. In fact, it has been demonstrated that first-year students who chose a constructivist learning environment already start with some different (i.e., in favour of constructivist learning assumptions) conceptions of constructivist learning at the beginning of the academic year, compared to students who chose to be enrolled in a conventional curriculum (Loyens et al., 2006). The present study shows that when second- and third-year students are also taken into account, differences become even more pronounced.

However, students in the problem-based learning group agreed less on the factor motivation to learn. This finding is somewhat surprising, since making students intrinsically motivated to learn is especially prominent in constructivist learning environments. However, this result is in line with previous research among starting, first-year students in a problem-based learning and lecture-based curriculum, with PBL students reporting less agreement on motivation to learn (Loyens et al., 2006). There is little research that bears directly on this issue in constructivist learning environments. Most research has instead investigated student satisfaction or confidence (Hmelo-Silver, 2004). There have been proposed some reasons why learning formats such as problem-based learning can possibly fail to motivate students. Although these learning formats can lead to effective solutions, it is usually unsystematic. This implies that when the problem-solving process fails, learners tend to ascribe this to their ability, rather than to their technique, which is detrimental to their motivation (Zimmerman & Campillo, 2003).

Students in constructivist learning environments also agree more on statements of self-regulation compared to students in the conventional curriculum under study. However, it should be noted that both students groups produce negative scores (i.e., disagree) with this construct, but students in the constructivist curriculum disagree less. Although being able to regulate your own learning is viewed as the key to successful learning in school and beyond (Boekaerts, 1999) and although self-regulation has positive effects on students' learning processes (e.g., Cantwell & Moore, 1996; Heikkilä & Lonka, 2006; Minnaert & Janssen, 1999; VanZile-Tamsen & Livingston, 1999), students tend to disagree. One can argue that goal setting, self-observation, self-assessment, and self-reinforcement, although important for learning, impose a substantial burden on students and calls for a great responsibility of learners. Devolving the responsibility for one's learning process (in terms of which subject matter needs to be studied, time management etc.) onto the teacher and relying on faculty goals (instead of setting one's own learning goals) can make students more confident (Lloyd-Jones & Hak, 2004). During the first two years of students' academic program, however, a positive development in their conceptions of self-regulation can be observed, as mentioned earlier.

Finally, comparison of the students enrolled in the problem-based learning and lecture-based curriculum showed that students in the problem-based learning group significantly agreed more on the construct of self-perceived inability to learn. However, both groups obtained negative scores (i.e., disagree) for this construct implying that, in general, students believe they are capable of attending higher education successfully. As mentioned before, open, constructivist learning environments are more demanding for learners in terms of being socially apt, self-regulated knowledge constructors. The results of this study indicate that students in constructivist learning environments have more feelings of doubt concerning one's own learning capacities compared to students in a lecture-based curriculum, but all in all, they disagree with this construct.

The present study provides unequivocal evidence for the influence of the learning environment on students' conceptions of constructivist learning activities. While earlier studies (e.g., Tynjälä, 1997) demonstrated the effect by manipulating the learning environment (i.e., by implementing certain learning tasks that were labelled as constructivist), we were able to demonstrate it in an actual learning environment.

In summary, the majority of students' conceptions of constructivist learning activities do alter in the course of their academic program. This development does not appear to be an ongoing process, since changes only take place during the first year of higher education. It has been argued that entering higher education leads to conflict and eventually to change of conceptions, since students encounter a different learning environment (Entwistle & Peterson, 2004). Unlike conceptions of learning and knowledge, however, conceptions of constructivist learning activities do not form a hierarchical system. Development of conceptions of constructivism implies greater agreement with certain assumptions or, in other words, becoming more convinced of the impact of these assumptions on one's learning process. Possibly, that is the reason why non-hierarchical conceptions do not show an ongoing development in the course of students' college years.

4.3 Implications

The present study indicated that the learning environment students are enrolled in has effects on students' conceptions. This implies that comparative educational research should take students' conceptions into account, since they can influence other aspects of learning (e.g., study approaches). In fact, two-way relationships have been proposed between conceptions and study approaches. Conceptions develop through experiences of teaching and studying, which influences subsequent learning activities (Entwistle & Peterson, 2004).

Secondly, the results of this study show that differences in conceptions due to a new learning program (i.e., higher education) happen in the first year. After this year, conceptions seem to consolidate. Therefore, training programs developed to alter students' conceptions should be administered in the first year of higher education, since this seems to be the 'critical period'.

4.4 Limitations and directions for further research

There is, however, a constraint to our findings. This study used a cross-sectional design while a longitudinal design could have mapped changes in conceptions more precisely. Another point of attention is that fourth-year psychology students, who are traditionally doing internships in this phase of the academic program, were not included in this study. During internships, students need to apply the knowledge they have learned into practice, which may reflect on their conceptions. For example, it can be argued that it is only during internships that students can fully acknowledge the value of for instance cooperative learning, since they have to work together with colleagues in a professional setting. Therefore, a direction for further research is to examine this particular group of students.

Chapter 7

Summary and general discussion

Constructivism is currently an influential view on learning. It advocates a student-centred perspective: Students are active learners who construct their own understanding (e.g., Slavin, 2006). Different types of constructivism can be distinguished (e.g., Phillips, 1995) that all acknowledge that the construction of knowledge is an *active* process. This active process can be described in terms of individual cognitive processes (i.e., cognitive constructivism), in terms of social processes (i.e., social constructivism), or in terms of sociocultural processes (i.e., constructionism; Phillips, 1997). Despite these differences, constructivist perspectives share a number of assumptions that should be considered in learning (e.g., Driscoll, 2005).

First, knowledge acquisition is a process of knowledge *construction* in which prior knowledge comprises the frame of reference for the interpretation of new information (Cunningham, 1992). This assumption goes against the idea of knowledge acquisition as pure knowledge accumulation (Blumenfeld, 1992). Second, learning involves interactions with others such as fellow-students or teachers. Cooperative learning is therefore another assumption shared by constructivist views. Constructivists are, however, not unanimous with respect to the role of cooperation in knowledge acquisition, but acknowledge, in variable degree, that social negotiation is an important part of it (Greeno, Collins, & Resnick, 1996). Furthermore, knowledge construction benefits from metacognitive skills such as to plan, monitor, and evaluate one's learning process. Learners who set their own learning goals, observe the progress they make in order to achieve these goals, make adjustments to their planning if necessary, and reinforce themselves at appropriate times are labelled as effective self-regulated learners (e.g., Winne, 1995b). Self-regulated learning is considered a third key assumption in learning according to constructivist views (Slavin, 2006). Finally, constructivists stress the importance of learning that takes places in an authentic context, preferably similar to future professional contexts. To that end, ill-structured problems are often used, which serve as organizers for students' learning (White & Frederiksen, 1998). These four assumptions of constructivist learning (i.e., knowledge construction, cooperative learning, self-regulated learning, and use of authentic tasks) constitute the building blocks for the studies reported in this thesis. The assumptions are studied from a student-perspective: How do students look at these assumptions? What are students' *conceptions* of constructivist learning? Do they acknowledge knowledge construction, cooperative learning, self-regulated learning, and the use of authentic tasks as important factors for their learning processes? Two additional factors were examined in this thesis: Self-perceived inability to learn as a possible negative side-effect of open, constructive learning environments (e.g., Duke, Forbes, Hunter, & Prosser, 1998) and motivation to learn as a well-known influencing factor on students' learning (e.g., Pintrich & Schunk, 1996).

Studying constructivist learning assumptions from a students' perspective is meaningful because research literature reports relationships between conceptions of learning and knowledge on one hand and study activities and performance on the other hand. Furthermore, research has demonstrated that educational intentions are not always in line with the way students look at these intentions (e.g., Parikh, McReelis, & Hodges, 2001). Since constructivism is prominent in the current literature, it may be insightful to shed light on this issue. Finally, examining students' conceptions of constructivist learning is, to our knowledge, new to the domain of educational research.

1. SUMMARY OF THE MAIN FINDINGS

In **Chapter 2**, two studies are reported focusing on the development of a questionnaire to measure the aforementioned conceptions of constructivist learning within a student population. Study 1 tested the questionnaire's underlying model (i.e., the hypothesized model) consisting of the factors knowledge construction, cooperative learning, self-regulated learning, the use of authentic problems, self-perceived inability to learn, and motivation to learn. Results showed a reasonable fit of the model with the data. All parcel (i.e., item clusters belonging to a specific latent factor) loadings were significant, indicating that every parcel contributed significantly to its latent construct. The correlation matrix revealed that higher levels of belief in the importance of knowledge construction appeared to be associated with higher levels of cooperation, motivation to learn, authentic problems, and lower levels of self-perceived inability to learn. Furthermore, the more students agreed on the construct of self-regulation, the more they agreed on motivation to learn, but the less they were convinced of the use of authentic problems and the less they believed in self-perceived inability to learn. Higher levels of motivation to learn were also associated with lower levels of self-perceived inability to learn. Significant correlations were found between cooperative learning and self-regulation, motivation to learn, and self-perceived inability to learn.

The second study described in Chapter 2 was conducted to test measurement invariance across different student populations. In seeking evidence of multi-group measurement invariance, it was examined whether conceptual agreement was reached with respect to the questionnaire's items across groups and whether the factorial structure of the questionnaire replicated across different groups. Results of Study 2 were similar to Study 1: Every parcel contributed significantly to its latent construct and factor correlations displayed the same pattern. Again, higher levels of knowledge construction appeared associated with higher levels of motivation to learn and the use of authentic problems. Self-regulation showed a significant, positive correlation with motivation to learn and negative associations with the use of authentic problems and self-perceived inability to learn. Higher levels of motivation to learn were associated with lower levels of self-perceived inability to learn. Contrary to Study 1, however, no significant correlations were found between cooperative learning and the five other latent constructs. Furthermore, factor loadings were invariant across the two student populations, meaning that relations between the parcels and their latent constructs were equal across different groups. Also, the factor structure of the questionnaire repeated itself over different populations, showing evidence of cross-validation. Finally, two alternative (i.e., competing) models were tested in order to check whether the six-factor structure provided the most appropriate model in representing our data. All fit measures showed poor model fit with the data in both student populations.

In **Chapters 3** and **4** relationships between students' conceptions of constructivist learning and academic achievement (Chapter 3), dropout (Chapter 3), and regulation and processing strategies (Chapter 4) were studied. In **Chapter 3**, the influence of conceptions of constructivist learning on students' observed learning activities (rated by their tutor) and self-study time and, consequently, academic achievement and dropout was the issue under study. Students' observed learning activities appeared a very strong predictor of academic achievement. Self-study time did not significantly contribute to academic achievement, but it did show a significant relationship with observed learning activities. This suggested that the number of hours students spend on self-study is not directly linked with performance, but individual study hours do show off in students' activities as observed by their tutors. With respect to observed learning activities, beliefs concerning the role of knowledge construction appeared a significant predictor. This was a pivotal finding because it implies that students' beliefs about being the central agent for their own knowledge acquisition have consequences for the actual learning activities they undertake. No other conceptions of learning contributed significantly to observed learning activities. Self-perceived inability to learn and motivation to learn both had significant, positive path estimates leading to self-study time.

Observed learning activities also emerged as a good predictor of dropout: The higher tutors rated students' learning activities, the lower the probability of dropout. In contrast to the analyses involving academic achievement, self-study time had an influence on dropout. The less time students spend on self-study, the higher the probability of premature dropout. Furthermore, self-study time entertained again a significant relationship with observed learning activities. With respect to students' conceptions, a pattern emerged similar to the model with academic achievement as a dependent variable. Similar to the model with academic achievement, conceptions of knowledge construction turned out to be the only significant predictor of observed learning activities. Conceptions regarding one's own learning ability and about the role of motivation to learn emerged as significant, positive paths to self-study time. Again, doubts about one's learning abilities entertained a positive relation with self-study time, suggesting that self-perceived inabilities stimulate rather than impede students' learning processes.

Chi-square difference tests, finally, revealed that the impact of conceptions of constructivist learning on achievement and dropout is completely mediated by students' observed learning activities and self-study time.

Chapter 4 described relationships between conceptions of constructivist learning and regulation and processing strategies, measured by corresponding scales of Vermunt's Inventory of Learning Styles (ILS; Vermunt, 1992) and the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich & de Groot, 1990). The hypothesized model relating conceptions of constructivist learning with the regulation and processing variables of the ILS showed a moderate fit with the data. Conceptions of self-regulated learning, self-perceived inability to learn, and motivation to learn contributed significantly to the regulation variables. More specifically, conceptions of self-regulated learning maintained a positive relationship with self-regulation and a negative relationship with external regulation. Conceptions of self-perceived inability to learn had a large positive effect on lack of regulation. This implies that students who express high levels of doubt with regard to their learning process are at risk for adopting an inadequate regulation strategy. Conceptions of motivation to learn had a negative relationship with lack of regulation and a fairly large positive effect on external regulation. Conceptions of knowledge construction did not show any significant relationships with the ILS regulation strategies. Furthermore, self-regulation had a very large effect on deep processing, a large effect on concrete processing, and a medium effect on stepwise processing. External regulation had a fairly large relationship with stepwise processing and no significant relationships with deep and concrete processing. Lack of regulation, finally, did not show significant path estimates with the operational level variables (i.e., deep, stepwise, and concrete processing).

Testing the hypothesized structural model relating the conceptions under study with the regulation and processing variables of the MSLQ resulted in an excellent fit with the data. Motivation to learn had a strong effect on self-regulation. The path coefficient from conceptions of self-regulated learning to reported self-regulation on the controlling level was significant at a .10 level, but not on the .05 level. No other conceptions of constructivist learning had significant relationships with self-regulation. Self-regulation strategies had a strong effect on cognitive strategy use, in line with the data of the ILS variables.

Similar to the study reported in Chapter 3, chi-square difference tests were used to investigate whether regulation strategies mediate the influence of conceptions on processing strategies. For the model with the ILS-variables, partially mediated relationships emerged between conceptions and processing strategies, whereas for the model with the MSLQ-variables, regulations strategies completely mediated the relationships between conceptions and processing strategies.

Chapters 5 and **6** focused on differences between conceptions of constructivist learning among students studying in a conventional, lecture-based curriculum and a constructivist, problem-based learning curriculum.

The study described in **Chapter 5** shed light on differences in conceptions of constructivist learning between starting, first-year psychology students of a conventional and a constructivist curriculum. Similar to Chapter 2, the test for measurement invariance showed that factor loadings were equivalent across both groups of students and that the questionnaire's underlying factor structure gave evidence of cross-validation. Significant differences were noticed on the latent factors of cooperative learning, authentic problems, and motivation to learn. Starting first-year students enrolled in a conventional, lecture-based curriculum scored significantly lower (i.e., agreed less) on the latent constructs of cooperative learning and authentic problems, but significantly higher on motivation to learn, compared to the problem-based learning group.

Finally, in **Chapter 6**, a cross-sectional design was used to map the development of students' conceptions of constructivist learning. Three groups (i.e., first-year, second-year, and third-year students) in two different curricula (i.e., conventional, lecture-based and constructivist, problem-based) were tested. Earlier research had shown that students' conceptions of knowledge as well as their conceptions of learning develop progressively through educational experiences (e.g., Hofer & Pintrich, 1997). Therefore, it was studied whether students conceptualize learning as constructivist to a larger extent with greater experience in their academic program. In addition, it was investigated to what extent conceptions of constructivist learning develop differently in a conventional, lecture-based curriculum as compared to a constructivist, problem-based learning curriculum. Results demonstrated a significant increase of the scores between year 1 and year 2 (but not between year 2 and 3) with respect to conceptions of knowledge construction, self-regulation, and the use of authentic problems, but not for cooperative learning and motivation to learn. For self-perceived inability, an interaction effect was found. While students in a conventional curriculum agreed significantly less on statements concerning self-perceived inability to learn in the course of their academic program, conceptions of students enrolled in a constructivist curriculum with respect to this factor do not differ significantly over the years. Furthermore, in line with the findings discussed in Chapter 5, results showed significant differences between the two curriculum groups. The problem-based learning group agreed more on knowledge construction, cooperative learning, self-regulated learning, and the use of authentic problems and agreed less on statements about motivation to learn.

2. DISCUSSION

The central focus of this thesis is on students' conceptions of constructivist learning. This topic is fairly new to the educational literature, at least to the extent that *constructivist* learning is concerned. As described in the previous section, a measurement instrument was developed to map these conceptions (Chapter 2), relationships with learning activities and achievement were examined (Chapters 3 and 4), effects of the learning environment were examined (Chapters 5 and 6), and the change of conceptions throughout students' academic program was analysed (Chapter 6). This section will interpret the main results of the studies in the light of previous research and will submit these findings to a closer examination.

2.1 Measuring students' conceptions of constructivist learning

The results of the studies reported in Chapter 2 indicated that the questionnaire was able to measure students' conceptions of constructivist assumptions in a reliable and valid way. Students were able to identify the six factors underlying the questionnaire, suggesting that they acknowledge the distinctiveness of beliefs about knowledge construction, cooperative learning, self-regulation, the use of authentic problems, self-perceived inability to learn, and motivation to learn as distinct influences on their learning process. Furthermore, conceptual agreement about the items was established and the questionnaire's factor structure also stood up to cross-validation. Testing two alternative models provided additional support for the questionnaire's structure with six latent factors. In sum, the questionnaire developed appeared an adequate instrument to measure students' conceptions of constructivist assumptions.

With respect to factor correlations, the studies in this thesis showed several consistent findings: Self-perceived inability to learn had negative associations with the other factors comprising the questionnaire, except for the use of authentic problems. Similarly, motivation to learn maintained positive relationships with students' conceptions of constructivist assumptions, with the exception of the role of authentic problems.

2.2 Self-perceived inability to learn

Feelings of doubt with regard to one's own learning capacities are detrimental for one's beliefs in the positive role of constructivism. On the other hand, the study discussed in Chapter 3 suggested that self-perceived inability had a positive effect on students' self-study time. This finding was explained in terms of dealing with the experienced feelings of doubt. It is argued that students' encounter with such uncertainty can be beneficial for their professional development. Since students have to work hard to deal with this uncertainty and by doing so, they may come to a degree of acceptance or tolerance of uncertainty, which may make them less averse to it in other settings (Block, 1996). Although self-perceived inability can lead to *more* study-activities, Chapter 4 explains that it does not lead to *better* (i.e., more effective) learning activities, since it has a strong link with 'lack of regulation'. Students who report feelings of doubt with regard to their learning process are therefore at risk for adopting an inadequate regulation strategy. Furthermore, an undirected learning style, which consists of lack of regulation, has been demonstrated to be consistently and negatively related to all types of examination results (Vermunt & Vermetten, 2004), underlining that students' expressing inability to learn are highly at risk. Comparison between students in a conventional, lecture-based curriculum and a constructivist, problem-based curriculum, demonstrated that with greater academic experience, students' beliefs of self-perceived inability diminished for students enrolled in a conventional curriculum, whereas students in a constructivist learning environment maintain these beliefs. Comparison of both student groups indicated that students in constructivist learning environments have more feelings of doubt (although those feelings are not very strong) concerning one's own learning capacities. These differences are, however, not yet present when students enter university, as argued in Chapter 5. This finding reflects the fact that open, constructivist learning environments require more responsibility from learners which can lead to a certain level of uncertainty and self-perceived inability (see also Duke et al., 1998). In sum, self-perceived inability to learn can be seen both as a negative element in learning of students (in the sense that it may lead to inadequate processing of information) and as an unavoidable by-product of an open learning environment (an experience students have to deal with as part of their learning process).

2.3 Motivation to learn

As mentioned earlier, motivation to learn entertained significant positive correlations with almost all other conceptions of constructivist assumptions. Having a mind to study, be willing to spend time on studying, and having interest in one's studies is linked with positive beliefs in knowledge construction, cooperative learning, and self-regulation (see Chapters 2, 3, and 4) and has a positive effect on students' self-study time (Chapter 3). Furthermore, as has been demonstrated in Chapter 4, a negative relationship of motivation to learn with the ILS subscale lack of regulation was observed. Students who agree with statements such as "I can easily find the motivation to study" are likely to study more and are not likely to adopt an undirected regulation strategy. Motivation to learn had no significant effect on the ILS self-regulation variable, but a strong, positive effect on the MSLQ self-regulation scale as well as a large effect on external regulation of the ILS. Pintrich and colleagues (e.g., Pintrich, 1999; Pintrich & de Groot, 1990) have frequently established the connection between self-regulation and motivation in previous studies. It is not clear why no relationship emerged with the ILS self-regulation variable while a large effect was found for the self-regulation variable of the MSLQ. The issue that comes to mind in this respect is the dichotomy intrinsic versus extrinsic motivation. However, this dichotomy was not as such integrated in the factor structure of the motivation to learn-variable, meaning that motivational aspects such as study goals (i.e., learning versus performance goals) were not explicitly questioned. It could be argued that some students can obtain high scores on statements such as "I can easily find the motivation to study" because they have high grades in mind (performance goals) and not because they are intrinsically motivated in the subject matter (learning goals). Using a more specific measure of motivation could shed light on this issue in future research. In addition, a more specific measure of motivation, discriminating between intrinsic and extrinsic motivation, could possibly clarify why students in a problem-based learning curriculum reported less motivation to learn compared to students in a conventional curriculum (Chapters 5 and 6) and that motivation to learn does not change throughout students' academic program (Chapter 6). With respect to the first finding, some reasons have been proposed why learning formats such as problem-based learning can possibly fail to motivate students. Although these learning formats can lead to effective learning, this learning is often unsystematic. This implies that when the problem-based learning process fails, learners tend to ascribe this to their ability, rather than to their approach, which is detrimental to their motivation (Zimmerman & Campillo, 2003). In sum, the present studies give evidence of an influential role for motivation to learn, in line with previous research (e.g., Pintrich & Schunk, 1996), but a more specific measure of motivation is needed to elucidate relationships with self-regulation as well as findings from comparative and cross-sectional research.

2.4 Conceptions of knowledge construction

Conceptions of knowledge construction significantly predicted observed learning activities, implying that the more students agree with actively constructing their own knowledge and the beneficial effects of relating new knowledge to previously acquired knowledge, the higher the rates they receive from their tutors on preparation of the subject matter, active participation in the tutorial group, and students' roles as chair and scribe. Furthermore, while initially there is no difference in beliefs about knowledge construction between students in a conventional, lecture-based and a constructivist, problem-based learning curriculum (Chapter 5), these conceptions significantly change in the first year of students' academic program, with problem-based learning students becoming more convinced of the role of prior knowledge, the benefits of elaboration, and active processing of subject matter (Chapter 6). This could be because they have experienced the beneficial and motivating effects of relating new subject matter with previous learned knowledge and because a problem-based learning environment lays more emphasis on it by the way the tutorial groups are designed. In sum, knowledge construction is a key element in constructivist views of learning (e.g., Cunningham, 1992) and the studies in this thesis show that students' conceptions of this factor are influential with respect to students' learning processes.

2.5 Conceptions of cooperative learning and authentic tasks

In Chapter 4 it is argued that cooperative learning and the use of authentic problems are curriculum characteristics. Students cannot avoid being confronted with these features of a constructivist learning environment; they work together in small groups on complex, ill-structured problems (e.g., Barrett, 2005; Barrows, 1996; Norman & Schmidt, 1992; Schmidt, Loyens, Van Gog, & Paas, in press). Therefore, these factors were not included in the study described in Chapter 4 and they did not show significant relationships with self-study time and observed learning activities in Chapter 3. Cooperative learning and the use of authentic problems describe the learning environment rather than behaviours of students, which may cause that students experience more difficulty in estimating the effects of these factors. Estimating the impact of concepts in which they are the actors (e.g., relating subject matter to previously acquired knowledge) might be easier. However, starting, first-year students enrolled in a problem-based learning curriculum agreed more on these factors compared to starting, first-year students in a conventional curriculum. Cooperative learning is indeed a key feature of constructivism, since social interactions contribute to the construction of knowledge (Steffe & Gale, 1995). Authentic problems are the driving force behind students' independent study in constructivist learning environments (Dolmans, Snellen-Balendong, Wolfhagen, & van der Vleuten, 1997). It is interesting to note that students, who have just entered university and who have chosen to be enrolled in a problem-based curriculum, already find the collaboration process and the use of authentic problems important, while students in conventional education do not.

2.6 Conceptions of self-regulated learning

Finally, conceptions of self-regulated learning entertained positive relationships with actual reported self-regulation activities, stressing the central role of conceptions for study behaviour. If students believe that self-regulation is beneficial for their learning processes, they are more likely to engage in self-regulated behaviour. Conceptions of self-regulation were negatively related to external regulation, implying that students who believe that aspects of self-regulation such as goal setting, self-observation, self-assessment, and self-reinforcement can be helpful for their learning process, do not believe that external regulation is useful for their learning. Previous research revealed that differences in self-regulated strategy use reflect on academic achievement (e.g., Cantwell & Moore, 1996; VanZile-Tamsen & Livingston, 1999). However, mean scores in Chapters 3, 4, and 6 show that the students who participated in our studies tend to disagree with the questionnaire's statements about self-regulated learning, although the negative scores are close to zero. For starting, first-year students, this disagreement could stem from the fact that these students could only rely on their previous educational experiences in secondary school. Since secondary education is typically teacher-centred, this may have coloured their answers: The teacher indicates which book chapters are important, the teacher clarifies subject matter, and the teacher helps students preparing for the tests. For students who had just entered university, it is therefore difficult to foresee what it would mean to be responsible for one's own learning and to plan, monitor, and regulate one's own learning activities independently. Results of Chapter 6, however, demonstrate that also second-year and third-year students still obtain negative scores (i.e., tend to disagree). This finding implies that their conceptions are not in favour of self-regulated learning, although being able to regulate your own learning is viewed as the key to successful learning in school and beyond (Boekaerts, 1999) and although self-regulation has positive effects on students' learning processes (e.g., Cantwell & Moore, 1996; Heikkilä & Lonka, 2006; Minnaert & Janssen, 1999; VanZile-Tamsen & Livingston, 1999). Furthermore, second-year and third-year students can rely on experiences from academic education and not exclusively on experiences from secondary education such as the first-year students. One can argue that goal setting, self-observation, self-assessment, and self-reinforcement, although important for learning, impose a substantial burden on students and calls for a great responsibility of learners. Devolving the responsibility for one's learning process (in terms of which subject matter needs to be studied, time management etc.) onto the teacher and relying on faculty goals (instead of setting one's own learning goals) can make students more confident (Lloyd-Jones & Hak, 2004). During the first two years of students' academic program, however, a positive development in their conceptions of self-regulation can be observed, although they keep on disagreeing with this constructivist assumption. With respect to the influence of the learning environment, it can be concluded that students in constructivist learning environments agree more on statements of self-regulation compared to students in the conventional curriculum under study. However, due to the negative scores of both groups, the appropriate conclusion is that students in the constructivist curriculum disagree less.

3. CONCLUSIONS

Based on the findings presented in the studies of this thesis, several conclusions can be put forward. A first conclusion, based on the study discussed in Chapter 2, is that we were able to develop an adequate instrument to measure students' conceptions of constructivist assumptions in a reliable and valid way. Conceptual agreement about the questionnaire's items was established and its factor structure disclosed cross-validation.

Furthermore, in line with previous research on conceptions of learning, conceptions of *constructivist* learning maintain (indirect) relationships with academic achievement. More specifically, as mentioned in Chapter 3, what students believe concerning knowledge construction predicts the learning activities they undertake and their self-perceived inability to learn and motivation can make predictions with respect to students' study time. What students believe with respect to aspects of learning and constructivism in particular, plays a role, though indirect, in students' regulation and processing strategies and learning outcomes. These results suggest that in order to improve academic achievement, changing study activities is not sufficient since these activities are to some extent dependent on students' conceptions. In addition, findings reported in Chapter 4 indicate relationships between a number of conceptions of constructivist learning and regulation and processing strategies. In sum, the relative importance of students' conceptions of constructivism for their learning became apparent in these studies. Traditionally, the teacher, instructional methods, learning materials, and study activities are considered as the elements of change in order to achieve the necessary knowledge reconstruction to promote performance (Sinatra & Pintrich, 2003). Our study suggests that the learner can and has to act as a controller. Hence, students' conceptions should receive more attention in education and specific instruction and training programs could help students in this respect (Lonka, Joram, & Bryson, 1996).

Finally, Chapters 5 and 6 showed that the curriculum in which students are enrolled has effects on students' conceptions. Starting first-year students come to university with pronounced conceptions of constructivist learning issues, as demonstrated in Chapter 5.

Problem-based learning students already recognize the importance of several constructivist learning principles more than students in a conventional curriculum. Therefore, studies on the comparison of conventional and problem-based learning curricula should take these initial differences into consideration, because students' conceptions of learning can influence other aspects of learning, as explained in Chapters 3 and 4. Most studies comparing constructivist with conventional programs solely highlight differences that evolve due to the curriculum, while this study was able to show that with respect to conceptions, to some extent 'different' students enter different programs. Hence, conceptions of constructivist learning activities can act as an important moderator of problem-based learning effects and should be considered in examining the effects of problem-based learning and probably in all comparative education research. In line with these findings, Chapter 6 provides unequivocal evidence for the influence of the learning environment on students' conceptions of constructivist learning. While earlier studies demonstrated the effect by manipulating the learning environment (i.e., by implementing certain learning tasks that were labelled as constructivist, e.g., Tynjälä, 1997), the study presented in Chapter 6 demonstrated this effect in an actual learning environment.

Furthermore, differences in conceptions due to a new learning program (i.e., higher education) happen in the first year. After this year, conceptions seem to consolidate. Therefore, training programs developed to alter students' conceptions should be administered in the first year of higher education, since this seems to be the "critical period".

4. DIRECTIONS FOR FURTHER RESEARCH

The studies reported in this thesis have shed light on conceptions of constructivist learning. We have mapped these conceptions and their relationships with academic achievement, dropout, regulation, and processing strategies. Furthermore, we have investigated the influence of the learning environment on students' conceptions as well as the development of these conceptions throughout students' academic program. A next step could be to investigate whether conceptions can be changed purposively and whether this would influence students' learning. Some studies have already been conducted with training programs. However, the content of these training programs is not unequivocal. Lonka and colleagues (1996), for example, considered an educational psychology course as a training program for changing students' conceptions of learning. Research on conceptual change, on the other hand, start from theoretical models with several factors influencing the probability of conceptual change (e.g., Dole & Sinatra, 1998). Applying these theoretical models on conceptions of constructivist learning, could pave the way for gaining insight in how conceptions of constructivist learning can be altered purposively. Consequently, developing effective training programs for changing students' conceptions would be of great value, since conceptions have been proven very influential for students' learning processes.

Furthermore, as argued in Chapter 4, using more specific measures of motivation could further specify the relationships between conceptions of constructivist learning and regulation strategies. We acknowledge that the parcels included in the questionnaire, might not have been exhaustive. We selected certain aspects of every latent construct for use in the questionnaire. Students' conceptions of constructivist assumptions are pivotal in the studies that were conducted, not the measurement of the assumptions themselves. Conclusions from the studies in this thesis are hence focused on students' conceptions of the selected latent constructs and their aspects. Several researchers have proposed other subdivisions of constructs like self-regulation (e.g., Boekaerts, 1999; Pintrich, 1999; Schunk & Zimmerman, 1994) and motivation (e.g., Pintrich & de Groot, 1990) and have developed instruments to measure them. Nevertheless, results showed that the created questionnaire was successful in mapping students' conceptions of the constructivist aspects included. Translation of the questionnaire into English as well as cross-validation would enable comparative research beyond Dutch speaking countries.

Chapter 8

Samenvatting en discussie

Constructivisme is vandaag de dag een invloedrijke visie op leren. De constructivistische stroming pleit sterk voor een studentperspectief: studenten zijn actieve lerenden die hun eigen kennis en begrip construeren (Slavin, 2006). Er kunnen verschillende types constructivisme worden onderscheiden (Phillips, 1995) die allemaal erkennen dat het construeren van kennis een actief proces is. Dit proces kan beschreven worden in termen van individuele, cognitieve processen (d.i. het cognitief constructivisme), in termen van sociale processen (d.i. het sociaal constructivisme), of in termen van socioculturele processen (d.i. het constructionisme; Phillips, 1997). Ondanks deze verschillen delen constructivistische perspectieven een aantal assumpties die bij leren in ogenschouw genomen moeten worden (bijv. Driscoll, 2005).

De eerste assumptie is dat kennisverwerving een proces van kennis*constructie* is waarbij eerder geleerde kennis het referentiekader vormt voor de interpretatie van nieuwe informatie (Cunningham, 1992). Deze assumptie gaat in tegen de idee van kennisverwerving als kennisaccumulatie (Blumenfeld, 1992). Daarnaast impliceert leren interactie met anderen zoals medestudenten of docenten. Samenwerkend leren is daarom een tweede assumptie die constructivistische visies delen. Constructivisten zijn echter niet unaniem over de rol die samenwerking speelt in kennisverwerving. Ze erkennen echter, in meer of mindere mate, dat sociaal onderhandelen deel uitmaakt van het kennisverwervingproces (Greeno, Collins, & Resnick, 1996). Kennisconstructie heeft verder baat bij metacognitieve vaardigheden zoals planning, *monitoring* en de evaluatie van het eigen leerproces. Lerenden die hun eigen leerdoelen stellen, hun eigen voortgang observeren bij het bereiken van deze doelen, hun plannen indien nodig aanpassen en zichzelf op gepaste ogenblikken belonen worden gelabeld als effectieve zelfreguleerders (Winne, 1995b). Zelfregulatie wordt dan ook beschouwd als een derde belangrijke assumptie voor leren volgens constructivistische visies (Slavin, 2006). Als laatste benadrukken constructivisten het belang van leren dat plaatsvindt in een authentieke context die bij voorkeur gelijkend is op de latere, beroepscontext van studenten. Daarvoor worden vaak complexe, *ill-structured* problemen gebruikt in het onderwijs die het leren van studenten organiseren en structureren (White & Frederiksen, 1998). Deze vier assumpties van constructivistisch leren (d.i. kennisconstructie, samenwerkend leren, zelfregulatie en het gebruik van authentieke problemen) vormen de pijlers voor de studies die gerapporteerd staan in dit proefschrift. De assumpties werden bestudeerd vanuit een studentperspectief: hoe kijken studenten aan tegen deze assumpties? Welke *concepties* hebben studenten ten aanzien van constructivistisch leren? Erkennen ze dat kennisconstructie, samenwerkend leren, zelfregulatie en het gebruik van authentieke problemen belangrijke factoren zijn in hun leerproces? Naast deze vier assumpties voor constructivistisch leren werden nog twee additionele factoren onderzocht in dit proefschrift: leeronzekerheid als een mogelijke, negatieve bijwerking van open, constructieve leeromgevingen (Duke, Forbes, Hunter, & Prosser, 1998) en leermotivatie als een alom bekende beïnvloedende factor op het leerproces van studenten (Pintrich & Schunk, 1996).

Het bestuderen van constructivistische leerassumpties vanuit een studentperspectief is betekenisvol omdat onderzoeksliteratuur frequent relaties rapporteert tussen concepties van leren en kennis enerzijds en studieactiviteiten en –prestaties anderzijds. Daarnaast heeft onderzoek aangetoond dat onderwijskundige intenties niet altijd in lijn zijn met de opvattingen van studenten over deze intenties (Parikh, McReelis, & Hodges, 2001). Het is daarom interessant dit gegeven voor constructivistische leerassumpties onder de loep te nemen. Een laatste argument voor het onderzoeken van concepties van constructivisme bij studenten is het feit dat deze thematiek, voor zover onze kennis reikt, nieuw is in het domein van onderwijspsychologisch onderzoek.

1. SAMENVATTING VAN DE BELANGRIJKSTE BEVINDINGEN

In **Hoofdstuk 2** worden twee studies gerapporteerd die handelen over de ontwikkeling van een vragenlijst om concepties van studenten betreffende constructivistisch leren te kunnen meten. De eerste studie van dit hoofdstuk testte het voorgestelde, onderliggende model van de vragenlijst, bestaande uit de factoren kennisconstructie, samenwerkend leren, zelfregulatie, het gebruik van authentieke problemen, leeronzekerheid en leermotivatie. De resultaten lieten zien dat het model een redelijke fit met de data vertoonde. Alle *parcel*-ladingen (d.i. itemclusters die tot een specifiek latent construct behoren) waren significant. Dit betekent dat elke *parcel* significant bijdraagt aan het latente construct waartoe het behoort. De correlatiematrix liet zien dat studenten die sterk overtuigd waren van het belang van kennisconstructie ook overtuigd waren van samenwerkend leren, leermotivatie en authentieke problemen, maar minder overtuigd waren van leeronzekerheid. Hoe meer studenten het eens waren met zelfregulatie, des te meer ze het eens waren met leermotivatie, maar des te minder ze het eens waren met het gebruik van authentieke problemen en met leeronzekerheid. Hoge scores op leermotivatie waren verder geassocieerd met lage scores op leeronzekerheid. Daarnaast werden significante correlaties gevonden tussen samenwerkend leren en zelfregulatie, leermotivatie en leeronzekerheid.

De tweede studie in Hoofdstuk 2 werd uitgevoerd om de meetinvariantie over verschillende studentpopulaties te toetsen. Om *multi-group* meetinvariantie te kunnen vaststellen, werd gekeken of de items van de vragenlijst conceptueel overeenkwamen en of de factorstructuur van de vragenlijst zich herhaalde over verschillende studentgroepen. De resultaten van deze tweede studie waren gelijkend aan die van de eerste studie: elke *parcel* laadde significant op het latente construct waartoe het behoort en factor correlaties lieten hetzelfde patroon zien. Opnieuw waren positieve opvattingen over kennisconstructie geassocieerd met positieve opvattingen over leermotivatie en het gebruik van authentieke problemen. Zelfregulatie vertoonde een significante, positieve correlatie met leermotivatie en negatieve associaties met het gebruik van authentieke problemen en leeronzekerheid. Leermotivatie bleek ook in deze studie negatief gecorreleerd met leeronzekerheid. In tegenstelling tot Studie 1 werden er geen significante correlaties gevonden tussen samenwerkend leren en de overige vijf latente constructen. Factorladingen bleken verder invariant over beide studentpopulaties, wat impliceert dat de relaties tussen de *parcels* en hun latente constructen gelijk zijn over verschillende groepen. De factorstructuur van de vragenlijst herhaalde zich over verschillende populaties wat blijk gaf van cross-validatie.

Tot slot werden twee alternatieve modellen getoetst om te kijken of het model met de zes latente factoren het beste model bleek om de data te verklaren. Dat bleek zo te zijn, aangezien alle fitmaten van de alternatieve modellen een slechte modelfit vertoonden met de data in beide studentpopulaties.

In **Hoofdstuk 3** en **4** werden relaties tussen concepties van constructivistisch leren en studieprestaties (Hoofdstuk 3), drop-out (Hoofdstuk 3) en regulatie- en verwerkingsstrategieën (Hoofdstuk 4) bestudeerd. In **Hoofdstuk 3** werd de invloed van concepties van constructivistisch leren op geobserveerde studieactiviteiten van studenten (beoordeeld door hun tutor), zelfstudietijd, academische studieprestaties en drop-out onderzocht. Geobserveerde studieactiviteiten van studenten bleken een zeer goede voorspeller voor studieprestaties. Zelfstudietijd droeg niet significant bij aan studieprestaties, maar wel aan geobserveerde studieactiviteiten. Deze bevinding suggereert dat het aantal studie-uren van studenten niet direct gerelateerd is aan studieprestaties, maar dat deze uren wel van invloed zijn op de studieactiviteiten van studenten. Opvattingen over de rol van kennisconstructie bleken een belangrijke voorspeller van geobserveerde studieactiviteiten van studenten. Dit is een belangrijke bevinding, aangezien opvattingen van studenten over kennisconstructie consequenties hebben voor de studieactiviteiten die ze effectief ondernemen. Naast kennisconstructie droegen geen andere concepties significant bij aan geobserveerde studieactiviteiten. Leeronzekerheid en leermotivatie vertoonden beide significante, positieve padcoëfficiënten met zelfstudietijd.

Geobserveerde studieactiviteiten bleken eveneens een goede voorspeller voor drop-out: hoe hoger tutoren de studieactiviteiten van studenten beoordeelden, des te kleiner de kans op drop-out. In tegenstelling tot de analyses met studieprestaties als afhankelijke variabele, had zelfstudietijd wel een significante, directe invloed op drop-out. Hoe minder studie-uren studenten rapporteerden, des te groter de kans op vroegtijdige uitval. Verder bleek zelfstudietijd opnieuw significant gerelateerd aan geobserveerde studieactiviteiten. Met betrekking tot concepties van studenten, kon eenzelfde patroon worden waargenomen als bij het model met studieprestaties als afhankelijke variabele. Concepties van kennisconstructie bleken namelijk ook in het model met drop-out de enige voorspeller van geobserveerde studieactiviteiten. Concepties van leeronzekerheid en leermotivatie vertoonden significante, positieve padcoëfficiënten met zelfstudietijd. Ook in dit model had leeronzekerheid een positieve relatie met zelfstudietijd, wat impliceert dat leeronzekerheid het leerproces van studenten stimuleert in plaats van hindert.

Chi-kwadraat verschiltoetsen lieten tenslotte zien dat de impact van concepties van constructivistisch leren op studieprestaties en drop-out volledig gemedieerd wordt door geobserveerde studieactiviteiten en zelfstudietijd.

Hoofdstuk 4 beschreef relaties tussen concepties van constructivistisch leren en regulatie- en verwerkingsstrategieën. Deze strategieën werden gemeten door middel van corresponderende schalen van Vermunts Inventaris LeerStijlen (ILS; Vermunt, 1992) en de *Motivated Strategies for Learning Questionnaire* (MSLQ; Pintrich & de Groot, 1990). Het model waarin concepties van constructivistisch leren gerelateerd werden aan de regulatie- en verwerkingsstrategieën van de ILS vertoonde een matige fit met de data. Concepties van zelfregulatie, leeronzekerheid en leermotivatie droegen significant bij aan de regulatievariabelen. Meer specifiek vertoonden concepties van zelfregulerend leren een positieve relatie met zelfregulatie en een negatieve relatie met externe regulatie. Concepties van leeronzekerheid onderhielden een sterke, positieve relatie met de ILS-variabele 'gebrek aan regulatie'. Deze bevinding impliceert dat studenten die hun twijfels uitdrukken ten aanzien van hun leerproces het risico lopen een inadequate regulatiestrategie aan te nemen. Concepties van leermotivatie hadden een negatieve relatie met gebrek aan regulatie en een vrij groot positief effect op externe regulatie. Concepties van kennisconstructie vertoonden geen enkel significant verband met de regulatiestrategieën van de ILS. Daarnaast had effectieve zelfregulatie een zeer groot effect op diepe verwerking, een groot effect op concrete verwerking en een middelgroot effect op stapsgewijze verwerking. Externe regulatie liet een vrij grote relatie zien met stapsgewijze verwerking, maar geen significante verbanden met diepe en concrete verwerking. De ILS variabele 'gebrek aan regulatie' vertoonde tenslotte geen significante padcoëfficiënten met de variabelen op het operationele niveau (d.i. diepe, stapsgewijze en concrete verwerking).

Toetsing van het voorgestelde model dat concepties relateerde aan de regulatie- en verwerkingsstrategieën van de MSLQ resulteerde in een excellente fit met de data. Concepties van leermotivatie hadden een sterk effect op zelfregulatie. De padcoëfficiënt behorend bij de relatie van concepties van zelfregulatie op effectieve zelfregulatie bleek alleen significant bij een significantieniveau van .10. Geen andere concepties van constructivistisch leren lieten significante verbanden zien met zelfregulatie. In lijn met de data van de ILS-variabelen hadden zelfregulatiestrategieën tenslotte een sterk effect op cognitieve strategieën.

Chi-kwadraat verschiltoetsen werden net zoals in Hoofdstuk 3 gebruikt om te onderzoeken of regulatiestrategieën de invloed van concepties op verwerkingsstrategieën medieerden. Voor het model met de ILS-variabelen bleken gedeeltelijk gemedieerde relaties van kracht te zijn tussen concepties en verwerkingsstrategieën. Voor het model met de MSLQ-variabelen daarentegen medieerden regulatiestrategieën de relatie tussen concepties en verwerkingsstrategieën volledig.

Hoofdstukken 5 en **6** handelden over verschillen in concepties van constructivistisch leren tussen studenten in een conventioneel, collegegestuurd curriculum en studenten in een constructivistisch, probleemgestuurd curriculum.

De studie beschreven in **Hoofdstuk 5** trachtte verschillen in concepties van constructivistisch leren te belichten tussen eerstejaars psychologiestudenten van een conventioneel en van een constructivistisch curriculum. Net zoals in Hoofdstuk 2 liet de test voor meetinvariantie zien dat factorladingen equivalent waren over beide studentgroepen en gaf de onderliggende factorstructuur van de vragenlijst blijk van cross-validatie. Er konden significante verschillen waargenomen worden op de latente factoren samenwerkend leren, het gebruik van authentieke problemen en leermotivatie. Eerstejaarsstudenten in een conventioneel curriculum scoorden significant lager (d.i. waren het minder eens) op de latente constructen samenwerkend leren en authentieke problemen, maar significant hoger op leermotivatie vergeleken met de groep in probleemgestuurd onderwijs.

In **Hoofdstuk 6** werd tenslotte een cross-sectioneel design aangewend om de ontwikkeling van concepties van constructivistisch leren in kaart te brengen. Drie groepen (d.i. eerste-, tweede- en derdejaarsstudenten) in twee verschillende curricula (d.i. conventioneel en constructivistisch) werden getest. Eerder onderzoek had aangetoond dat opvattingen die studenten hebben over kennis en leren progressief ontwikkelen door toedoen van onderwijservaringen die studenten hebben (Hofer & Pintrich, 1997). Daarom werd in deze studie onderzocht of studenten het meer eens worden met constructivistische assumpties met toenemende ervaring in hun studieprogramma. Daarnaast werd bekeken of concepties van constructivistisch leren zich verschillend ontwikkelen in een conventioneel curriculum vergeleken met een probleemgestuurd curriculum. De resultaten lieten zien dat scores significant toenamen tussen het eerste en het tweede jaar (maar niet tussen het tweede en derde jaar) wat concepties van kennisconstructie, zelfregulatie en authentieke problemen betrof. Voor concepties van samenwerkend leren en leermotivatie bleek er geen toename in scores van studenten tussen jaar 1 en jaar 2, noch tussen jaar 2 en jaar 3. De factor leeronzekerheid vertoonde een interactie-effect. Terwijl studenten in een conventioneel curriculum het gedurende hun academische studie significant minder eens werden met stellingen over leeronzekerheid, veranderden deze concepties niet binnen de groep die probleemgestuurd onderwijs volgde. Daarnaast werden, in lijn met de bevindingen van Hoofdstuk 5, significante verschillen gevonden tussen de twee curriculum groepen. Studenten in probleemgestuurd onderwijs waren het meer eens met kennisconstructie, samenwerkend leren, zelfregulatie en het gebruik van authentieke problemen in onderwijs. Deze studenten waren het echter minder eens met stellingen over leermotivatie.

2. DISCUSSIE

Het centrale thema van dit proefschrift betreft concepties die studenten hebben van constructivistisch leren. Dit onderwerp is relatief nieuw in de onderwijspsychologische literatuur, met name wat *constructivistisch* leren betreft. Zoals beschreven in de vorige sectie, werd een meetinstrument ontwikkeld om deze concepties in kaart te brengen (Hoofdstuk 2), werden relaties onderzocht tussen deze concepties en studieactiviteiten en –prestaties (Hoofdstuk 3 en 4), werden effecten van de leeromgeving geanalyseerd (Hoofdstuk 5 en 6) en werd de verandering van concepties gedurende het academische programma van studenten onder de loep genomen (Hoofdstuk 6). In wat volgt zullen de belangrijkste bevindingen van dit proefschrift geïnterpreteerd worden in het licht van eerder onderzoek.

2.1 Concepties van constructivistisch leren meten

De resultaten van de studies uit Hoofdstuk 2 geven aan dat de ontwikkelde vragenlijst in staat was concepties van constructivistische leerassumpties op een betrouwbare en valide manier te meten. Studenten konden de zes factoren die ten grondslag liggen aan de vragenlijst identificeren. Dit impliceert dat ze opvattingen over kennisconstructie, samenwerkend leren, zelfregulatie, authentieke problemen, leeronzekerheid en leermotivatie kunnen onderscheiden als distinctieve invloeden op hun leerproces. De items van de vragenlijst vertoonden verder overeenstemming op conceptueel niveau en de factorstructuur gaf blijk van cross-validatie. Het testen van twee alternatieve modellen bevestigde nogmaals de onderliggende structuur van de vragenlijst. Kortom, de ontwikkelde vragenlijst bleek een adequaat instrument om concepties van constructivistisch leren te meten.

Correlaties tussen de factoren van de vragenlijst lieten een aantal consistente patronen zien in de verschillende studies van dit proefschrift. Concepties van leeronzekerheid hadden negatieve associaties met alle andere factoren, behalve met authentieke problemen. Concepties van leermotivatie vertoonden, eveneens met uitzondering van authentieke problemen, positieve relaties met de andere concepties van constructivistische assumpties.

2.2 Concepties van leeronzekerheid

Gevoelens van onzekerheid en twijfel met betrekking tot de eigen leercapaciteiten zijn nefast voor het toebedelen van een positieve rol aan constructivisme. De studie beschreven in Hoofdstuk 3 laat echter zien dat leeronzekerheid een positief effect had op de zelfstudietijd van studenten. Deze bevinding werd verklaard in het licht van de manier waarop studenten omgaan met twijfelgevoelens die ze ervaren. Het ervaren van deze gevoelens kan namelijk in een bepaald opzicht gunstig zijn voor de professionele ontwikkeling van studenten. Studenten zullen immers hard gaan werken als reactie op deze gevoelens, waardoor ze tot een zekere mate van tolerantie of acceptatie van deze gevoelens komen (Block, 1996). Hoewel leeronzekerheid kan leiden tot *meer* studieactiviteiten maakt Hoofdstuk 4 duidelijk dat deze onzekerheid niet leidt tot *betere* (d.i. effectievere) studieactiviteiten, aangezien deze factor een sterke relatie heeft met 'gebrek aan regulatie'. Studenten die twijfelgevoelens rapporteren met betrekking tot hun leerproces, lopen daarom risico op het aannemen van inadequate regulatiestrategieën. Daarnaast is in eerder onderzoek regelmatig aangetoond dat een ongerichte leerstijl, waar 'gebrek aan regulatie' deel van uitmaakt, negatief gerelateerd is aan allerhande types examenresultaten (Vermunt & Vermetten, 2004) wat aangeeft dat studenten die het eens zijn met stellingen over leeronzekerheid een risicogroep vormen. Vergelijking van studenten in een conventioneel curriculum met studenten in een constructivistische leeromgeving liet zien dat de eerste groep het minder eens werd met stellingen over leeronzekerheid tijdens hun studie, terwijl de opvattingen over deze factor in de probleemgestuurde studentgroep niet veranderden. Deze groep rapporteert meer twijfels (hoewel deze gevoelens niet sterk blijken) met betrekking tot hun leercapaciteiten. Dit verschil in leeronzekerheid tussen beide groepen is nog niet aanwezig bij startende, eerstejaarsstudenten, zoals blijkt uit Hoofdstuk 5, maar ontwikkelt zich in de loop van de studie. Open, constructivistische leeromgevingen blijken meer verantwoordelijkheid te eisen van lerenden wat kan leiden tot een gevoel van onzekerheid (Duke et al., 1998). Samengevat kan gesteld worden dat leeronzekerheid gezien kan worden als een negatieve factor in het leerproces van studenten (in de zin dat het kan leiden tot een inadequate verwerking van informatie) maar ook als een 'bijwerking' van open leeromgevingen (een ervaring waar studenten mee moeten leren omgaan als deel van hun leerproces).

2.3 Leermotivatie

Zoals reeds eerder aangestipt, had de factor leermotivatie significante, positieve correlaties met alle andere concepties van constructivistische assumpties. Zin hebben in studeren, tijd willen spenderen aan de studie en interesse hebben in de studie hangen samen met positieve opvattingen over kennisconstructie, samenwerkend leren en zelfregulatie (zie Hoofdstuk 2, 3 en 4) en hebben een positief effect op de zelfstudietijd van studenten (Hoofdstuk 3). Daarnaast bleek uit Hoofdstuk 4 dat leermotivatie negatief geassocieerd is met de subschaal 'gebrek aan regulatie' van de ILS. Studenten die het eens waren met stellingen zoals "Ik kan makkelijk de motivatie vinden om te studeren" rapporteerden meer studie-uren en zullen niet snel een ongerichte regulatiestrategie aannemen. Leermotivatie vertoonde geen significante relatie met de variabele 'zelfregulatie' van de ILS, maar vertoonde wel een sterk, positief effect met de subschaal zelfregulatie van de MSLQ alsook met 'externe regulatie' van de ILS. Pintrich en collega's (Pintrich, 1999; Pintrich & de Groot, 1990) hebben de relatie tussen zelfregulatie en motivatie veelvuldig aangetoond. Het is daarom niet duidelijk waarom er geen relatie gevonden werd met de zelfregulatievariabele van de ILS, maar wel een sterke relatie met de variabele zelfregulatie van de MSLQ. Wat mogelijk een rol speelt in dit opzicht is het onderscheid tussen intrinsieke en extrinsieke motivatie. Dit onderscheid was niet als zodanig geïntegreerd in de factorstructuur van de variabele leermotivatie. Motivationele aspecten zoals studiedoelen (d.i. leerdoelen versus prestatiedoelen) zijn niet expliciet bevraagd in onze vragenlijst. Het kan beargumenteerd worden dat sommige studenten hoog scoren op stellingen zoals "Ik kan makkelijk de motivatie vinden om te studeren" omdat ze het behalen van hoge cijfers in gedachten hebben (prestatiedoelen) en niet omdat ze intrinsiek gemotiveerd zijn in de leerstof (leerdoelen). Gebruik van een specifiekere motivatiemaat zou deze verklaring kunnen toetsen in toekomstig onderzoek. Daarnaast zou een specifiekere motivatiemaat die onderscheid maakt tussen intrinsieke en extrinsieke motivatie, licht kunnen werpen op de bevinding dat studenten in probleemgestuurd onderwijs het minder eens waren met stellingen omtrent leermotivatie vergeleken met studenten in een conventioneel curriculum (Hoofdstuk 5 en 6) en op de bevinding waarom leermotivatie niet verandert tijdens het studieprogramma van studenten (Hoofdstuk 6). Waarom kunnen onderwijsvormen zoals probleemgestuurd onderwijs studenten niet altijd motiveren? Hoewel deze onderwijsvormen kunnen leiden tot effectief leren, zijn ze vaak onsystematisch. Wanneer het probleemgestuurde proces niet werkt, hebben studenten vaak de neiging om dit aan hun vaardigheden toe te schrijven in plaats van aan de manier waarop ze het probleem benaderd hebben. Dergelijke attributies zijn nefast voor de motivatie (Zimmerman & Campillo, 2003). De studies in dit proefschrift tonen aan dat leermotivatie een belangrijke, beïnvloedende factor is, wat in lijn is met eerder onderzoek (Pintrich & Schunk, 1996). Een specifiekere motivatiemaat is echter nodig om de relatie met zelfregulatie, alsook de bevindingen uit de vergelijkende en cross-sectionele studies van dit proefschrift verder te onderzoeken.

2.4 Concepties van kennisconstructie

Concepties van kennisconstructie bleken een significante voorspeller van geobserveerde studieactiviteiten. Hoe meer studenten het eens waren met het actief construeren van eigen kennis en de voordelen van elaboreren, des te hoger de beoordelingen die deze studenten ontvingen van hun tutoren inzake de voorbereiding van de leerstof, het actief deelnemen aan de onderwijsgroepen en hun rol als gespreksleider en notulist. Verder bleken er geen verschillen in concepties over kennisconstructie tussen studenten in een conventioneel en een constructivistisch curriculum bij aanvang van hun studie (Hoofdstuk 5). Gedurende het eerste jaar van het academische programma ontstonden er echter wel verschillen tussen beide studentgroepen inzake concepties van kennisconstructie. Studenten in probleemgestuurd onderwijs geraakten meer overtuigd van de rol van eerder geleerde kennis, de voordelen van elaboreren en het actief verwerken van de leerstof (Hoofdstuk 6). Mogelijk hebben deze studenten de positieve en motiverende effecten van bijvoorbeeld elaboratie aan den lijve ondervonden, aangezien een probleemgestuurd curriculum hier meer nadruk op legt door de manier waarom onderwijsgroepen zijn ingericht. Kortom, kennisconstructie is een cruciaal element in constructivistische visies (Cunningham, 1992). De studies in dit proefschrift tonen aan dat ook *concepties* over kennisconstructie een belangrijke rol spelen in leerprocessen van studenten.

2.5 Concepties van samenwerkend leren en authentieke problemen

In Hoofdstuk 4 werd beargumenteerd dat samenwerkend leren en het gebruik van authentieke problemen curriculumkenmerken zijn. Studenten worden er automatisch mee geconfronteerd in een constructivistische leeromgeving: er wordt in kleine groepen gewerkt aan complexe, *ill-structured* problemen (Barrett, 2005; Barrows, 1996; Norman & Schmidt, 1992; Schmidt, Loyens, Van Gog, & Paas, in press). Daarom werden samenwerkend leren en authentieke problemen niet meegenomen in de studie van Hoofdstuk 4 en vertoonden deze factoren geen significante relaties met zelfstudietijd en geobserveerde studieactiviteiten in Hoofdstuk 3. Ze beschrijven de leeromgeving en niet het gedrag van studenten, wat ertoe kan leiden dat studenten het moeilijker vinden om de invloed van deze factoren op hun leerproces in te schatten. Het inschatten van de invloed van factoren waarin studenten zelf een rol spelen (bijvoorbeeld nieuwe informatie relateren aan eerder geleerde kennis) is makkelijker. Desondanks waren eerstejaarsstudenten in een probleemgestuurd curriculum het meer eens met deze factoren vergeleken met een studentenpopulatie in een conventionele leeromgeving. Samenwerkend leren is dan ook een belangrijk element van constructivisme aangezien sociale interacties bijdragen aan de constructie van kennis (Steffe & Gale, 1995). Authentieke problemen zijn op hun beurt de drijvende kracht achter de zelfstudie van studenten in constructivistische leeromgevingen (Dolmans, Snellen-Balendong, Wolfhagen, & van der Vleuten, 1997). Het is interessant om vast te stellen dat studenten die net begonnen zijn aan hun academische studie in een probleemgestuurde leeromgeving de factoren samenwerkend leren en authentieke problemen reeds als belangrijk bestempelen, terwijl studenten in een conventionele leeromgeving dat niet doen.

2.6 Concepties van zelfregulatie

Tot slot vertoonden concepties van zelfregulatie positieve relaties met effectief gerapporteerde zelfregulatie-activiteiten wat de centrale rol van concepties voor effectief studiegedrag nogmaals onderstreept. Als studenten ervan overtuigd zijn dat zelfregulatie hun leerproces ten goede komt, zullen ze meer waarschijnlijk zelfregulerend gedrag vertonen. Concepties van zelfregulatie waren negatief gerelateerd aan externe regulatie. Deze bevinding impliceert dat studenten die geloven dat aspecten van zelfregulatie zoals het stellen van doelen, zelfobservatie, zichzelf regelmatig toetsen en belonen hun leerproces vooruit helpen, niet geloven dat externe regulatie nuttig is voor hun leren. Eerder onderzoek heeft laten zien dat verschillen in het gebruik van zelfregulatiestrategieën hun weerslag hebben op academische prestaties (Cantwell & Moore, 1996; VanZile-Tamsen & Livingston, 1999). Gemiddelde scores op de factor zelfregulatie van de door ons ontwikkelde vragenlijst lieten zien dat studenten die deelnamen aan onze studies het eerder oneens waren met vragenlijststellingen over zelfregulatie, hoewel de scores dicht bij nul lagen (Hoofdstuk 3, 4 en 6). Voor startende eerstejaarsstudenten zou deze onenigheid kunnen voortvloeien uit het feit dat hun eerdere onderwijservaringen zich beperkten tot middelbaar onderwijs. Middelbaar onderwijs is namelijk typisch docent-gestuurd: de docent geeft aan welke boekhoofdstukken belangrijk zijn, hij/zij legt leerstof uit en helpt de student ter voorbereiding op examens. Het is mogelijk dat dit referentiekader de antwoorden van eerstejaarsstudenten gekleurd heeft, aangezien zij moeilijk kunnen voorzien wat het betekent om verantwoordelijkheid te nemen voor het eigen leerproces en wat het betekent om leeractiviteiten te plannen, monitoren en reguleren. De resultaten van Hoofdstuk 6 laten daarentegen zien dat tweede- en derdejaarsstudenten het nog steeds oneens zijn met stellingen over zelfregulatie, terwijl je eigen leren kunnen reguleren gezien wordt als de sleutel tot succesvol leren in het onderwijs en daarbuiten (Boekaerts, 1999). Daarnaast hebben vele studies aangetoond dat zelfregulatie positieve effecten heeft op leren (Cantwell & Moore, 1996; Heikkilä & Lonka, 2006; Minnaert & Janssen, 1999; VanZile-Tamsen & Livingston, 1999). Bovendien hebben tweede- en derdejaarsstudenten wel academische onderwijservaringen waardoor ze niet enkel ervaringen van het middelbaar onderwijs als referentiekader hebben zoals de eerstejaarsstudenten. Aspecten van zelfregulatie zoals het stellen van doelen en de eigen vooruitgang monitoren zijn, hoe belangrijk ook, belastend voor studenten en vragen om een grote verantwoordelijkheid. Indien studenten deze verantwoordelijkheid (in termen van welke leerstof bestudeerd moet worden bijvoorbeeld) bij de docent kunnen leggen en indien ze in plaats van hun eigen leerdoelen na te streven zich kunnen richten op vooropgestelde leerdoelen van de faculteit of docent, dan geeft dat studenten vertrouwen (Lloyd-Jones & Hak, 2004). Gedurende de eerste twee jaar van hun studie vindt er echter een positieve ontwikkeling plaats met betrekking tot de opvattingen over zelfregulatie, hoewel de scores negatief blijven. De invloed van de leeromgeving is ook bij deze factor waarneembaar: studenten in constructivistische leeromgevingen zijn het meer eens met stellingen over zelfregulatie vergeleken met studenten in conventioneel onderwijs. Gezien de negatieve scores is een correctere conclusie echter dat studenten in probleemgestuurd onderwijs het minder oneens zijn met stellingen over zelfregulatie.

3. CONCLUSIES

Op basis van de bevindingen van de studies in dit proefschrift kunnen verscheidene conclusies geopperd worden. Een eerst conclusie, gebaseerd op de studie uit Hoofdstuk 2, is dat we in staat zijn geweest om een adequaat instrument te ontwikkelen om concepties die studenten hebben van constructivistische assumpties betrouwbaar en valide te meten. De items van de vragenlijst vertoonden overeenstemming op conceptueel vlak en de factorstructuur van de vragenlijst gaf blijk van cross-validatie.

Daarnaast zijn er, in lijn met eerder onderzoek op het vlak van leerconcepties, (indirecte) relaties tussen concepties van constructivistisch leren en academische prestaties. Meer specifiek, zoals beschreven in Hoofdstuk 3, voorspellen opvattingen van studenten over kennisconstructie de studieactiviteiten van deze studenten. Leermotivatie en leeronzekerheid zijn op hun beurt voorspellend voor de zelfstudietijd. Opvattingen van studenten spelen verder ook, zij het indirect, een rol in de regulatie- en verwerkingsstrategieën van studenten, alsook in de leerresultaten. Deze resultaten impliceren dat om studieprestaties te verbeteren, het onvoldoende is studieactiviteiten te verbeteren, aangezien deze activiteiten in bepaalde mate afhankelijk zijn van de concepties van studenten. Samengevat blijkt het belang van concepties over constructivistisch leren uit de studies van dit proefschrift. Traditioneel werden docenten, instructiemethoden, leermateriaal en studieactiviteiten beschouwd als de elementen die veranderd dienden te worden om prestaties te kunnen bevorderen (Sinatra & Pintrich, 2003). Onze studies suggereren dat de lerende zelf een controlerende rol kan en dient uit te oefenen. Daarom dienen concepties van studenten meer aandacht te krijgen in het onderwijs. Speciale instructie en trainingsprogramma's zouden hierbij kunnen helpen (Lonka, Joram, & Bryson, 1996).

Hoofdstuk 5 en 6 lieten zien dat het curriculum waarin studenten onderwijs volgen invloed heeft op de concepties van studenten. Startende eerstejaarsstudenten vangen hun universitaire studie aan met uitgesproken concepties over constructivistische leerassumpties, zoals bleek uit Hoofdstuk 5. Studenten in probleemgestuurd onderwijs erkennen het belang van verschillende constructivistische leerprincipes meer dan studenten in conventioneel onderwijs. Vergelijkende curriculumstudies dienen deze initiële verschillen in acht te nemen omdat, zoals werd uitgelegd in Hoofdstuk 3 en 4, concepties andere aspecten van leren kunnen beïnvloeden. De meeste studies die constructivistische leeromgevingen vergelijken met conventionele benadrukken enkel verschillen die ontstaan ten gevolge van het curriculum. Dit proefschrift toont aan dat wat concepties betreft, 'verschillende' studenten in verschillende leeromgevingen starten. Concepties kunnen daarom als een belangrijke moderator van effecten van probleemgestuurd onderwijs fungeren en zouden bijgevolg meegenomen moeten worden in studies die effecten van probleemgestuurd onderwijs analyseren en mogelijk in al het vergelijkende onderwijsonderzoek. Daarop aansluitend levert Hoofdstuk 6 eenduidig bewijs voor de invloed van de leeromgeving op concepties van constructivistisch leren. Eerder onderzoek op dit vlak toonde effecten van leeromgevingen aan door middel van manipulaties (d.i. gebruik van bepaalde leeropdrachten die gelabeld werden als constructivistisch, Tynjälä, 1997). De studie beschreven in Hoofdstuk 6 laat dit effect echter zien in een feitelijke leeromgeving.

Tot slot bleek uit dit proefschrift dat veranderingen in concepties ten gevolge van een nieuwe leeromgeving (in ons geval hoger onderwijs) plaatsvinden in het eerste jaar. Na dit eerste jaar blijken concepties te consolideren. Trainingsprogramma's die erop gericht zijn concepties van studenten te veranderen, zouden daarom in het eerste jaar van het hoger onderwijs aangeboden moeten worden, omdat dit de 'kritieke periode' blijkt te zijn.

4. RICHTLIJNEN VOOR VERVOLGONDERZOEK

De studies in dit proefschrift hebben een licht geworpen op concepties van constructivistisch leren. De concepties werden in kaart gebracht en relaties met academische studieprestaties, drop-out en regulatie- en verwerkingsstrategieën. Daarnaast werd de invloed van de leeromgeving onderzocht alsook de ontwikkeling van concepties gedurende het academische programma van studenten. Een volgende stap zou kunnen zijn om te onderzoeken of concepties doelgericht veranderd kunnen worden en of dit het leerproces van studenten beïnvloedt. Er zijn reeds studies verricht op dit vlak, meer bepaald met trainingsprogramma's. De inhoud van deze trainingsprogramma's is echter niet eenduidig. Lonka en collega's (1996) beschouwden bijvoorbeeld het vak onderwijspsychologie als een trainingsprogramma voor het aanpakken van concepties van leren. Onderzoek naar *conceptual change* start daarentegen vanuit theoretische modellen met verschillende factoren die de waarschijnlijkheid van *conceptual change* beïnvloeden (Dole & Sinatra, 1998). Het toepassen van theoretische modellen op concepties van constructivistisch leren zou inzicht kunnen verschaffen in de manier waarop deze concepties doelbewust veranderd kunnen worden. De ontwikkeling van effectieve trainingsprogramma's voor het veranderen van concepties zou van grote waarde zijn, aangezien concepties het leerproces van studenten kunnen beïnvloeden. Uit Hoofdstuk 4 bleek verder dat het gebruik van specifiekere motivatiematen de relatie tussen concepties over constructivistisch leren en regulatiestrategieën verder zou kunnen specificeren. We erkennen dat de *parcels* van onze vragenlijst niet uitputtend waren. We hebben bepaalde aspecten van elke latente factor geselecteerd om in de vragenlijst te gebruiken. Concepties van constructivistische assumpties stonden centraal in de studies van dit proefschrift, niet het meten van de assumpties zelf. Conclusies die uit onze studies getrokken kunnen worden, hebben betrekking op concepties van de door ons geselecteerde factoren. Verscheidene onderzoekers hebben andere onderverdelingen voorgesteld van bijvoorbeeld zelfregulatie (Boekaerts, 1999; Pintrich, 1999; Schunk & Zimmerman, 1994) en motivatie (Pintrich & de Groot, 1990) en hebben meetinstrumenten ontwikkeld om deze factoren te meten. Desalniettemin laat dit proefschrift zien dat de door ons ontworpen vragenlijst succesvol gebleken is het in kaart brengen van concepties van studenten van die constructivistische aspecten die ingesloten werden in de vragenlijst. Vertaling van de vragenlijst naar het Engels alsook cross-validatie van deze vertaalde versie zou vergelijkend onderzoek buiten Nederlandstalig grondgebied mogelijk maken.

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Appendix A

Description of the parcels with item examples (translated from Dutch)

Please note that we are currently working on an English version of the questionnaire. The questionnaire was developed in Dutch and was only administered to Dutch speaking student populations. An English version of our questionnaire needs to be tested first in English speaking student populations to investigate validation and cross-validation. A mere translation does not guarantee that the observed psychometrical properties of the Dutch version also account for the translated version. To avoid distributing an untested English version, we chose not to report the complete translation. However, an English version of our questionnaire can be expected in the near future.

1. KNOWLEDGE CONSTRUCTION (*n* = 10)

Parcel 1 – Importance of prior knowledge (n = 2): Concerns the role of previous learned knowledge and its influence on subject matter to be mastered
Example: "Previous learned facts are the building blocks of new knowledge"
Parcel 2 – Relating subject matter with prior knowledge (n = 5): Concerns the actual process of elaboration by students
Example: "I always try to relate new subject matter to knowledge that I have already acquired"
Parcel 3 – Active processing of subject matter (n = 3): Concerns the role of the learner as an active agent in the process of knowledge acquisition
Example: "Subject matter can be optimally remembered when you repeat in own words what you have read"

2. COOPERATIVE LEARNING (*n* = 9)

Parcel 1 – Role of fellow-students (n = 3): Concerns the role of fellow-students in the knowledge acquisition process
Example: "Discussing subject matter with fellow-students leads to a better understanding"
Parcel 2 – Advantages of cooperation (n = 3): Concerns the advantages of studying together versus studying alone
Example: "Studying alone yields more benefit than studying with fellow-students" (reversed scoring)
Parcel 3 – Efficiency of cooperation (n = 3): Concerns the appreciation and efficiency of group work
Example: "I like working together with fellow-students"

3. SELF-REGULATION (*n* = 9)

Parcel 1 – Teachers are responsible (n = 4): Concerns the role of the teacher as a guiding authority
Example: "Preparing a test is difficult when the teacher has not pointed out exactly what has to be studied" (reversed scoring)
Parcel 2 – Students are responsible (n = 2): Concerns the responsibility of students when they are encountered with difficult subject matter
Example: "If subject matter is difficult, you should better ask the teacher for explanation instead of sifting it out yourself" (reversed scoring)
Parcel 3 – Disadvantages of self-regulation (n = 3): Concerns the reverse side of students' selection of the subject matter
Example: "Enabling students to make their own selection of the subject matter, leads to deficiencies in their knowledge and abilities" (reversed scoring)

4. AUTHENTIC PROBLEMS (*n* = 7)

Parcel 1 – Dealing with authentic problems (n = 2): Concerns the way, in which students handle authentic problems during study
Example: "A good way of studying is to ask yourself how you can use knowledge in the future (e.g., in your job)"
Parcel 2 – Emphasis on practice (n = 2): Concerns the degree, in which practice is emphasized
Example: "Emphasis on practical abilities during the curriculum gives you a head start in your future job"
Parcel 3 – Importance of applying knowledge (n = 3): Concerns the application of knowledge in practice situations
Example: "Above all, acquired knowledge has to be useful for practice situations"

5. SELF-PERCEIVED INABILITY TO LEARN (*n* = 12)

Parcel 1 – Doubting one's own capacities (n = 5): Concerns the uncertainty about being able to succeed
Example: "I doubt if I can complete this study successfully"
Parcel 2 – Doubts about what to study (n = 5): Concerns the uncertainty about what to study
Example: "I often feel uncertain about what I have to study"
Parcel 3 – Doubts about what main and side issues are (n = 2): Concerns uncertainty about main and side issues in subject matter
Example: "I can easily distinguish main and side issues" (reversed scoring)

6. MOTIVATION TO LEARN (*n* = 8)

Parcel 1 – Having a mind to study (n = 4): Concerns the motivation and enthusiasm with which students encounter their study and learning activities
Example: "I easily find the motivation to study"
Parcel 2 – Willingness to spend time on studying (n = 2): Concerns finding the motivation to do study activities in time
Example: "I preferably postpone my study activities until the very last moment" (reversed scoring)
Parcel 3 – Interest in one's studies (n = 2): Concerns the motivation and interest with which students approach their learning activities
Example: "I do not have a study approach" (reversed scoring)

Appendix B

Tutor rating scale for observed learning activities (translated from Dutch)

PREPARATION

1. The student gave evidence of high-quality self-study activities.
2. The student's contributions to the group discussion were of high quality.
3. The student was able to distinguish main and side issues in the subject matter.
4. The student studied relevant additional literature on top of the minimal requirement of two literature sources per problem.
5. The student was able to explain the subject matter in his/her own words.

PARTICIPATION

6. The student took actively part in the brainstorm and problem analysis of the problem to be studied.
7. The student took actively part in the discussion of the problem.
8. The student was motivated to specify problems to be studied in detail.
9. The student brought profundity in the group discussion by asking critical questions.
10. The student looked for relationships among theories and/or group members' contributions.
11. The student listened carefully to contributions of other group members.
12. The student gave evidence of interest and involvement.
13. The student was on time for the tutorial meetings.

ROLE AS CHAIR AND SCRIBE

14. As a chair, the student had prepared his or herself well. He/she had a clear overview of the subject matter that needed to be discussed in the tutorial group.
15. As a chair, the student structured the group discussion well.
16. As a chair, the student summarized the subject matter well and at the right moments.
17. As a chair, the students stimulated all group members to contribute to the discussion.
18. As a chair, the student asked the group concrete questions to stimulate the discussion.
19. As a scribe, the student was able to write down contributions of group members in a short and clear way.

Curriculum Vitae, Publications, and Presentations

CURRICULUM VITAE

Sofie Loyens was born on May 20, 1978 in Bilzen, Belgium. She completed her secondary education in 1996 at the Heilig Graf Instituut in Bilzen. In June 2001, she received her Master's degree in clinical psychology at Maastricht University. After her graduation, she worked as a psychological assistant at the out-patient clinic for eating disorders and later as a psychosocial therapist at the general psychiatry unit of the Maastricht University Hospital (azM). From November 2001 till February 2004, she became a co-worker of the ZAP-project ('Zeer Actieve Psychologie') at the Department of Psychology of Erasmus University Rotterdam. She was involved in the development of short, interactive, ICT-based programs (called ZAPs), which give students a firm understanding of fundamental concepts by allowing them to experience psychological phenomena firsthand. From June 2002 on, she combined the activities of the ZAP-project with a position as a researcher at the Department of Psychology. Her research concerned students' conceptions of constructivist learning and resulted in the present dissertation. She has also been coordinating the first-year course on educational psychology and from January 2007, she has been coordinating the internships at the Department of Psychology of Erasmus University Rotterdam.

PUBLICATIONS AS FIRST AUTHOR

Loyens, S. M. M., Rikers, R. M. J. P., & Schmidt, H. G. (in press-a). Students' conceptions of distinct constructivist assumptions. *European Journal of Psychology of Education*.

Loyens, S. M. M., Rikers, R. M. J. P., & Schmidt, H. G (in press-b). The impact of students' conceptions of constructivist assumptions on academic achievement and dropout. *Studies in Higher Education*.

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PUBLICATIONS AS CO-AUTHOR

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PRESENTATIONS

Loyens, S. M. M., Rikers, R. M. J. P., & Schmidt, H. G. (2006, April). *Students' conceptions of constructivist assumptions: What is their relationship with academic achievement?* Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA.

Loyens, S. M. M., Rikers, R. M. J. P., & Schmidt, H. G. (2006, April). *Students' conceptions of constructivist learning: A comparison between a traditional and a problem-based learning curriculum*. Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA.

Loyens, S. M. M., Rikers, R. M. J. P., & Schmidt, H. G. (2005, August). *The impact of students' conceptions of constructivist assumptions on academic achievement and dropout*. Paper presented at the Biennial Conference of the European Association for Research in Learning and Instruction, Nicosia, Cyprus.

Loyens, S. M. M., Rikers, R. M. J. P., & Schmidt, H. G. (2005, August). *Students' conceptions of constructivist learning: A comparison between a traditional and a problem-based learning curriculum*. Paper presented at the Biennial Conference of the European Association for Research in Learning and Instruction, Nicosia, Cyprus.

Schmidt, H. G., Loyens, S. M. M., & Rikers, R. M. J. P. (2005, April). *Generality of a causal model of problem-based learning: Further evidence*. Paper presented at the Annual Meeting of the American Educational Research Association, Montréal, Quebec.

Loyens, S. M. M., Rikers, R. M. J. P., & Schmidt, H.G. (2005, January). *Students' conceptions of constructivist assumptions*. Paper presented at the Hawaii International Conference on Education, Honolulu, HI.

Eysink, T. H. S., Hulshof, C. D., Loyens, S. M. M. (2003, August). *Experiental learning in psychology: The ZAP project*. Paper presented at the Biennial Conference of the European Association for Research on Learning and Instruction, Padova, Italy.

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Loyens, S. M. M., Te Winkel, W. W. R., Eysink, T. H. S., Hulshof, C. D., Schmidt, H. G., & de Jong, T. (2003, April). *Application of ICT in problem-based learning: ZAP – an evaluation*. Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL.

Loyens, S. M. M., Rikers, R. M. J. P., & Sins, P. H. M. (2002, April). *The generation of clinical knowledge in medical expertise*. Poster presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA.