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Research into the Theoretical Base of Learning Styles in View of Educational Applications in  
a University Setting

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## **Voorwoord**

Het proefschrift dat voor u ligt is het resultaat van vier jaar zoeken, moeizaam beslissen, bijschaven en doorwerken. Dit proces was niet altijd even gemakkelijk, en verschillende mensen hebben ertoe bijgedragen dat ik dit tot een goed einde heb kunnen brengen.

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## General Introduction

Since Allport (1937) introduced the idea of “style” to psychology, the term has been used to refer to patterns of behavior that are consistent over long periods of time and across many areas of activity (Grigorenko & Sternberg, 1995). The concept has always been associated with individuality, relative stability and consistency (Rayner & Riding, 1997). In educational psychology, *learning style* generally refers to consistent individual differences in the way individuals set about learning something (Adey, Fairbrother, Wiliam, Johnson, & Jones, 1999). Since the end of the seventies, the concept has gained growing popularity among educators (Rayner & Riding, 1997; Stahl, 1999; Wilson, 1998). Today, it is a common conception in many educators’ vocabulary to talk and think about individuality in learning.

In sharp contrast to this popularity are the critical conclusions of the majority of review articles about learning styles, published during the last two decades (Adey et al., 1999; Curry, 1983; Furnham, 1995; Grigorenko & Sternberg, 1995; Joughin, 1992; Messick, 1984; Moran, 1991; Rayner & Riding, 1997; Reynolds, 1997; Sadler-Smith, 2001; Stahl, 1999; Stellwagen, 2001; Sternberg & Grigorenko, 1997; Tiedemann, 1989; Wilson, 1998). Three main problems emerge.

A first problem is related to the conceptual confusion that is abundant in the learning style research field. Learning style is not an unequivocal concept. There exist a multitude of definitions, theoretical models, and learning style instruments. What further adds to the confusion is the fact that ever so often the concept is used as synonym for *cognitive style* (Adey et al., 1999; Curry, 1983; Grigorenko & Sternberg, 1995; Moran, 1991; Rayner & Riding, 1997; Reynolds, 1997; Riding & Cheema, 1991).

The second problem is that there is little guidance as to the way learning styles should be applied in educational practice (Joughin, 1992; Rayner & Riding, 1997; Sadler-Smith, 2001). Some authors explicitly point out the risk of pigeon-holing and stereotyping pupils or students (Adey et al., 1999; Reynolds, 1997; Stellwagen, 2001).

In most cases, educational applications of learning styles follow guidelines based on the so-called “matching-hypothesis”. This hypothesis builds on aptitude-treatment-interaction (ATI) research (Cronbach & Snow, 1977), and states that if a teacher matches instruction to the individual learning styles of his or her students, the latter will perform better, or at least they will appreciate the instruction more.

The difficulties with this educational application of learning styles are however manifold. First, there seems to be little reliable empirical evidence that consistently supports the matching-hypothesis (Adey et al., 1999; Furnham, 1995; Moran, 1991; Reynolds, 1997; Sadler-Smith, 2001; Stahl, 1999; Stellwagen, 2001). Second, the original ATI-researchers actually never had the intention to prescribe generally applicable matching-guidelines (Boekaerts, 2002). They explicitly warned for such oversimplifications. Third, the rigid application of matching-guidelines not only leads to practical and organizational problems (Dixon, 1985), especially at university; it also raises ethical questions: when one decides to capitalize on the strengths of a student’s learning style, this implies that the weaknesses remain undeveloped, and vice versa (Messick, 1984; McKeachie, 1995; Adey et al., 1999).

The third problem is the psychometric quality of many learning style instruments. Almost every review author points at the questionable reliability and validity of the learning style measures (Rayner & Riding, 1997; Reynolds, 1997; Sadler-Smith, 2001, Stahl, 1999; Stellwagen, 2001).

In this dissertation, our primary aim is to tackle the first and the second problem in view of educational applications of the learning style concept in a university setting. The third problem is taken into account throughout the dissertation with regard to the measuring instruments used.

Chapter 1 focuses on the first problem, the conceptual confusion in the learning style research field. Learning style as well as cognitive style are the concepts of interest. After explaining why the existing attempts to systematize the conceptual field have not been able to give a full understanding of the complete learning and cognitive style literature, we present citation analysis as a technique to develop an alternative

organization of this literature. The key research question of this chapter is: What are the dominant theoretical orientations in the field, what is their relative impact and how do they interrelate? Application of the citation analysis technique enabled us to solve the conceptual confusion between learning style and cognitive style on the one hand, and the confusion between the various learning style definitions and models on the other.

Overall, there appear to be three distinct theoretical orientations within the learning style literature. Two of them shape the American tradition in learning styles research and are related to the work of Kolb, the author with the strongest impact on the learning style literature. Within this American tradition, which forms the core of the learning styles research, it is generally accepted that there is no “good” or “bad” learning style, and that it is of prime importance that education meets the specific strengths and weaknesses of learners. Further in this dissertation, the term “learning style” is only used to refer to this specific interpretation of the concept. In the third, British-European orientation, the central authors are Entwistle and Marton. Also Vermunt belongs to this orientation. These authors want to understand the experience of learning from the perspective of the student, in naturalistic higher education settings. Instead of “learning style”, they prefer to use the concept “approaches to learning” to point at individual differences.

Chapter 1 is accepted for publication in *Educational Psychology*.

Chapters 2 to 5 report on four studies that build on an experiment set up in the authentic context of university education and focused on the educational application of learning styles.

With regard to this application of learning styles in university education, this dissertation investigates the potential of the “learning style awareness” hypothesis as an alternative for the “matching-hypothesis”. Some authors suggest that promoting awareness of and reflection on one’s own learning style could improve the learning process and foster self-regulated learning ( Andrew, Pheiffer, Green, & Holley, 2002; Carns & Carns, 1991; Carry, 1999; Cook, 1991; Dixon, 1985; Ehrhard, 2000; Labour,

2002; Lacina, 1991; McLaughlin, 1996; Moran, 1991; Nickles, 2003; O'Phelan, 1994; Rayner & Riding, 1997; Raviotta, 1989; Riding & Rayner, 1998; Sadler-Smith, 2001; Sandiford, MacDonald, Robinson, Davenport, Elliot, & Hicks, 2002). In this manner, the learning style concept becomes an element of the broader process of self-regulated learning. Zimmerman (2002) explicitly states that self-regulated learning presents a way to compensate for individual differences in learning. We hypothesize that this theoretical position is a promising starting point to elaborate a fruitful educational application of learning styles in higher education.

Throughout this dissertation, self-regulated learning is conceptualized according to the social cognitive perspective on self-regulated learning (Schunk, 2001; Zimmerman, 1989, 2000). This perspective, based on Bandura's social cognitive theory (1986), is distinctive in viewing self-regulation as determined by the "triarchic reciprocal causation" among personal, environmental, and behavioral factors and processes, which are constantly changing during the course of learning and performance. According to social cognitivists (Schunk, 2001; Zimmerman, 1989, 1995, 2000), self-regulated learning consists of three self-oriented feedback loops: behavioral self-regulation, environmental self-regulation, and covert self-regulation. The different self-regulatory processes and accompanying beliefs fall into three cyclical phases: forethought, performance or volitional control, and self-reflection.

There are two reasons why exactly social cognitive theory was chosen. The most important reason is that the triarchic system clearly describes how the surplus value of learning style awareness in the self-regulated learning process can be realized: a student becomes aware of his or her learning style, by which he or she can adapt the environment and/or behavior to manage his or her limitations and to optimize the learning process. The second reason is that the social cognitive perspective shows that self-regulated learning is a very complex process. It embeds rational metacognitive processes within a larger system that also includes subjective, behavioral and social-environmental factors. Without losing clarity, the model gives an encompassing view on the topic. As a consequence it is more easily linked to various other theoretical

insights from the extensive literature on for example (meta)cognition, (self-regulated) learning, and motivation.

However, the difficulty with the “learning style awareness” hypothesis is that it still lacks sound theoretical and empirical foundations.

With regard to the need for a theoretical base, we present a hypothetical process model to describe and explain the surplus value of learning style awareness in the learning process.

To gather empirical evidence, an experimental study was set up, based on pretest-posttest design and a specific intervention. During the academic year 2002-2003, an elective academic counseling program with a focus on self-regulated learning was organized for the first-year medical students in the Faculty of Medicine and Health Sciences at Ghent University. The program consisted of 5 sessions that were spread over the academic year. The program was elaborated in collaboration with the faculty’s academic counselor. Two versions of this program were developed. The control group received a standard self-regulated learning program, without explicit information about their individual learning style. The experimental group participated in a self-regulated learning program in which learning style awareness was explicitly promoted. The third, reference group chose not to participate in the program.

The instructional approach used during the counseling sessions integrated four characteristics, namely social learning through small group interaction; direct instruction; referring to a realistic context and content; and stimulating metacognitive awareness. At the content level, the program reflected the overall structure of the social cognitive model of self-regulation. Kolb’s learning style model was chosen as frame of reference for the experimental program. The choice for this specific learning style approach was based on the outcomes of the citation analysis. Secondly, it is a model that is straightforward, intelligible, and therefore easily accessible for students who are unfamiliar with the learning style concept.

The “learning style awareness” hypothesis will be tested in the fifth chapter. The three preceding chapters describe studies that focus on underlying research questions.



Chapter 2 studies the learning styles of first-year medical students. In Flanders, entrance to medical studies is restricted. Students have to take – a centrally organized – admission examination. The central assumption is that this will be reflected in the specific learning styles of these students. A comparison is made with the learning styles of first-year pedagogical sciences students. There is no restricted admission to this university study.

This chapter is submitted for publication in *Medical Teacher*.

Chapter 3 focuses on the general effectiveness of the counseling program, regardless of version. Its effects on academic performance, method of learning, and perceived self-efficacy are investigated. The students who attended the full program (both versions) are compared with the students who dropped out and the students who did not participate. The following three hypothesis are investigated: (a) the students who attended the full program will show higher academic performance than the drop-out and the non-participating students, (b) the participating students will be more likely to report a method of learning incorporating self-regulated learning, and (c) the participating students will have a higher level of perceived self-efficacy than the drop-out and the non-participating students. Also the direct and interaction effects on each dependent variable of the individual differences factors sex, learning style, and whether the students were freshmen or not, are explored.

This chapter is submitted for publication in *Contemporary Educational Psychology*.

The research in chapter 4 focuses on the dynamic interaction between the key variables in the social cognitive model of self-regulated learning. Based on the data gathered from the first-year medical students, the hypothetical relationships between person and behavior variables are studied. The following core person and behavior variables are included in the analyses: prior and domain knowledge, cognitive processing skills, sex, age, cognitive style, learning style, perceived self-efficacy, method of learning (including self-regulated learning), and academic performance.

Four sub-questions help to find an answer to the general research question of this study:

- How are the person and behavior variables, as measured at the start of the academic year, interrelated?
- Which of these antecedent variables have the highest predictive value for perceived self-efficacy at the end of the academic year? We hypothesize that prior and domain knowledge, and method of learning as measured at the start of the academic year, will be the strongest predictors, for they best reflect the students' previous learning experiences.
- Which of the person and behavior variables best predict method of learning, including self-regulated learning, at the end of the academic year? According to the social cognitive model, perceived self-efficacy should play a crucial role, next to method of learning measured at the start of the academic year.
- To what extent do the person and behavior variables predict academic performance at the end of the academic year? Following the theory, perceived self-efficacy and method of learning should make a significant contribution.

Chapter 4 is submitted for publication in *Journal of Educational Psychology*.

Finally, chapter 5 tackles the central question about the potential of the “learning style awareness” hypothesis within the context of university education. In the first part of this chapter, a hypothetical process model is presented to explain the expected surplus value of learning style awareness in the learning process. In the second part of the chapter, students from the learning style based version of the counseling program are compared with students from the control condition, to test the hypothesis that the former will benefit more from the program. The following hypotheses regarding the core elements of our theoretical process model are tested:

- Students in the learning style condition will report to a higher extent a method of learning incorporating effective metacognitive monitoring and self-regulated learning.
- Students in the learning style condition will have developed more and more refined metacognitive knowledge about the person factor in learning.

- Students in the learning style condition will have incorporated “learning styles” in their language when talking and thinking about their learning.
- Students in the learning style condition will be more motivated and will report less fear of failure.
- Students in the learning style condition will report higher judgments of accuracy of self-knowledge.

In addition, we hypothesize that students in the learning style condition will show higher appraisal for and interest in the program, especially for the parts in which their personal learning style was explicitly addressed.

This chapter is submitted for publication in *Higher Education*.

The final section of this dissertation will bring together the findings of the subsequent chapters and present an integrated overview of the research results.

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## Chapter 1

### Mapping the Learning Styles “Jungle”

#### An Overview of the Literature based on Citation Analysis\*

*Educationists and researchers who consider the use of the learning style concept to address individual differences in learning, are often daunted by the multitude of definitions, models and instruments. It is difficult to make an informed choice. The confusion with cognitive style, a term often used as a synonym, makes it even more complicated. Reviews of the literature give some direction, but there are a number of arguments why the available reviews raise new problems. In this paper, citation analysis is presented as a technique to develop an alternative organisation of the learning style and cognitive style literature. Application of this technique results in a review that clarifies dominant theoretical orientations in the literature, is helpful to identify the relative impact of different orientations and helps to illuminate their interrelationships. As such, the alternative review of the literature can serve as a road-map for novices to the styles field.*

Since the end of the seventies, learning styles have been embraced by educationists and researchers as a way to address individual differences in learning. Educationists and researchers who consider using learning styles as a key variable are often daunted by the multitude of definitions, theoretical models and learning style instruments. This leads to questions such as: How to find a way through this jungle? How to make an informed choice? Furthermore, *learning style* is not a univocal concept and it is sometimes used as a synonym with *cognitive style*, adding to the confusion in the literature (Adey, Fairbrother, Wiliam, Johnson & Jones, 1999; Curry, 1983; Grigorenko & Sternberg, 1995; Moran, 1991; Rayner & Riding, 1997; Reynolds, 1997; Riding & Cheema, 1991).

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Although several attempts to systematize the conceptual field have been proposed (Curry, 1983, 1987, 2000; Grigorenko & Sternberg, 1995; Jonassen & Grabowski, 1993; Miller, 1987; Riding & Cheema, 1991; Rayner & Riding, 1997; Rayner, 2000), the question of how the style literature should be organised continues to be posed (Cassidy, 2003; Coffield, Modely, Ecclestone & Hall, 2003).

The existing reviews are of value and helpful for a first orientation in the field. But they are less helpful to get a full understanding of the complete learning style and cognitive style literature and tradition. This becomes clear when we compare the different reviews. A number of key concerns with these existing reviews are listed below.

A first concern is related to the autonomous development process of the different reviews. Their authors developed them independently and hardly interlink them. Reviewers base their organization of the literature on a particular approach towards the concepts of learning style and cognitive style. This is not always made explicit and/or is difficult to reconcile with the position of other reviewers. What Kreuzman (2001) states about the establishment of intellectual traditions in philosophy, can as such easily be translated to the organisation of the learning style and cognitive style literature: “. . . it is usually done in a variety of informal ways, for example, by interpreting the writings of the relevant individuals and by looking at the focus and the tone of the work. Although such approaches are useful, they are subject to the biases of the individual doing the classification. The resulting classification may reveal more about the person doing the analysis than the writings being examined. (p. 527)”. This results in reviews that are difficult to compare or integrate. Therefore, putting reviews next to one another, does not help to make the overall field more transparent. Intuitively, relationships between the different review structures can be assumed, but have not been unambiguously established by the original authors.

Another concern is the selective nature of the reviews. Exclusion of certain definitions, models, and instruments results in incomplete overviews of the available literature at a certain moment in time. The problem is that inclusion or exclusion of models in the reviews is not based on clear criteria. There is also a lack of clear and operational criteria to distinguish between categories or dimensions in the reviews.

Most reviews include only a general description of the categories and a few exemplary style models per category. This makes it very difficult to expand existing reviews with new or other learning or cognitive style models.

A next point of concern is the fact that the available reviews hardly give information about the scientific impact of the different learning and cognitive style conceptions. Although it is well known that some style definitions, models, and instruments have a larger influence on research or practice than others, the reviews suggest an equivalent scientific impact.

A last point of concern is that only limited information is given about the context of the individual style definitions, models, and instruments when they are included in a review. Reference to the developers' original motivation, theoretical background, and position in the scientific community is hardly made. This might reflect a conception of science, that considers the development of knowledge as linear and progressive, instead of the result of the work of different researchers, with their own motivations and within their own contexts (Sanders & Van Rappard, 1982).

In this paper, we use citation analysis to develop an alternative organisation of the learning style and cognitive style literature. Considering the already mentioned conceptual confusion, both the literature on learning style and cognitive style will be involved in the study. The citation analysis method is expected to take into account the critical concerns raised above and is expected to result in a more workable overview of the field. The key research question of the study is therefore: What are the dominant theoretical orientations in the cognitive style and learning style literature, what is their relative impact and how do they interrelate?

## Method

### *Citation Analysis: A General Introduction*

Citation analysis is a quantitative research approach based on the use of the citation indexes. Two measures of scientific activity are used: (1) citation rates of authors, documents, and journals and (2) the number of co-citations, i.e., citation links between

authors, documents and journals (Garfield, 1979). In this paper, we will mainly focus on the authors.

### *Citation Rates*

The citation rate of a given author equals the number of times individual scholars cite this author in their own work. It is considered as an objective measure for evaluating the research performance of specific individuals or groups.

The validity of this approach is not generally accepted in the scientific community (Garfield, 1979; Hauffe, 1994; Kostoff, 1998; MacRoberts & MacRoberts, 1996). The left column in Table 1 summarizes the objections most often raised against a too strong focus on citation rates. The criticisms focus mostly on the process of citation itself and the fact that it is not entirely free from subjective and biased practices. They are especially related to the evaluative use of citation rates. Protagonists of the use of citation rates do not deny these potential limitations. They admit that citation indexes have to be used with care. As Garfield (1983) states: “Citation analysis is not a shortcut to be used as a replacement for thinking” (p. 371). In the literature, a number of methodological and interpretive guidelines have been suggested to direct the use of citation rates. They are summarized in column two of Table 1 (Garfield, 1979; Kostoff, 1998; Phelan, 1999). They will also be taken into account while carrying out the analysis for the present study.

Another important question is whether citation rates inform us about the quality of the work of a particular author. A particular question in this context is whether citation data provide information about the psychometric qualities of the instruments they developed. Garfield (1979) is clear about this issue and states that the only responsible claim that can be made for citation counts, is that they provide a measure of the utility or impact of scientific work. They say nothing about the nature or quality of the work. On the other hand, validation studies indicate that high citation rates correlate with peer judgments of scientific excellence (Garfield, 1979). They help to introduce an objective element into a more general evaluation process (Phelan, 1999). But it would be wrong to use them as a single measure of scientific quality.

Table 1

*Citation Rates: Objections and Methodological and Interpretive Guide-Lines*

Objections	Methodological and interpretive guidelines
A paper, author, or journal might be cited frequently in refutation or as a negative example.	Scientists tend to ignore inferior work that is of little importance. Work being criticised, is mostly of some importance.
A citation rate can be inflated by self-citations.	Studies show that up to 10% of all citations are self-citations. It is a common and accepted practice. If authors try to use self-citation to inflate a rate, this will be very obvious and easily detected.
A prestigious journal might draw more citations than a less prestigious one.	First, the ISI impact factor can be used to take into account this “prestige” factor. Second, studies show that the effect of journal prestige on citation counts may not be overestimated.
Methodological contributions tend to be cited more frequently than theoretical publications.	This is an objection especially raised by scientists who feel that methodological advances are less important than theoretical ones. The validity of this statement can be questioned. Second, studies show that methodological papers do not inevitably draw on a large number of citations.
Citations also serve political, financial and ego-satisfaction purposes.	Aggregating citations from different publications cancels out the impact of this type of bias.
Cronyism: researchers especially cite their colleagues.	It is true that there are groups of researchers who tend to cite each other. But, if the groups consist of highly cited individual authors, they can be considered as “gatekeepers” that form an invisible “college” in a particular field or area. Cronyism is then little more than a manifestation of the power relations within the scientific field.
Obliteration: not all authors cite the obvious, classical antecedents.	This phenomenon is usually observed in the work of scientists whose work has become part of the main body of knowledge. However, before this takes place, the citation count and the reputation of these scientists usually reach a level that makes additional citation credits less necessary. To take this criticism into account, evaluation of citation rates should always be made by people acquainted with the field of study.

For the study of the social sciences and the humanities, Garfield (1979) proposes that the number of documents in which a specific author is cited, should be noted. This is because it is common practice that authors accumulate several citations per article. This provides a measure that gives a more accurate indication of the actual impact of an author's work.

### *Citation Links*

Next to citation rates, also citation links between authors will be used to build up a structure of the literature on learning style and cognitive style. These citation links build on co-citation coupling. The basic assumption behind the technique is that if two authors are cited together in a third document, they are considered as related to one another by a shared intellectual focus (Garfield, 1979). Co-citation analysis, the study of these citation links, is a method to define in an objective way the intellectual structure of a scientific field (Small, 1973; Small & Griffith, 1974). This builds on a perception of science that is made up of a structure of specialties that can be uncovered by organising the authors, papers or journals into clusters and by showing the relationships between these clusters (Garfield, 1979). In contrast to the study of citation rates, this study of citation links generates relatively little critical comments from the scientific community.

### *Design*

#### *Sample*

This study uses citation data from the Institute for Scientific Information's (ISI) Social Science Citation Index (SSCI 1972-present), provided on-line through the Web of Science. The SSCI fully indexes more than 1,725 scholarly journals across 50 social sciences disciplines, and it indexes individually selected, relevant items from over 3,300 of the world's leading scientific and technical journals.

This information was accessed via the Ghent University library website. In September 2001, two general keyword searches were carried out in this database: one on learning style (which resulted in 349 records), and one on cognitive style (with a result of 866 records). The searches were done "in topic", which means that the search

term is to be found in the title, the author's abstract, or the author's keyword lists. There was no restriction for language or document type.

All the records were saved into two separate files. The combination of these files resulted in a master file that consisted of 1091 records. An overlap of 124 records appeared in both files.

### *Research Questions*

Two research questions directed the citation analysis:

1. Citation rates: Who are the most cited first authors in the cognitive and learning style literature since 1972? This gives information about the relative impact of the authors and consequently also about the impact of the theoretical orientation they belong to.
2. Citation links: Which first authors are cited together in the cognitive and learning style literature since 1972 and on this basis, how does co-citation analysis result in specific author cluster? Answering this question will shed light on the intellectual structure of these fields and on the questions: What are the dominant theoretical orientations? What are the relations between them?

### *Data Analysis*

The data were analysed using Bibexcel, a tool-box for manipulating bibliographic data, developed by Olle Persson from the Inforsk research group at Umeå University, Sweden (Persson, 2001). This programme enabled us to import the records from the database queries, select the CR (cited references) field, limit it to cited first authors, count frequencies of citations, and look for co-occurrences to establish co-citation pairs of authors. This last procedure has a limited processing capacity which is why only authors with a citation rate of 10 or higher were included in the co-citation analysis.

The Bibexcel software uses a specific *cluster pairs procedure* to group co-citation pairs. It is a hierarchic clustering routine which the co-citation pairs entered in order of frequency of co-occurrence.



## Results and Discussion

To make the results section meaningful for those unfamiliar with the cognitive and learning style literature, the citation-analysis results are accompanied by an interpretation based on a detailed study of the content of this literature. For each co-citation cluster, the references of the central authors' most cited publication in the cognitive or learning style literature are included. Citation rates of publications were used to obtain this information.

Within the scope of the present article, we restrict the overview and discussion of the analysis results to the most important authors, clusters and relationships. The detailed citation-analysis results, including the complete lists of citation rates of authors and publications and lists of authors per cluster are available from the first author.

### *Research Question 1 - The Most Cited First Authors*

The most cited first authors in the cognitive style and the learning style literature are listed in Table 2. These authors appear to have had the highest impact on both research fields.

The authors are ordered according to citation rates. As Garfield suggested, it is also interesting to look at the number of citing documents to judge an author's impact more accurately. When two authors have the same citation rate (see for example Riding and Entwistle in the learning style file), the number of citing documents indicates how many different documents account for these citation rates. As an example, Entwistle's impact on the learning style literature appears to be broader than Riding's. If Table 2 is ordered according to the number of citing documents, the rankings change considerable (see numbers in parentheses). Only the most important authors do not change in rank.

Table 2 indicates that Kolb is the most cited author in the learning style literature with 49% of all documents in the ISI-based learning style file (349/172) citing Kolb at least once. Dunn appears as the second most influential author. In the cognitive style literature, Witkin has the chief impact: 39% of all documents in the cognitive style file (866/340) mention Witkin at least once. He is followed by Kagan and Kirton.

Table 2

*Most Cited First Authors of the Cognitive and Learning Style Literature*

Cognitive style			Learning style		
Author	Citation rate	Number of citing documents	Author	Citation rate	Number of citing documents
Witkin, H.A.	807	340 (1)	Kolb, D.A.	341	172 (1)
Kagan, J.	254	128 (2)	Dunn, R.	195	77 (2)
Kirton, M.J.	249	106 (3)	Freedman, R.D.	68	41 (4)
Riding, R.J.	246	57 (7)	Schmeck, R.R.	65	40 (5.5)
Tetlock, P.E.	224	37 (19.5)	Riding, R.J.	62	18 (27.75)
Beck, A.T.	110	45 (11)	Entwistle, N.J.	62	47 (3)
Messick, S.	94	82 (4)	Witkin, H.A.	57	40 (5.5)
Pascual Leone, J.	93	28 (33)	Sims, R.R.	45	32 (8)
Goldsmith, R.E.	84	31 (24)	Keefe, J.W.	45	37 (7)
Suedfeld, P.	81	18 (63)	Biggs, J.B.	44	31 (9)
Foxall, G.R.	77	20 (53.5)	Gregorc, A.F.	42	22 (20)
Goodenough, D.R.	77	60 (6)	Marton, F.	41	28 (11.5)
Oltman, P.K.	75	64 (5)	Curry, L.	39	29 (10)
Kogan, N.	70	53 (9.5)	Furnham, A.	39	14 (38)
Myers, I.B.	69	54 (8)	Carbo, M.	38	13 (43)
Eysenck, H.J.	66	42 (13)	Laschinger, H.K.	36	13 (43)
Piaget, J.	60	43 (12)	Myers, I.B.	35	28 (12)
Simonton, D.K.	60	6 (439)	Price, G.E.	35	27 (13.5)
Messer, S.B.	56	53 (9.5)	Atkinson, G.	34	23 (17.5)
Gardner, R.W.	55	38 (17)	Eysenck, H.J.	33	12 (49.5)
Rokeach, M.	55	32 (22)	Merritt, S.L.	33	27 (13.5)
Saracho, O.N.	54	21 (49)	Vermunt, J.D.	33	18 (27.75)
Cronbach, L.J.	50	40 (15)	Katz, N.	30	22 (20)
...			Veres, J.G.	28	26 (15)
			Johnson, D.W.	28	11 (54)
			Honey, P.	27	25 (16)
			Cornwell, J.M.	26	19 (24)
			Pask, G.	26	23 (17.5)
			...		

*Note.* Only the authors with the twenty highest citation rates are included. Between parentheses, their rank number based on the number of citing documents is added.

Table 2 also indicates that there is little overlap between the cognitive style and learning style author lists. Authors much cited in both research areas are Witkin, Riding, Myers, and Eysenck. This may be because Witkin and Riding both developed concepts defined as cognitive style which are applied in the context of learning and instruction (as e.g. in Witkin, Moore, Goodenough, & Cox, 1977, and Riding & Sadler-Smith, 1992). This explains their re-appearance as key authors in the learning style literature. In contrast, Myers' and Eysenck's dual influence is of a different kind. These authors developed a personality theory (Eysenck, 1964; Myers & McCaulley, 1985) that apparently inspired both the research on cognitive style and the research on learning style.

### *Research Question 2 - Theoretical Orientations*

As stated earlier, the results of the co-citation analysis are expected to shed light on the intellectual structure of the cognitive style and learning style research fields. Figure 1 gives a visual representation of the alternative organisation that can be derived from the complex analysis results. This graphical representation facilitates the comprehension of the different clusters, their impact and the interdependencies.

- The left part of figure 1 comprises the key authors cited in the literature on cognitive style, the right part the key authors cited in the literature on learning style.
- Each quadrangle represents a cluster that results from the different analyses. The letters A, B, etc. indicate the order in which the clusters resulted from the hierarchical clustering procedure.
- The surface area of the quadrangles represents the relative size of the clusters. The numbers in parentheses are the numbers of authors included.
- The depth of the quadrangle shades represents the relative impact of a cluster, based on the citation rates of its central authors.
- The ~-sign should be read as: "Research about cognitive style or learning style, in relation to...". Due to the size of some quadrangles, this text is abbreviated.

- A fuller elaboration of the theoretical context for the specific learning style or cognitive style cluster is given in the text.
- The dots (“...”) indicate that also other authors belong to this cluster. A comprehensive list for each cluster can be obtained from the first author.
  - The position of the quadrangles is arbitrary, except the position of those that touch the border between the cognitive style part and the learning style part of the figure. They represent the clusters where both fields meet each other.

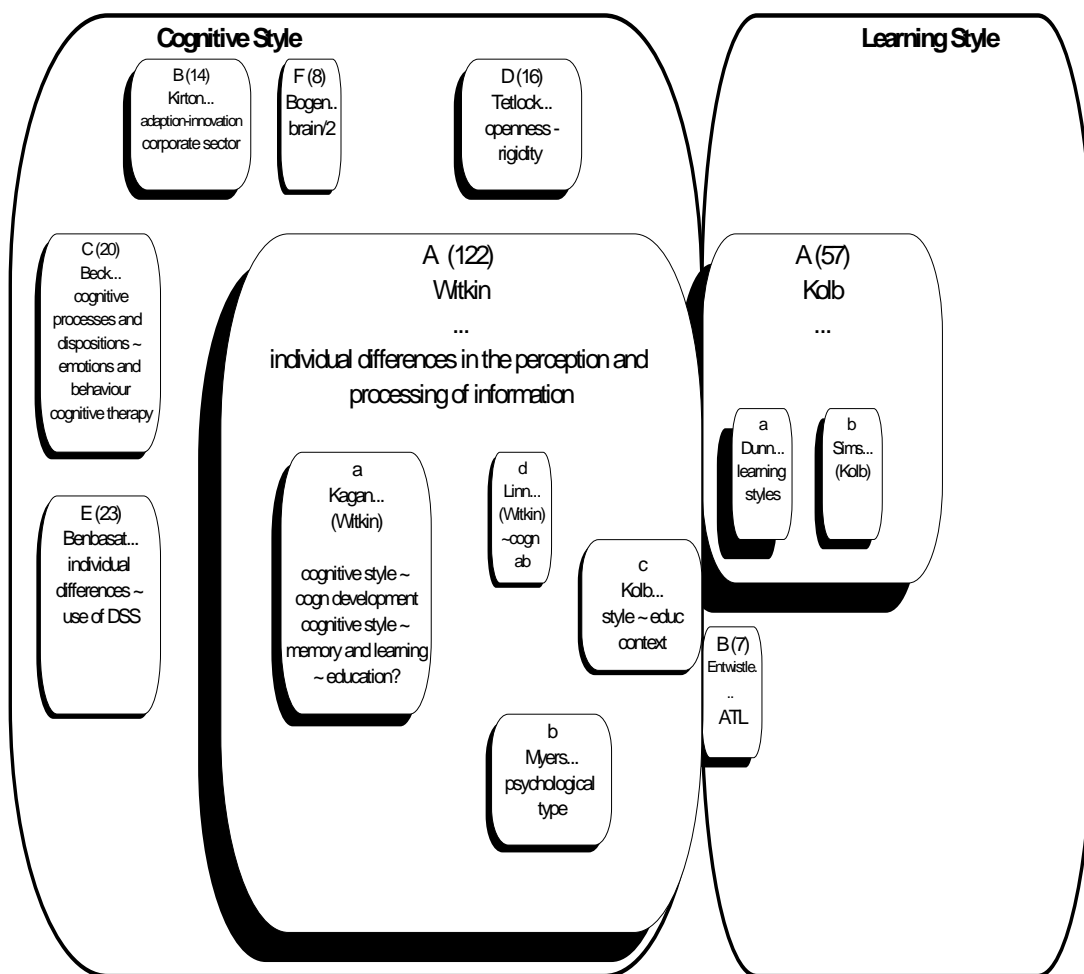


Figure 1. Visual representation of the alternative organisation.

### *The Cognitive Style Literature*

Co-citation analysis of the first authors cited by the cognitive style literature since 1972 results in 6 main clusters of different sizes. Only the 337 authors with a citation rate of 10 or higher were included in the analysis. 203 of these authors belonged to a distinctive cluster. The others remain alone.

#### *Cluster A.*

Cluster A is clearly the largest cluster. It centres around Witkin (1971). Other pivotal authors (i.e. authors with a high number of citation links with other authors in the cluster), are Kagan (1964), Myers (1985), Gardner (1953), Messick (1976), Riding (Riding & Cheema, 1991), and Kolb (1976). Referring to these authors' citation rates is suggested that it is a cluster with a very high impact on the field.

According to Witkin et al. (1971), cognitive styles are "... the characteristic, self-consistent modes of functioning which individuals show in their perceptual and intellectual activities" (p. 3). They are conceived as manifestations of broad dimensions of personal functioning which cut across diverse psychological areas. Witkin started his laboratory studies into perception in the 1940s. He developed the field-dependence/independence cognitive style construct: in a field-dependent mode of perceiving, perception is strongly dominated by the overall organisation of the surrounding field, in a field-independent mode of perceiving, parts of the field are experienced as discrete from the background. Field-dependence/independence is supposed to be an expression of the extent of differentiation of an individual's psychological structure. The Embedded Figures Test was developed to assess a subject's level of field-independence.

Although nearly every other author within the Witkin-cluster developed a distinctive style model, the analysis results indicate a very close relationship with Witkin in the cognitive style research field. There is indeed the shared characteristic that they all study individual differences in the perception and/or processing of information. But these results might be influenced by a particular type of ceiling effect, caused by the fact that 39% of all publications in the cognitive style file have cited Witkin at least once. As a consequence, the probability that another author occurs

in a reference list together with Witkin is very likely. We expect that this large cluster will break up into different clusters if Witkin is excluded from the analysis. Repeating the co-citation analysis without Witkin confirms this assumption. The authors from Cluster A are spread over four different clusters.

#### Cluster Aa:

The largest cluster is centred around Kagan (1964). Other pivotal authors are Messick (1976), Goodenough (1976), Pascual Leone (1970), and Oltman (1968). These are all authors with a considerable impact on the field, as reflected in their citation rates.

In general, the Aa cluster represents a theoretical orientation in which the concept of cognitive style is defined as a consistent, stable, pervasive, personality-related individual way of organizing and processing information (compare Witkin's definition). The concept is further examined to look at its implications for cognitive development, memory, and learning. The idea that education should take cognitive style differences into account becomes an additional issue.

Kagan (1964) investigated factors that contribute to individual differences in the cognitive development in children. Kagan particularly defined the cognitive style dimension *reflection* versus *impulsivity* ("conceptual tempo") in complex problem situations where many solutions are possible. He measured reflection by registration of response times to e.g., the Design Recall Test and the Matching Familiar Figures Test. Goodenough and Oltman were collaborators of Witkin right from the start. They investigated the implications of field-dependent/independent cognitive style, and focused especially on learning and memory. The three were affiliated to the Downstate Medical Center of New York State University, and later to the Educational Testing Service. Messick was vice president for research at the Educational Testing Service when he wrote an overview of the cognitive style research and questioned its implications for education (1976). Pascual Leone used Witkin's cognitive style as an explanatory variable in his later work. And comparable to Kagan (1964), he aimed at explaining cognitive development.

#### Cluster Ab:

In this second cluster, the central author is Myers (1985). Other pivotal authors are Mitroff (1981) and Jung (1921/1971). *Psychological type*, as identified by Jung, is the central concept in this theoretical orientation. Myers' (1985) extended this operationalisation. She refers to an individual's preferences on four dimensions: extraversion or introversion, sensing or intuition, thinking or feeling, and judging or perceiving. It affects what is attended to in any given situation and also how conclusions are drawn about what has been perceived. Each pole of a dichotomy is valuable and at times indispensable in its own area of operation. A central instrument in this tradition is the Myers-Briggs Type Indicator (MBTI) personality inventory (Myers & McCaulley, 1985).

#### Cluster Ac:

The third cluster centres on Kolb (1976), but Riding (Riding & Cheema, 1991), Entwistle (1979), and Pask (1972) are all essential authors. Except for Riding, the individual citation rates of these authors are relatively low in the cognitive style literature; their impact on the learning style literature is higher. This is probably because this theoretical orientation focused on pragmatic ways to develop a style concept in instructional contexts and to explain differences in real-life learning, out of the laboratory situation. A remarkable result is that most of the authors of the review papers discussed in the introduction are also part of this cluster. These review authors share this pragmatic orientation: by writing their review, they also wanted to enhance application in practice.

#### Cluster Ad:

The fourth cluster identifies Linn (1978) as the central author, together with Strawitz (1984). Although these authors do not have a great impact on the field, as reflected in lower citation rates, they do seem to represent an independent research tradition. They study the relationship between Witkin's field-dependent/independent cognitive style and various formal cognitive abilities in the context of mathematics and science education.

#### *Cluster B.*

Kirton (1976) is the central author in cluster B. Also Goldsmith (1984) and Clapp (1993) are fundamental authors. They both build on Kirton's model of cognitive style. This model distinguishes individuals with an ability to "do things better" without challenging the structure surrounding a problem (adaptors), from those with an ability to "do things differently" by treating the surrounding structure as part of the problem (innovators). Kirton defined cognitive styles as different, potentially equally valuable, modes of problem perception and problem solving that form a basic dimension of one's personality. His aim was to allow better mutual appreciation and cooperation between adaptors and innovators in the context of commercial and industrial organisations. The Kirton Adaption-Innovation Inventory (KAI) was developed to locate respondents on this adaptiveness-innovativeness continuum. Considering Kirton's high citation rate, this theoretical orientation has had a considerable impact.

#### *Cluster C.*

Beck (1976) is the central author of Cluster C. Other relevant authors are Abramson (1978), Watson (1984), and Seligman (1979). The impact of this cluster on the cognitive style research is rather moderate. The particular focus of this theoretical orientation is on the relation between cognitive processes and dispositions (like attributions, misconceptions,...) on the one hand, and emotions and behaviour on the other. Beck, Abramson, and Seligman were affiliated to the University of Pennsylvania, where they developed cognitive therapy to treat e.g. depression in a clinical setting. The concept of *cognitive style* is not explicitly used by the authors, but reference is made to *attributional style* and to *negative affectivity* as a stable and pervasive trait.

#### *Cluster D.*

This cluster centres around Tetlock (1983). Other key authors are Eysenck (1964), Rokeach (1960), and Schroder (1967). This cluster has a considerable impact on the cognitive style field. What connects these authors is that they study the openness-rigidity in people's belief system as aspects of personality. Tetlock linked these



characteristics to political ideology and political decision making. He specifically used Schroder's integrative complexity model of cognitive style as a way to operationalise openness. Integrative complexity refers to individual consistencies in the extent to which categories or dimensions of information are perceived to be interrelated in multiple and different ways.

#### *Cluster E.*

The central author in this cluster is Benbasat (Benbasat & Dexter, 1982). Other fundamental authors are Huber (1983), Zmud (1979), and Simon (1977). The main research interest of these authors is how designers of decision support systems (DSS) and management information systems (MIS) in the corporate sector should take individual differences in information handling abilities into account. They do not stick to one specific cognitive style model. This theoretical orientation does not have a high impact on the field.

#### *Cluster F.*

This cluster centres on Bogen (1969) and Kinsbourne (1972). Other central authors are Paivio (1971) and Galin (1972). None of these authors are highly cited, suggesting that this is a theoretical orientation with a relatively low impact on the cognitive style literature. It mainly concerns research in neurology to establish the idea that the brain consists of two entities (right-left brain) with different characteristics and different functions. Without explicitly defining the concept, cognitive style here refers to the part of the brain that is most dominant.

### *The Learning Style Literature*

Co-citation analysis of the first authors cited by the learning style literature since 1972 resulted in two main clusters. Only the 95 first authors with a citation rate of 10 or higher were included in the analysis. Sixty-seven of these authors belong to a specific cluster. The others remain alone.

A first observation, after examining the affiliations of the authors, is that the authors in Cluster A are for the most part working in the US, whereas the authors included in Cluster B seem to form a distinct British-European (and Hong Kong) theoretical orientation in learning style research.

#### *Cluster A.*

Cluster A is the largest cluster. It centres around Kolb (1976). Other key authors are Dunn (1978), Honey (1982), and Plovnick (1975). The cluster includes the two most highly cited authors in the learning style literature (Kolb and Dunn) and thus has a very high impact on the learning style research field.

Within an experiential learning framework, Kolb (1984) defined learning styles as distinctive individual differences in the learning process that arise from consistent patterns of transaction between the individual and his or her environment. Kolb's theory is that, through their past and present experiences, learners program themselves to grasp reality through a particular degree of emphasis on the four modes of learning: concrete experience, reflective observation, abstract conceptualization, and active experimentation. The Learning Style Inventory (1976) was created to assess these orientations towards learning.

Because we know that 49% of all documents in the learning style file cite Kolb at least once, a ceiling effect might also explain the broad impact of this cluster. The result of repeating the co-citation analysis without Kolb confirms this assumption. The authors from Cluster A are spread over two different clusters.

#### *Cluster Aa:*

In the first cluster, Dunn (1978) is the central author. Also Myers (1980), Witkin (1977), and Curry (1987) are pivotal authors. This cluster groups a variety of learning style models. However, together these authors form a theoretical orientation

that is at the heart of the learning styles research. They all are of the same opinion that learning styles are consistent individual differences in the way people learn, that there is no “good” or “bad” learning style, and that it is of prime importance that education meets the specific strengths and weaknesses of learners.

Dunn’s Learning Style Inventory (LSI, Dunn, Dunn & Price, 1975) was the first instrument to assess an individual’s learning style in grades 3 through 12. The instrument helps to summarize the environmental, emotional, sociological, and physical preferences of a student for learning. It explicitly does not measure underlying psychological factors.

It is interesting to see that Witkin and Myers, who are pivotal authors in the cognitive style literature, are also central authors in this learning style orientation. But the publications with which they have the highest impact on the learning style literature are of a different kind: instead of defining a cognitive style model (as in Witkin, 1971 and Meyers, 1985), they explicitly explain what the impact of this model is on educational practice (see Witkin, 1977 and Meyers, 1980).

#### Cluster Ab:

In the second cluster, Freedman (1980) is the central author. Other key authors are Sims (1986) and Merritt (1984). These authors all had a considerable impact on the learning style research field. They make up a theoretical orientation that critically examines the usefulness and properties of Kolb’s learning style model, mainly in the context of business and business education. Their focus is on the (weak) measurement properties of the Learning Style Inventory.

#### *Cluster B.*

Entwistle (1983) is the central author in Cluster B. Other pivotal authors are Marton (1976) and Biggs (1993). They form the phenomenographic tradition (Marton, 1981) in the research into individual differences in learning. Cluster B represents a distinctive theoretical orientation with a considerable impact on the learning style research field.

These authors want to understand the experience of learning from the student’s perspective, in naturalistic settings in higher education. Data are collected through

interviews and self-reports. They use the concept of *approaches to learning* (ATL) to point at individual differences instead of learning styles.

The main idea is the distinction between a deep approach to learning, through which the student seeks personal understanding, and a surface approach where the student simply tries to reproduce the information presented during a course (Marton et al., 1997). These approaches comprise both motivational and strategy components and are only meaningful in context. They are also related to student intentions, to the teaching/learning context, and to the quality of the learning outcome. Therefore, they are less static than learning styles or cognitive styles (Biggs, 1993).

The Approaches to Studying Inventory (ASI) (Entwistle & Ramsden, 1983), and several subsequent versions of this instrument, were developed to assess these approaches to learning.

#### *Analysis of the Master File*

Co-citation analysis of the master file that comprises both the cognitive style and the learning style literature generated an interesting result.

The cognitive style Clusters B, C, D, E, and F reappear in a comparable fashion. However, the largest cluster resulting from this new analysis incorporates now the original cognitive style Cluster A and also all learning style clusters. This is not surprising, because Witkin is very highly cited in the learning style literature and the core authors of the learning style clusters (Kolb and Entwistle) were also present in cognitive style Cluster Ac.

## Conclusions

Citation analysis was used to develop an alternative overview of the cognitive style and learning style literature. The key research question of the study was: What are the dominant theoretical orientations in the literature, what is their relative impact and how do they interrelate? Nine theoretical orientations could be distinguished in the literature on cognitive style. Four of them showed to be strongly related to the founding work of Witkin, who is the author with the highest impact on the cognitive style research field. In the learning style literature, three distinct theoretical orientations were identified. Two of them form the American tradition in learning styles research and are related to the work of Kolb, the author with the strongest impact on the learning style literature. These two are at the core of the learning styles research field. The third, British-European, orientation rather focuses on phenomenographic research into approaches to learning.

The alternative overview also aids in solving the conceptual confusion between *learning style* and *cognitive style*. When the theoretical orientations studying these concepts are compared, some differences become clear. Most cognitive style models are developed in laboratory or clinical settings to explain individual differences in cognitive processing, and they are applied in various fields. The recurrent features of the concept seem to be stability, pervasiveness, bipolarity and a strong interdependence with personality.

The learning style models are developed and used in various educational contexts to explain and accommodate individual differences in learning. Learning styles are generally defined as relatively stable and consistent. It is however acknowledged that the characteristics of the learning environment and learning experiences influence their development.

The results also highlight the similarities between learning styles and cognitive styles. There is a strong relationship between them: the citation analysis showed that Witkin's work is fundamental for both study specialities. The conceptual confusion between learning styles and cognitive styles probably arises from the work of the authors who have investigated the applications of cognitive styles in an educational context (e.g., Witkin, Riding, Myers, etc.). The alternative overview also enables us to

point at the theoretical orientations where there is a high chance that both concepts are interchangeably used: Cluster Ac in the cognitive style literature, and Cluster Aa in the learning style literature. In other words, cognitive styles applied in education are being perceived as learning styles.

At the start of this article, we discussed a number of key concerns that could be raised by researchers and practitioners when they read existing reviews of the learning style and cognitive style literature. The question is whether the alternative organisation responds in an adequate way to these critical remarks.

The review approach adopted in this study focuses on the entire field of learning style and cognitive style research and includes a very broad and consistent set of authors/publications. The reader might remark that this “new” overview of the learning style field is again not related to the existing reviews of the literature. But, as was discussed in the result section, we have been able to map the existing reviews on this new overview. The specific theoretical orientation that grounded these earlier reviews could be identified.

A very central critique that was raised in relation to the earlier reviews was the selective nature of inclusion or exclusion of style models, instruments, and definitions. In the current approach all the cognitive and learning style literature retrieved from the SSCI database was included in the analysis. This suggests that the data set is very comprehensive. However, some remarks can be made about the database search procedure, the database itself, and the analysis procedure. As to the database search procedure, learning style and cognitive style were used as separate search terms. Using learning style\* and cognitive style\* in addition would have generated a fuller picture. Also publications that did not contain the search term learning style or cognitive style in their title, abstract, or keywords might have been overlooked. As to the database used for the literature search, we have to indicate that the SSCI only indexes scholarly journals, from 1972 on. Monographs, book chapters, more popular literature, commercial publications, research reports, and older literature are not included. Since the SSCI is the only database that includes cited references, a necessary condition for our research approach, there was no other option. We also repeat that we applied some strict criteria to include or exclude authors during the analysis procedure. Authors that

did not meet the minimum citation rate of 10, were dropped from the co-citation analysis. Also authors that could not be situated in a specific cluster were removed from the analysis. Citation analysis also overlooks recent work that did not receive any citations. We exclude in this way a group of authors about which we suggest that they have had little or no impact on the learning style or cognitive style field. We however do not repudiate the possible intrinsic quality of their work.

For all these reasons, we do not state that the overview is exhaustive, but that it is at least more complete than the existing reviews.

The alternative overview of the learning style and cognitive style field also gives a clear answer to the question about clear and operational criteria to include or exclude authors and models in a certain dimension or category. On the base of co-citation, an unambiguous and unbiased structure could be developed. It was only post hoc that, on the base of a content analysis of the publications of the authors in a cluster that a common label was extrapolated. Moreover, the reader can repeat this labelling activity since the references of the authors included in the clusters are available for post hoc analysis.

We already referred to the fact that citation analysis is a more objective way to organise the literature. Neither at the level of the initial selection of the literature, nor at the level of inclusions or exclusion in clusters, did the researchers influence the process. Only in the discussion of the cluster structures, is it possible that our assumptions might have been in play. Due to the transparency of the research procedure, these assumptions can be easily tested by others. Ultimately, the adoption of citation analysis as a research technique can also reflect a bias. The technique implies that the researcher accept the logic and assumptions behind this quantitative analysis technique.

A clear attempt was made to take into consideration differences in scientific impact. This was done by using the citation rates.

The alternative organisation of the learning style and cognitive style literature also reflects the original and broader context of the various cognitive and learning style definitions, models, and instruments. The clusters demonstrate how the *contexts*

*of discovery* (Sanders & Van Rappard, 1982) of the cognitive style research and the learning style research differ from, and relate to, one another.

Further refinement of the citation-analysis technique is however needed. We have to stress the fact that only basic bibliometric data have been used. A possible improvement would be the incorporation of the impact scores of the journals in which the authors publish. Also, more sophisticated multidimensional scaling techniques could be used to perform the co-citation analysis.

In conclusion, this alternative organisation will be very helpful for educationists and researchers entering the cognitive styles and learning styles research field. Despite certain imperfections, it can definitely serve as a road-map: it gives an overview of the dominant theoretical orientations in the field, points at their specific interrelationships, and clarifies the broader context of definitions, models, and instruments. It also shows the differences and overlap between *learning style* and *cognitive style*. For all these reasons, it will enable researchers and practitioners who consider using “learning styles” to address individual differences in learning to make a more informed choice about which definition, model, and instrument to use.



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## Chapter 2

### Learning Styles of First-Year Students in Medicine and Pedagogical Sciences\*

#### *Objectives*

*This study uses Kolb's theory to investigate the learning styles of first-year medical students to get more insight in whether the admission examination selects the "right" students. Their learning styles are contrasted with those of first-year pedagogical sciences students.*

#### *Design*

*The Learning Style Inventory was administered and the variable primary learning style was defined, indicating a preference for concrete experience, reflective observation, abstract conceptualization or active experimentation.*

#### *Setting*

*Ghent University, Belgium*

#### *Subjects*

*First-year medical students ( $n = 132$ ) and first-year pedagogical sciences students ( $n = 203$ )*

#### *Results*

*More than half of the medical students preferred the abstract conceptualization primary learning style. Another third of them showed a preference for active experimentation. This active experimentation primary learning style was dominant in the pedagogical sciences sample. The second learning style in this group was abstract conceptualization. There was a significant relationship between learning style and academic discipline. The distribution of the primary learning styles was different in both groups: the pedagogical sciences students showed greater diversity.*

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\* Based on: Desmedt, E., Carette, L., Valcke, M., & Derese, A. Learning Styles of First-Year Students in Medicine and Pedagogical Sciences. The present chapter is submitted for publication in *Medical Teacher*.

## *Conclusion*

*Knowing that medical studies and the medical profession demand versatility, the learning styles of the medical students seem very one-sided. They match the scientific and medical aspects very well, but they are not in line with the personal, interpersonal and social demands of the discipline. Medical educators should be sensitive to this mismatch and provide extra support for the development of social and reflective skills.*

Entrance to medical education is restricted by an admission examination in many countries. Through this process of selective admission, one tries to attract those students that are expected to be successful in medical studies and eventually in the medical profession. This a precarious task: will the “right” students be picked out (Kay-Lambkin, Pearson, & Rolfe, 2002; Searle & McHarg, 2003)? Information about the characteristics of the selected students can give insight in this crucial question. In other research, personality (Lievens, Coetsier, De Fruyt, & De Maeseneer, 2002), motivation (Vaglum, Wiers-Jenssen, Ekeberg, 1999), intellectual and ethical development level (Cleave-Hogg & Muzzin, 1993), socioeconomic characteristics (Dhalla, Kwong, Streiner, Baddour, Waddell, & Johnson, 2002), and attitude towards science (Vodopivec, Vujaklija, Hrabak, Lukić, Marušić, & Marušić, 2002) of first-year medical students have been considered.

In this contribution, we look at the learning styles of a sample of first-year medical students who have successfully passed the Flemish admission examination. This national examination assesses scientific knowledge and insight on the one hand, and information processing skills on the other. The sciences covered in the scientific knowledge and insight part are physics, chemistry, biology, and mathematics. The focus is on application of the scientific knowledge base. The information processing part consists of a case-based assessment of information acquisition and a test of cognitive reasoning (Lievens, Coetsier, Janssen, & Decaesteker, 2001). The learning styles of these students will be contrasted with those of students of a very different academic discipline, namely pedagogical sciences. There are no admission restrictions for freshmen opting for this field of study.

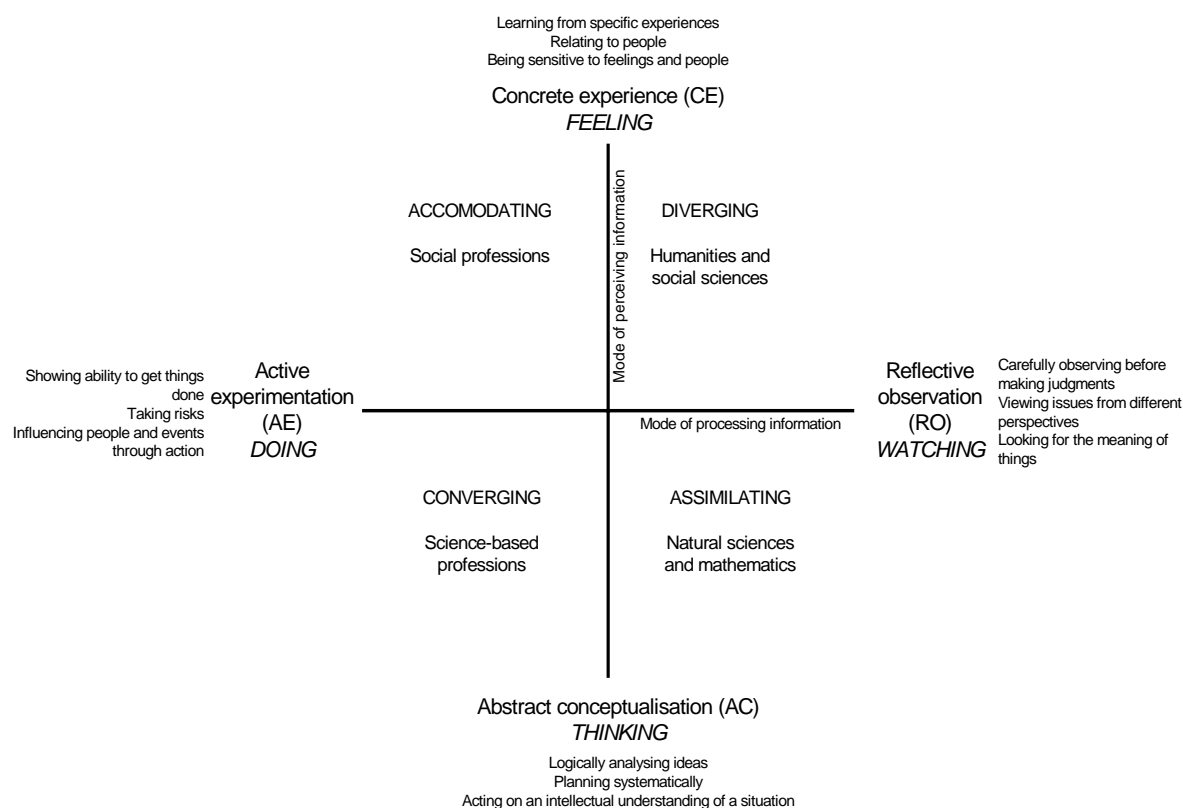
Kolb's learning style model (Kolb, 1984, 1999) is used. Kolb defines learning style as one's preferred mode of perceiving (Through concrete experience or abstract conceptualization?) and processing information (Through reflective observation or active experimentation?) in learning from experience. By crossing these two dimensions, Kolb differentiates four learning styles: diverging, assimilating, converging, and accommodating. He developed the Learning Style Inventory (LSI) (first version: 1976) to assess these learning styles. Each style is considered to have its own strengths and weaknesses. Whether a learning style is beneficial or not depends to a large extent on the demands of the learning environment.

Kolb's learning style model is particularly interesting for this research because one of the central ideas in his work is that each learning environment, and each academic discipline or profession imposes specific demands on the learner (Kolb, 1981, 1984): different disciplines have different learning requirements and incline towards different styles of learning. Students are likely to choose an academic discipline which matches their learning style and which, through socialization in the course of learning in that discipline, consequently enforces it. Kolb (1981) proposes a fourfold typology of disciplines, each relating to a particular learning style: "In the abstract-reflective quadrant are clustered the natural sciences and mathematics, while the abstract-active quadrant includes the science-based professions, most notably the engineering fields. The concrete-active quadrant encompasses what might be called the social professions, such as education, social work and law. The concrete-reflective quadrant includes the humanities and social sciences". This typology resembles the disciplinary groupings used by Nulty & Barret (1996).

Figure 1 summarizes Kolb's learning style theory.

On the basis of this typology and our knowledge about the Flemish admission test, we hypothesize that first-year medical students will show a preference for the assimilating learning style (reflective observation and abstract conceptualization). The examination they passed reflects the abstract-reflective quadrant of Kolb's typology. On the other hand, a preference for the converging learning style (abstract conceptualization and active experimentation) also seems a plausible hypothesis. The examination, with its focus on application of scientific knowledge, and the medicine

discipline, seen as a science-based profession, equally well fit the abstract-active quadrant.



*Figure 1. Kolb's learning styles and the related typology of disciplines*

Two hypotheses focus on the comparison of the learning styles of medicine and pedagogical sciences students. A first hypothesis is that the pedagogical sciences students form a more heterogeneous group, in which the different learning styles are more equally distributed. The first-year medical students will have a learning style that reflects the orientation of the admission examination, and as a group they will show a more homogeneous learning style. A second hypothesis concerns the nature of the differences between both groups. The pedagogical sciences curriculum consists of a broad range of education-related knowledge domains: instructional sciences, orthopedagogics, social work, sociology, psychology, and so on. Considerable attention goes to reflective pedagogical practice: students observe and learn in a diversity of real-life educational situations and reflect on the theoretical knowledge

base to develop a fundamental pedagogical attitude. According to Kolb's typology, the pedagogical science discipline thus rather fits the concrete-reflective or concrete-active quadrant. It is therefore hypothesized that the pedagogical sciences students will have a preference for the concrete experience learning styles diverging and accommodating.

## Method

### *Participants and Procedure*

335 students at Ghent University (Belgium) filled out the Learning Style Inventory. The first-year medical students completed it at the beginning of the academic year 2002-2003, the first-year pedagogical sciences students at the start of the second semester.

### *Instrument*

A Dutch translation of the third version of the Learning Style Inventory (Kolb, 1999) was used. It is a 12-item questionnaire: each item asks respondents to rank four sentence endings that correspond to four different learning modes. In that way, the LSI measures an individual's relative preference for each of these learning modes. Table 1 lists the Cronbach's  $\alpha$  reliability coefficients of the translated version of the LSI-1999 in our sample.

Table 1

#### *Reliability of the Dutch Translation of the LSI-1999*

	$\alpha$	
	Medicine ( <i>n</i> = 132)	Pedagogical sciences ( <i>n</i> = 203)
Concrete experience (CE)	.75	.82
Reflective observation (RO)	.65	.71
Abstract conceptualization (AC)	.77	.79
Active experimentation (AE)	.73	.74

These reliability scores are acceptable. Because the LSI is an ipsative measure, the interpretation of these  $\alpha$  – scores is however not straightforward. Applying the usual correlation-based analysis techniques for psychometric evaluation with ipsative scores yields results that are difficult to interpret. They have to be considered as an artefact of the ipsative scoring method (Anastasi & Urbina, 1997; Cornwell & Dunlap, 1991; Henson & Hwang, 2002; Pickworth, 2000). To be able to appropriately analyze the LSI scores, an alternative statistical procedure will be applied.

### *Statistical Analysis*

First, the original LSI scores were transformed following the procedure that was proposed by Cornwell and his colleagues (Cornwell & Dunlap, 1991; Cornwell & Manfreda, 1994). By using only an individual's first rank order of the final LSI ipsative scores, a nominal variable was defined, named primary learning style (PLS), indicating a preference for one of the four learning *modes*: abstract conceptualization (AC), active experimentation (AE), reflective observation (RO), and concrete experience (CE). According to Cornwell and his colleagues, this nominal variable can be used successfully in theory building and testing: because the final ipsative score is calculated as the sum of 12 separate ipsative items, this final score should be more reliable than the individual scores.

The cases for which it was not possible to define a PLS, because two original ipsative scores both should have received the first rank, were treated as missing values. A total of 278 valid cases remained.

Frequency analysis, analysis of cross-classified data and the appropriate inferential statistics were applied to investigate the hypotheses under study.

### *Results*

The total sample consisted of 335 students: 132 first-year medical students (92.3% of total) and 203 first-year pedagogical sciences students (96.7% of total). Gender distribution showed that 96.3% of the pedagogical sciences students ( $n = 157$ ) and 67.7% of the medical students ( $n = 88$ ) were female.

The frequency distribution of the primary learning styles for the separate academic disciplines is given in Table 2.

Table 2

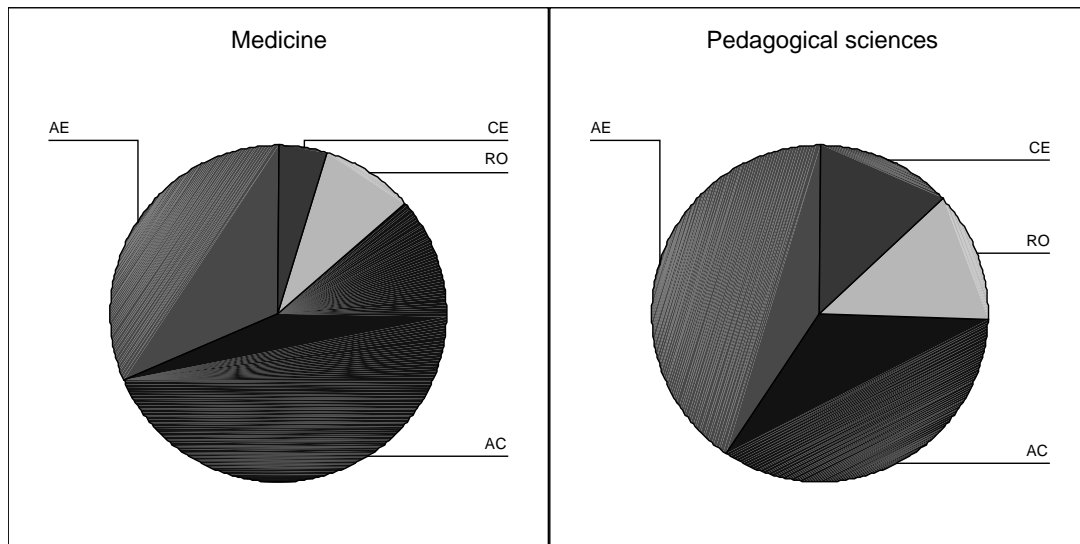
*Primary Learning Style \* Academic Discipline Contingency Table with Row and Column Percentages*

	Medicine	Pedagogical sciences	Row total
Concrete experience (CE)	6 23.1% <sup>a</sup> 4.8% <sup>b</sup>	20 76.9% 13.1%	26 100% 9.4%
Reflective observation (RO)	11 36.7% 8.9%	19 63.3% 12.4%	30 100% 10.8%
Abstract conceptualization (AC)	69 56.7% 54.8%	52 43.3% 34%	121 100% 43.3%
Active experimentation (AE)	39 38.6% 31.5%	62 61.4% 40.5%	101 100% 36.5%
Column total	125 44.8% 100%	153 55.2% 100%	278 100% 100%

<sup>a</sup> % within primary learning style. <sup>b</sup> % within academic discipline.

Table 2 and Figure 3 point out that the majority of the medical students has a preference for the abstract conceptualization primary learning style. Another third (31.5%) prefers the active experimentation primary learning style. The concrete experience and reflective observation primary learning styles are underrepresented in this group. Equal frequency goodness-of-fit chi-square test confirms that the four primary learning styles are not equally distributed,  $\chi^2(3, n = 125) = 81,048, p < .000$ .



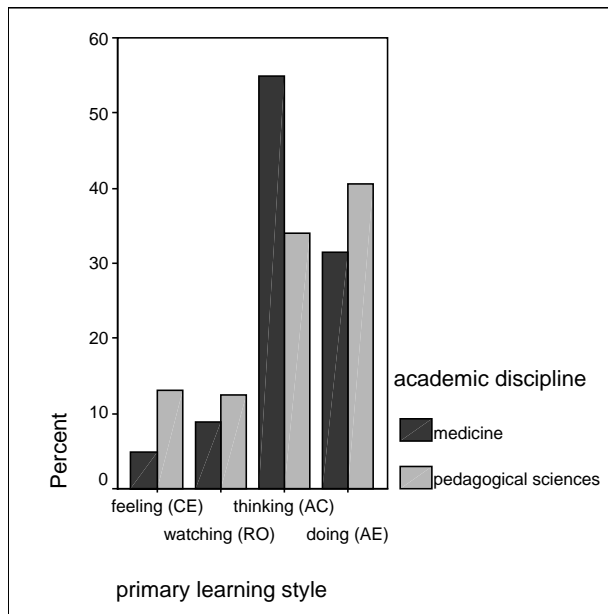


*Figure 3. Pie Charts of the Primary Learning Style Distributions*

Also in the pedagogical sciences sample, the four primary learning styles are not distributed equally,  $\chi^2(3, n = 153) = 38.085, p < .000$ . Comparison of  $\Phi^2$  ( $\chi^2/n$ ) for both groups (medicine  $\Phi^2 = 0.648$ ; pedagogical sciences  $\Phi^2 = 0.249$ ) indicates that the residuals, indicative of the difference with the hypothesized equal distribution, are higher for the medicine sample than for the pedagogical sciences sample. So the distribution of the four primary learning styles is less skewed in the pedagogical sciences sample than in the medicine sample.

Table 2 and Figure 3 reveal that the pedagogical sciences students mainly prefer the active experimentation primary learning style. The second dominant primary learning style is abstract conceptualization, with 34% of the students having this preference. The concrete experience and reflective observation primary learning styles each are preferred by approximately one eighth of the pedagogical sciences students.

All this information indicates that an association between learning style and academic discipline is prevalent in the data. The distribution of the primary learning styles is different in both academic disciplines. Figure 4 illustrates these differences.



*Figure 4. Primary learning styles of medicine and pedagogical sciences students*

In both academic disciplines, the dominant primary learning styles are abstract conceptualization and active experimentation. But in the medicine group, the majority of students shows a abstract conceptualization style, while in the pedagogical sciences group, the largest group of students reports active experimentation as their primary learning style. There are more students with a concrete experience and reflective observation primary learning style among the pedagogical sciences students.

Goodman and Kruskal's  $\tau_y$  was computed to measure the strength of the association. When primary learning style was considered as dependent variable  $\tau_y = .023, p < .000$ . When academic discipline was considered as dependent variable  $\tau_y = .053, p = .002$ . Since  $\tau_y$  can range between 0 and 1, these results imply that there is a rather weak association between primary learning style and academic discipline. The  $\tau_y$  values have to be interpreted as follows:

- The proportionate reduction in errors of predicting category placement of primary learning style when prior information about academic discipline is available is 2.2%.
- The proportionate reduction in errors of predicting category placement of academic discipline when prior information about primary learning style is available is 5.1%.

The association is stronger when academic discipline is considered as dependent variable. Chi-square test of independence indicates that the association between primary learning style and academic discipline is statistically significant:  $\chi^2(3, N = 278) = 14.626, p = .002$ .

## Discussion

This study demonstrates that first-year students in medicine and pedagogical sciences have significantly different learning styles. The expectation that the four primary learning styles would be more equally distributed in the pedagogical sciences group than in the medicine group was confirmed: the pedagogical sciences students showed greater diversity as to primary learning style.

In the medicine sample, the students with an abstract conceptualization primary learning style formed the dominant group. More than half of the medical students showed this preference. This confirms the results found by Davis (1999). Another third of the students preferred the active experimentation primary learning style. This is not completely in line with the initial hypothesis derived from Kolb's theory, namely that these students would prefer an abstract-*reflective* learning style. It rather confirms the second plausible option, notably that they would have a converging, abstract-*active* learning style. This would imply that the Flemish admission examination selects students whose learning style matches the concept of medicine, not as a pure science, but as a science based profession. According to Kolb's description (1999), these medical students are students who "... are best at finding practical uses for ideas and theories ... have the ability to solve problems and make decisions based on finding solutions to questions or problems ... would rather deal with technical tasks and problems than with social and interpersonal issues ... prefer to experiment with new ideas, simulations, laboratory assignments, and practical applications".

Also the pedagogical sciences students were characterized by a particular learning style profile. These students mainly preferred the active experimentation primary learning style. The second dominant primary learning style in this group was abstract conceptualization. The hypothesis that most pedagogical sciences students

would have a preference for concrete experience can therefore not be confirmed. This however does not imply that all these students have chosen an academic discipline that is not in line with their learning style. When formulating the hypothesis, it was probably inconsiderate to categorize the pedagogical sciences unambiguously on the concrete experience side of the typology of disciplines. The pedagogical sciences study at university indeed emphasizes concrete, practical experience, but is still theory-based. All experiences are to be reflected on and confronted with theory, and theory is to be applied during educational practice. The pedagogical sciences discipline is therefore illustrative for Kolb's remark that some fields include within their boundaries considerable variation in inquiry norms, knowledge structures and specialties that emphasize different learning styles (Kolb, 1981).

The results of the present study should be considered in the light of a few limitations. First, it is unclear to what extent the situation of the Flemish first-year students at Ghent University can be generalized. But, because choosing a university is mainly based on geographic criteria in Flanders, and all university curricula are relatively similar, we can be quite confident that our results are representative for Flanders. Nevertheless, broader generalizations should only be made when the similarity of academic contexts, admission terms and curricula has been considered. Secondly, the administration of the LSI of the medical students and the pedagogical sciences students was done at a different moment in the academic year (October – March). Therefore, the first examination period can have had a selective effect on the pedagogical sciences students. This however does not thwart the interpretation of our results: we actually compared two groups of students who have sustained a first selection in their academic discipline.

Finally, we come to the question that motivated our inquiry: can the medical students be considered as the “right” students, the students with the necessary characteristics to be successful in medical studies and in medical profession? The definition of this “right” student, showing medical aptitude, is however a changing social construction (McGaghie, 2002), derived from the prevailing conception of the “good” doctor. Currently the international consensus is that a good doctor should have “five-star” quality to take up his/her responsibilities as care provider, decision-maker,

communicator, community leader, and manager (Boelen, 1993). This consensus is reflected in modern medicine curricula. These do not only emphasize scientific and medical aspects, but also personal, interpersonal and social knowledge, skills, and attitudes. As such, medical studies and the medical profession appeal to all primary learning styles/learning modes and ask for a versatile personality. The learning styles of the medical students in our study therefore seem very one-sided. The preference of most students for abstract conceptualization or active experimentation will probably match the scientific and medical aspects of the studies and the profession very well, but the personal, interpersonal and social aspects might impose demands that are not in line with these learning styles.

Two implications can be derived from this conclusion. First, medical educators should be sensitive to this mismatch. Medical students should receive extra support in developing the social and reflective skills that are more proper to the concrete experience and reflective observation primary learning styles. Maybe the learning style framework can be used to discuss these strengths and weaknesses with students and with educators. Future longitudinal research into the development of learning styles over the course of medical education is needed to investigate to what extent the new curricula stimulate the evolution in the direction of a versatile, “five star” doctor. A second implication involves the admission examination. This probably selects the “right” students for the first year of medical education, which still tends to strongly emphasize sciences. However, the examination does not guarantee that these students are versatile enough to be successful in further medical studies and in the medical profession. Therefore, our results suggest that the development of methods to also take personal, non-academic characteristics seriously when selecting students has to be continued and fully supported (McGaghie, 2002).

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## Chapter 3

### **An Intervention to Promote Self-Regulated Learning in First-Year University Students. Effects on Academic Performance, Method of Learning and Perceived Self-Efficacy\***

*This study investigates the effectiveness of an elective counseling program to promote self-regulated learning in first-year medical students. Dependent variables were academic performance, method of learning and perceived self-efficacy. The program was set up as a relational intervention based on social cognitive theory. It was based on the instructional principles of social learning, direct instruction, realistic context and content, and metacognitive awareness. The results show that, as expected, the participating students developed a method of learning incorporating self-regulated learning and a higher level of self-efficacy in self-regulated learning. Contrary to the expectations, the program had no effect on academic performance. By including the individual differences factors sex, learning style, and whether the students were freshmen or not, in the analyses, gender differences and interaction effects were revealed. These interaction effects suggest that the self-regulated learning program was able to abridge differences that were related to personal characteristics of the students.*

Self-regulated learning (SRL) refers to those forms of learning that are metacognitively guided, at least partly intrinsically motivated, and strategic (Winne, 2001). Although the many theoretical perspectives on self-regulated learning emphasize different features (for an overview, see Puustinen & Pulkkinen, 2001; Zimmerman & Schunk, 2001), Zimmerman (2001) proposes the following general definition: “Students are self-regulated to the degree that they are metacognitively,

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motivationally, and behaviorally active participants in their own learning process. These students self-generate thoughts, feelings, and actions to attain their personal learning goals” (p. 5). Research has clearly demonstrated that students who employ self-regulated approaches to learning achieve more and are more satisfied with their work. Self-regulatory processes lead to increases in students’ motivation and to success in school (Boekaerts, 1997; Schunk & Zimmerman, 1998; Zimmerman & Schunk, 2001). Therefore, self-regulated learning is a worthy objective for students of all ages in all disciplines (Paris & Paris, 2001).

For many students however, the first time they really have to self-regulate their learning is as a freshman in higher education. Not only do the academic tasks at this level demand higher-level thinking and independent learning, also the organization of tertiary education gives students more freedom and responsibility in controlling their own learning process. Few teachers in secondary education effectively prepare students for this task (Zimmerman, 2002). Because in secondary education teachers generally take the central decisions about the learning process, the students do not have the opportunity and do not feel the need to set personal learning goals, and to metacognitively plan, monitor and evaluate their own learning process. The consistent research findings that freshmen students are not self-regulated learners affirm this contention (Simpson, Hynd, Nist, & Burrell, 1997).

Building on the large body of research evidence that self-regulated learning can be taught by providing adequate instructional support (Boekaerts, 1997; Simpson et al., 1997; Vermunt & Van Rijswijk, 1988; Weinstein, Husman, & Dierking, 2000; Zeegers & Martin, 2001; Zimmerman, 2002), we developed a program to stimulate self-regulated learning in first-year university students. It was organized within the context of academic counseling, as an elective course outside the normal teaching context.

Because a meta-analysis of the effects of learning skills interventions (Hattie, Biggs, & Purdie, 1996) showed that such elective courses are most effective if they are organized as a “relational intervention”, we chose this format: all components of the self-regulated learning program were integrated in a metacognitive and conditional framework, suiting the individual’s self-assessment, and orchestrated to the demands

of the particular task and context. The conceptual framework, instructional method, and practical organization of our program are described in the first part of this article.

The second and the third part of this article report the method and results of an experimental study to test the effectiveness of this program. It is known from the meta-analysis (Hattie et al., 1996) that these kinds of interventions are particularly effective in the domains of performance, study skills, and affect, over all ages and ability levels. Accordingly, the central question of this study was whether our intervention to support self-regulated learning in university students had an effect on these three domains. A quasi-experimental design, with pre- and post-test and three groups was employed. The students who attended the full program were compared with the students who dropped out and the students who did not participate; the dependent variables were academic performance, method of learning (cf. study skills) and perceived self-efficacy (cf. affect).

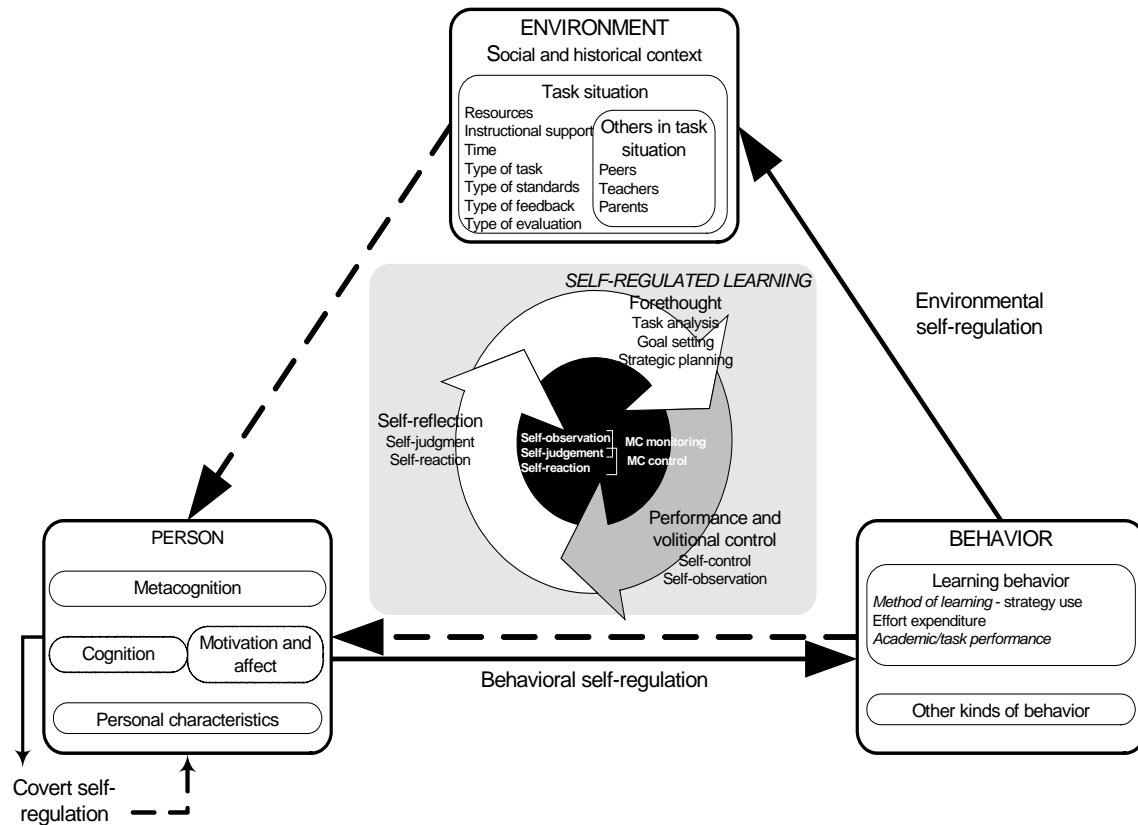
Three main hypotheses were formulated. First, we predicted that the students who attended the full program would show higher academic performance than the drop-out and the non-participating students. Second, we predicted that the participating students would be more likely to report a method of learning incorporating self-regulated learning. Third, we predicted that participating students would have a higher level of perceived self-efficacy than the drop-out and the non-participating students.

In addition, we also explored the direct and interaction effects of the individual differences factors sex, learning style, and whether the students were freshmen or not, on each dependent variable.

## The Self-Regulated Learning Program

### *Conceptual Framework*

The social cognitive perspective on self-regulated learning (Schunk, 2001; Zimmerman, 1989, 1995, 2000) was chosen as the general conceptual framework of the self-regulated learning program. This framework, as summarized in Figure 1, considers self-regulated learning as a very complex interactive process. Without losing clarity, it gives an encompassing view on the topic and it can easily be linked to various other theoretical insights from the extensive literature on (meta)cognition, (self-regulated) learning, motivation, and so forth.



*Figure 1.* General conceptual framework of the self-regulated learning program, based on social cognitive theory.

According to social cognitivists (Schunk, 2001; Zimmerman, 1989, 1995, 2000), self-regulated learning consists of three self-oriented feedback loops: behavioral self-regulation, environmental self-regulation, and covert self-regulation. The different self-regulatory processes and accompanying beliefs fall into three cyclical phases:

1. Forethought. This refers to the processes that precede efforts to act and set the stage for it, like task analysis, goal setting, and strategic planning. It includes self-beliefs that lay the foundation of motivation, such as self-efficacy, outcome expectations, and goal orientation.
2. Performance or volitional control. This phase involves processes that occur during learning and affect attention and action, like self-control and self-observation.
3. Self-reflection. Self-reflection comprises processes that occur after performance efforts and influence a person's response to that experience. Self-judgment involves self-evaluating one's performance by comparing it with a standard or goal, and attributing causal significance to the results; self-reaction involves perceptions of (dis)satisfaction and associated affect, and inferences about how one needs to alter his or her self-regulatory approach during subsequent efforts to learn.

Social cognitive theory (Schunk, 2001; Zimmerman, 1989, 1995, 2000) embeds these self-regulatory processes within a larger system that also includes personal, behavioral and social-environmental factors.

We have integrated important elements from the theory on (meta)cognition, (self-regulated) learning, motivation, and so forth in the further description of these factors.

## Person

Figure 2 represents the personal factors and processes relating to self-regulation.

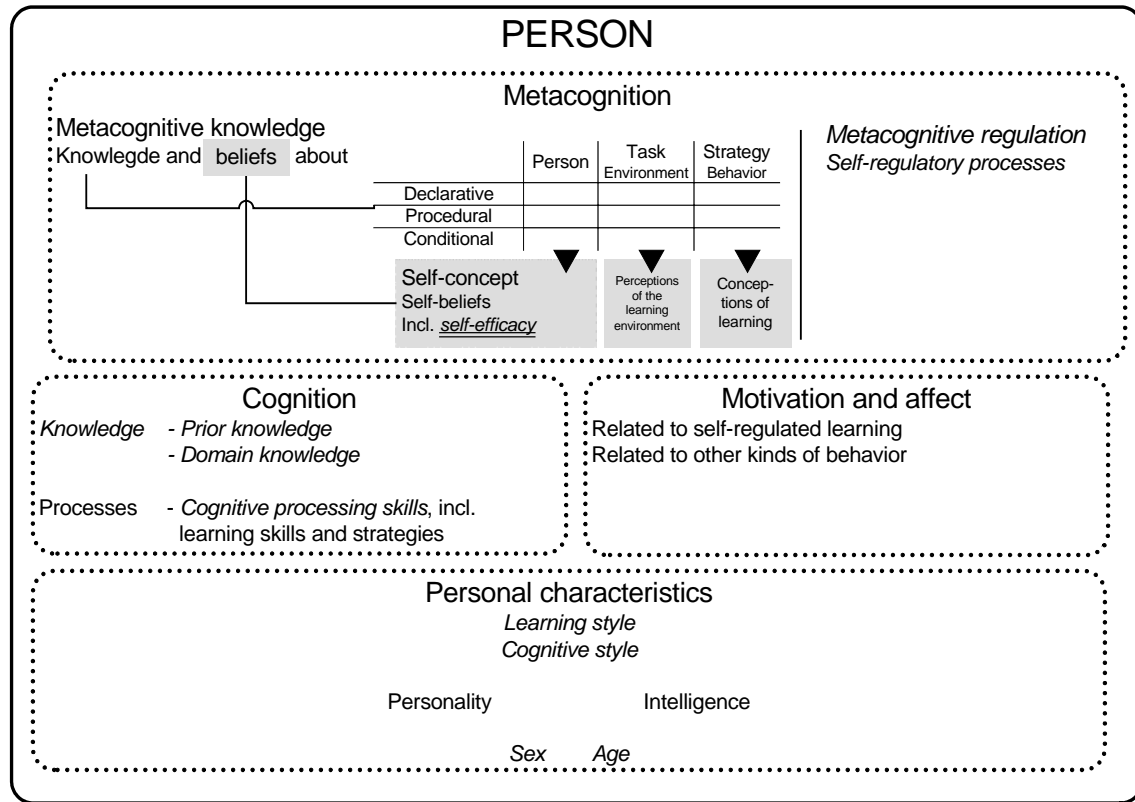


Figure 2. Personal factors and processes relating to self-regulated learning.

Within these personal factors and processes relating to self-regulation, which are all interrelated, more and less stable elements can be assumed. Among the more stable personal characteristics are cognitive style and learning style. Others are sex, age, personality, and intelligence. The less stable and more context-sensitive elements can be roughly sub-divided into cognition, motivation and affect, and metacognition.

## Cognition.

Cognition comprises a student's base of prior knowledge and domain knowledge on the one hand, and his or her base of cognitive processing skills on the other. The latter also includes the learning skills and strategies that he or she masters (Winne, 2001).

### *Motivation and affect.*

Motivation refers to the will to self-regulate and to learn. Affect refers to all kinds of feelings that accompany and influence self-regulated learning, for example fear of failure and stress. Also motivation for other behavior than studying, and feelings that have other sources, can affect and be affected by self-regulation. Motivation and affect are strongly determined by the metacognitive beliefs a student holds (Bandura, 1997; Boekaerts, 1995, 1996; Paris, Byrnes, & Paris, 2001; Pintrich & De Groot, 1990).

### *Metacognition.*

Metacognition is generally assumed to have two components: metacognitive knowledge and metacognitive regulation or control (Brown, 1987; Hacker, 1998; Schraw, 2001). Metacognitive regulation refers to the self-regulatory processes central to self-regulated learning. Metacognitive knowledge was originally defined by Flavell as “that segment of one’s stored world knowledge that has to do with people as cognitive creatures and with their diverse cognitive tasks, goals, actions, and experiences” (Flavell, 1979, p. 906). In his later work, he broadened this definition to include knowledge and beliefs, about anything psychological, including emotions, motives, and so forth. (Flavell, 1987). Metacognitive knowledge is commonly classified according to two dimensions. The first dimension is Flavell’s (1979, 1987) distinction between knowledge of person variables, of task variables, and of strategy variables. The second dimension is the distinction between declarative, procedural, and conditional knowledge (Schraw & Moshman, 1995; Schraw, 2001).

Because people’s level of motivation, affective states, and actions are based more on what they believe than on what is objectively true (Bandura, 1997), the believe-aspect of metacognitive knowledge is very important. For social cognitivists, perceived self-efficacy is the key self-belief affecting learning. It refers to people’s beliefs in their capabilities to produce desired effects by their actions (Bandura, 1997). Change in self-efficacy is considered the main outcome of feedback: it serves as a sort of thermostat that regulates strategic efforts to acquire knowledge and skill. Self-efficacy is known to affect behavior in several ways: it influences the choices individuals make and the course of actions they pursue, it determines their level of



effort, persistence, and resilience, and influences individuals' thought patterns and emotional reactions. As a result, self-efficacy beliefs are strong determinants and predictors of the level of accomplishment that individuals finally attain (Bandura, 1989; Pajares, 1996). Zimmerman added that a high level of self-efficacy is associated with better quality learning strategies, more self-monitoring, and finally, higher academic achievement (Zimmerman, 2000). In comparison with these self-beliefs, metacognitive beliefs about environmental or behavioral variables receive little attention in the literature on self-regulation. In the research on approaches to learning however, it was found that students' perceptions of academic learning environments are important mediators of the effects of these environments on study behavior (Entwistle & Tait, 1990). Also students' conceptions of learning ("What do you mean by learning?"), which can be seen as metacognitive beliefs about learning behavior developed through experiences of teaching and studying, influence the way in which is actually learned (Marton, Beaty, & Dall'Alba, 1993; Marton, Hounsell & Entwistle, 1997).

### *Behavior*

Behavior includes learning behavior like method of learning (strategy use), effort expenditure, and academic or task performance. It is however also important to pay attention to other kinds of behavior (sleeping habits, hobbies,...) that can stimulate or hamper self-regulated learning.

### *Environment*

Lastly, environmental factors can relate to the task situation or to others in the task situation (Corno, 2001). Elements of the task situation that can influence or might be influenced by self-regulated learning are the resources available, the instructional support, time allocation, the type of task, the type of standards, the type of feedback, and the type of evaluation (Schunk, 2001; Winne, 2001). Relevant others in the task situation are peers, teachers, and parents. In general, these environmental factors are crucial because they define the extent to which students have the freedom and opportunity to self-regulate.

This conceptual framework itself and all its elements were, explicitly or implicitly, part of the program's content. It obliged use to pay equal attention to the various cognitive, metacognitive, motivational and affective sub-processes of self-regulated learning when constructing the program, thus preserving us from the one-sidedness that various authors observed in other study skills interventions (Hattie et al, 1996; Kaldeway & Korthagen, 1994; Simpson et al, 1997).

### *Instructional Method*

The instructional approach used during the program sessions integrated four general principles that often reoccur in the literature on self-regulatory strategy instruction. As such, we aligned ourselves with the tradition of learning-to-learn courses like those developed by McKeachie, Pintrich, and Lin (1985) and Weinstein et al. (2000).

First, we worked with small groups of students to enable interaction between peers. This reflects Zimmerman's conviction that self-regulated learning is *social*: each self-regulatory process or belief can be learned from instruction or modeling by parents, teachers, coaches and peers (Zimmerman, 2002). It also gave ample opportunity for "reflective discourses" about how to use strategies appropriately and to learn effectively (Paris & Paris, 2001), without telling students what to do or what strategies should be applied. The dynamics of small group instruction allowed for an inductive approach, starting from problems raised by the students.

On the other hand, the program consisted of *direct instruction* (Hattie et al, 1996; Lapan, 2002; Simpson et al, 1997). Each program session had clear instructional goals, and structured and sequential materials were provided. The self-regulatory strategies were explained to the students, and they were told for which types of tasks, for which types of learners, and why they were helpful. Various examples were used. As such, the students were stimulated to acquire declarative, procedural and conditional metacognitive knowledge, which was expected to make it more likely that they would transfer the strategies to other learning tasks. The students also had ample opportunity to practice the strategies, after which feedback was provided.

Third, the self-regulatory strategies were taught within a *realistic context and content area*, always referring to the demands of the curriculum (Hattie et al, 1996; Simpson et al, 1997). Real learning tasks and assignments were used. Although most researchers agree that ideally, self-regulatory strategy training ought to be embedded in the teaching of content (Boekaerts, 1997; Hattie et al., 1996; Masui, 2002; Pressley & Harris, 1990; Paris & Paris, 2001; Vermunt, 1994; Volet, 1991, 1995), this advice could not be followed. From the position of academic counselor, we had no impact on the medicine curriculum.

Lastly, a high degree of learner activity and *metacognitive awareness* was promoted by asking questions to stimulate reflection (Hattie et al, 1996; Lapan, 2002). We thereby capitalized on the principle of reactivity (Zimmerman, 2002), which says that students' metacognitive awareness of particular aspects of their functioning (through for example self-recording) can enhance their self-control.

### *The Program in Practice*

The self-regulated learning (SRL) program was practically elaborated at the Faculty of Medicine and Health Sciences at Ghent University, in collaboration with the faculty's academic counselor. The program consisted of four sessions, plus one evaluation session. Each session took 1,5 hours. They were spread over the academic year; the aim was to guide the students through the self-regulated learning phases during the course of the year, parallel with the curriculum. Table 1 gives an overview of the planning and content of the sessions. The third and the fourth column indicate which self-regulatory processes from which phase of self-regulated learning were addressed in each session.

The researcher and the counselor also mentored the program. They randomly assigned themselves to the various groups and sessions. A workbook was developed that served as a guideline/learning environment during the sessions. It was used by the mentors as a standardized scenario. The students could use it as a learning tool and reference book during studying. To make the link with the students' authentic learning environment, the program focused on studying for one specific course (general

chemistry in the first semester - biochemistry in the second semester), and the students were stimulated to transfer the information to their study process as a whole.

Table 1

*Planning and Content of the Self-Regulated Learning (SRL) Program*

Session	Planning	Content	SRL Phase
Introduction and pre-test			
1	End of October	<ul style="list-style-type: none"><li>- Introduction on SRL</li><li>- Analysis of learning environment and task demands</li><li>- Analysis of personal characteristics</li></ul>	Forethought
2	End of November Beginning of December	<ul style="list-style-type: none"><li>- Goal setting</li><li>- Strategic planning</li><li>- Procrastination and fear of failure</li></ul>	Forethought
Exams January 2003			
3	February	<ul style="list-style-type: none"><li>- Self-judgment: self-evaluation and causal attribution</li><li>- Self-reaction</li></ul>	Self-reflection
4	End of March Beginning of April	<ul style="list-style-type: none"><li>- Study skills and strategies</li><li>- Stress management</li></ul>	Performance and volitional control
5	May	Evaluation of program by students	
Post-test			
Exams June 2003			

## Method

### *Participants*

The self-regulated learning program was developed and implemented at the Faculty of Medicine and Health Sciences at Ghent University. All first-year medicine students ( $N = 145$ ) had the opportunity to participate in the self-regulated learning program. The students who attended the full program and the pre- and post-test, received two cinema tickets. Informed consent was obtained and anonymity of data-processing was guaranteed.

132 students (92.3 % of total) participated in the pre-test session. Their aged varied between 17 and 26, with a mean of 18,2. 32% were male, 68% female. It is important to know that in Flanders, entrance to medical education is restricted by an admission test which assesses scientific knowledge and insight and information processing skills. All these students had passed this examination.

After the introductory session, 101 students agreed to participate in the self-regulated learning program. They were assigned to 7 matched groups of 13 students on the average. Learning style was the matching variable. The eighth group consisted of 7 students who had already spent one or more years in higher education.

Overall, there were 38 students who participated in four or five sessions. Because the fifth session was an evaluation session, all these students were considered as students who attended the full program. 61 students did not participate, although half of them initially registered for participation. The group of drop-out students, those who participated but did not complete the program, consisted of 33 students. They randomly came from all 7 groups.

To mobilize the students for participation in the post-test session, this session was explicitly announced in a preceding lesson. Finally, a total of 59 students attended the post-test session.

### *Instruments*

The variables that were operationalized with the measures below are italicized in Figure 1 and Figure 2.

#### *Academic Performance*

The students' final exam results were obtained from the faculty administration. The information included the separate scores (on 20) for each course bloc (cell 1, cell 2, cell 3, health and society, infection and defence, information processing, first aid and communication, exploration and Studium Generale), and a total exam score on 1000.

#### *Method of Learning*

Two instruments were used to assess method of learning, namely the Leuven Executive Regulation Questionnaire (LERQ), which focuses on self-regulation, and the Approaches and Study Skills Inventory for Students (ASSIST), which focuses on the broader concept of approach to studying. These instruments were administered during the pre-test session and during the post-test session.

Both the LERQ and the ASSIST are self-report measures of learning behavior. They measure self-regulated learning and approach to studying as an aptitude, not as an event. Self-report questionnaires aggregate over or abstract some quality of learning based on multiple learning events, and de-emphasize contextual and temporal variability. A problem therefore is that they do not reveal what learners actually do (as contended by a.o. Veenman, Prins & Verheij, 2003; Winne & Jamieson-Noel, 2002). They only provide information about learner's memories and interpretations of their actions and their explanations of cognitive and metacognitive processes. On the other hand, self-report measures are the most frequently used measurement protocols, mainly because they are efficient: economical in terms of labor and relatively fast and inexpensive to score. But the ensuing research has also shown consistent findings among constructs. (Patrick & Middleton, 2002; Perry, 2002; Winne, 2000).

*Leuven Executive Regulation Questionnaire (LERQ).*

The Leuven Executive Regulation Questionnaire (Minnaert, 1996) is a 63-item self-report questionnaire designed to investigate whether, to what extent and how students regulate their study activities in higher education. Students are requested to respond to statements that relate to nine regulation activities (goal-setting, orienting, planning, monitoring, testing, diagnosing, on-line regulating, evaluating, reflecting). Each of the statements has to be judged on a five-points scale. This questionnaire was used as a post-test. As pre-test the LERQSO, a reformulation of the LERQ in terms of studying in secondary education (Masui, 2002), was used. Both questionnaires were used in original language version.

Minnaert (1996) reports a factor analysis resulting in five orthogonal scales. The first scale (23 items) is interpreted as effective self-regulation in study activities (process and content). The second scale (12 items) reflects incompetence to regulate study activities, partially due to a lack of metacognitive knowledge about studying in higher education. The third scale (16 items) reveals procrastination of regulating own study activities combined with a passive, field dependent regulation. The fourth scale (8 items) is interpreted as strategic, systematic regulation of study activities with a focus on planning and process monitoring, and the fifth scale (4 items) refers to active, field dependent regulation of study activities.

After missing values were completed by applying the mean substitution technique, we examined reliability and validity of this instrument in our sample of pre-test session participants ( $n = 132$ ). All LERQSO scales, except the fifth scale ( $\alpha = .52$ ), showed good internal consistency. Cronbach's  $\alpha$ 's ranged between .79 and .83. Factor analyses were applied to investigate the factorial validity of this instrument. Three of the five LERQSO scales could be clearly recognized in the factor solution: the effective self-regulation scale, the incompetence to regulate scale, and the strategic, systematic regulation scale. We decided to retain these three scales for further analyses. Sum scores were used.

*Approaches and Study Skills Inventory for Students (ASSIST).*

The Approaches and Study Skills Inventory for Students (Entwistle, Tait & McCune, 1999; “Scoring key”, 2003; Tait & Entwistle, 1996; Tait, Entwistle & McCune, 1998) is a 52-item self-report questionnaire to investigate approaches to studying. The students have to respond to the items on a five-points scale. It is an extensively trialed and validated instrument, with a long history of development work (for an overview, see Tait, Entwistle, McCune, 1998). It was translated in Dutch using the parallel blind technique with the researcher as one of the translators (Behling & Law, 2000).

The inventory distinguishes three approaches to studying, each consisting of various 4-item sub-scales. The deep approach comprises the sub-scales seeking meaning, relating ideas, use of evidence, and the motive interest in ideas. The strategic approach consists of the sub-scales organized studying, time management, alertness to assessment demands, monitoring effectiveness, and achieving motivation. The surface apathetic approach comprises the sub-scales unrelated memorizing, lack of purpose, syllabus boundness, and the motive fear of failure. Sum scores are used (“Scoring key”, 2003).

After missing values were completed by applying the mean substitution technique, we examined reliability and validity of this instrument in our sample of pre-test session participants ( $n = 132$ ). Reliability analysis indicated that the three main scales of the ASSIST showed good internal consistency. Cronbach’s  $\alpha$ ’s ranged from .73 to .86. The developers of this instrument (Tait, Entwistle, McCune, 1998) considered .50 as the acceptable minimum  $\alpha$  for the sub-scales. All sub-scales, except the “using evidence” sub-scale ( $\alpha = .17$ ), reached this ultimate value. Cronbach’s  $\alpha$ ’s ranged from .50 to .82. The three original main scales could be recognized in factor analysis at sub-scale level. Confirmatory factor analysis showed that the original factor structure fitted the data relatively well. There was no good fit,  $\chi^2 (62, N = 132) = 140.36$ ,  $p = .000$ , GFI = .87, CFI = .85, RMSEA = .10, but the GFI and CFI could be considered as reasonably high. Also all parameter estimates were significant and had values consistent with the theory.



### *Perceived Self-Efficacy*

A self-efficacy scale was developed following Bandura's "Guide for constructing self-efficacy scales" (2001). It was administered at the beginning of every program session and during the post-test session.

The scale consisted of 33 items and was divided into four parts. The students had to respond to each item on a 0-100 scale. Part one consisted of one statement that taps learning efficacy in general, namely "When I work hard enough, I can actually learn everything". Part two consisted of 21 items that asked for self-efficacy in self-regulated learning (3 items per sub-process: task analysis, goal setting, strategic planning, self-observation, self-control, self-judgment, and self-reaction). Part three comprised 12 items referring to self-efficacy in accuracy of self-knowledge. And last, in part four, tapping self-efficacy in academic performance, the students were asked which study results they think they could achieve, for one specific course (general chemistry/biochemistry) and for all courses together. Each possible range of scores (4-5, 6-7, ... , 16-17, 18 or more) had to be judged on a 0-100 scale. This part consisted of 18 items.

The psychometric properties of this self-efficacy scale were examined with data from the sub-sample of students who participated in Session 1 ( $n = 67$ ). Item analysis was conducted separately for the four parts of the self-efficacy scale. Before that, non-discriminating items were eliminated.

First, Item 1, tapping general learning efficacy, had  $M = 77.95$ ,  $SD = 14.62$  and a range of 70. This indicated that this item was sufficiently able to differentiate among students with varying learning efficacy.

Second, principal components analysis of the 21 items asking for self-efficacy in the various sub-processes of self-regulated learning resulted in five orthogonal components with eigenvalue  $> 1$ . Results of the scree test suggested focusing only on the first three components, which explained 57.66% of the variance. Component I was called self-efficacy in performing self-regulated learning, because it referred to self-efficacy in goal-setting, strategic planning, and self-control, core sub-processes of self-regulated learning. This sub-scale had Cronbach's  $\alpha = .88$ . Component II loaded high on the items about self-efficacy in task analysis. Cronbach's  $\alpha$  was .76. Component III

referred to the self-reflection sub-processes of self-regulated learning. This sub-scale had Cronbach's  $\alpha = .85$ . The sub-scale means were used.

Third, Cronbach's  $\alpha$  for the self-efficacy in accuracy of self-knowledge sub-scale was .84. The mean scale-score was used.

Last, the self-efficacy in academic performance part showed to be difficult to complete for the students. While the instruction was that each possible range of scores had to be judged on a 0-100 scale, some students just checked off one range of scores, others wanted to make sure that the sum of their replies equaled 100, and so forth. This resulted in a lot of missing values. It was decided to retain the two items with the smallest number of missing values and the largest standard deviations as separate variables: self-efficacy in achieving 14 to 15 (on 20) on biochemistry, and self-efficacy in achieving 700 to 799 (on 1000) as total exam score.

#### *Learning Style - Learning Style Inventory (LSI, Version 3)*

A Dutch translation of the third version of the Learning Style Inventory (Kolb, 1999) was developed using the parallel blind technique with the researcher as one of the translators (Behling & Law, 2000). It was administered during the pre-test session. The LSI is a 12-item questionnaire that measures a student's relative preference for concrete experience, reflective observation, abstract conceptualization, and active experimentation by asking them to rank four sentence endings that correspond to these four different ways of learning.

Table 2 lists the Cronbach's  $\alpha$  reliability coefficients of the translated version of the LSI-1999 in our sample of participants in the pre-test session ( $n = 132$ ).

Table 2

#### *Reliability of the Dutch Translation of the LSI-1999*

	$\alpha$
Concrete experience (CE)	.75
Reflective observation (RO)	.65
Abstract conceptualization (AC)	.77
Active experimentation (AE)	.73

These reliability scores seem to be acceptable. Because the LSI is an ipsative measure, the interpretation of these  $\alpha$  – scores is however not straightforward. Applying the usual correlation-based analysis techniques for psychometric evaluation with ipsative scores yields results that are difficult to interpret. They have to be considered as an artefact of the ipsative scoring method (Anastasi & Urbina, 1997; Cornwell & Dunlap, 1991; Henson & Hwang, 2002; Pickworth, 2000).

To be able to appropriately analyze the LSI scores, an alternative statistical procedure was applied: the original LSI scores were transformed following the procedure that was proposed by Cornwell and his colleagues (Cornwell & Dunlap, 1991; Cornwell & Manfreda, 1994). By using only an individual's first rank order of the final LSI ipsative scores, a nominal variable was defined, named primary learning style, indicating a preference for one of the four learning modes. According to Cornwell et al., this nominal variable can be used successfully in theory building and testing: because the final ipsative score is calculated as the sum of 12 separate ipsative items, this final score should be more reliable than the individual scores.

#### *Background Information – Questionnaire*

A questionnaire was developed to inquire after relevant background information during the pre-test session: age, sex, self-reported study result in secondary education (mean end-examination score on 100), studies last year (to see if they were freshman or not) and results on the Flemish entrance examination. The latter consisted of a score on 20 for knowledge of and insight in sciences, and a score on 20 for information processing.

#### *Data Analysis*

Multiple analysis of covariance was the main data analysis technique used in this study. However, due to our relatively small sample size, empty cells often occurred. Type IV sums of squares were used to deal with this problem (Tabachnick & Fidell, 1996, p. 345). Effect sizes were computed to be able to uncover potentially interesting and valuable effects that are not significant, but that might have yielded more

significant results if there were only more subjects in the study (Kramer & Rosenthal, 1999; Olejnik & Algina, 2000). Partial  $\eta^2$  and Cohen's  $d$  were used as effect size estimates. All results with a significance level up to  $\alpha = .150$  and having medium to large effect size were considered interesting. Consequently, pre-specified significance levels were:  $^+ p < .150$ ,  $^* p < .100$ ,  $^{**} p < .05$ ,  $^{***} p < .01$ ,  $^{****} p < .001$ .

## Results

### *Data Screening*

Prior to analysis, all variables were examined for accuracy of data entry, missing values, outliers, normality, and multicollinearity, according to the procedure described by Tabachnick and Fidell (1996). Randomly missing data were estimated using mean or mode substitution. Cases with standardized scores in excess of 3.29 were considered as univariate outliers. These cases were deleted or their raw score was changed into a score that was one unit smaller or larger than the next most extreme score in the distribution. Examination of Mahalanobis distances revealed no multivariate outliers.

Normality of the variables was assessed by examining skewness and kurtosis. The variables total exam score and cell 3 were significantly negatively skewed. A transformation was applied to normalize these variables:  $NEWX = \text{SQRT}(K-X)$ , for moderate negative skewness. For further interpretation it is important to keep in mind that these transformed variables have reversed meaning.

Multicollinearity was examined separately for the background variables, the academic performance variables, the method of learning variables, and the perceived self-efficacy variables, by computing all bivariate correlations. A correlation of .70 or more was considered indicative of multicollinearity. There was no multicollinearity among the background variables.

There was multicollinearity among the academic performance variables. Principal components analysis with varimax rotation revealed two components with eigenvalues  $> 1$ , together explaining 68.61% of the variance. Component I comprised the exam results that were highly correlated with the total exam score: cell 1, cell 2, cell 3, infection & defence, health and society, and information processing. Total exam score

was used as representative variable for this group of academic performance variables. Component II consisted of first aid and communication, and exploration and Studium Generale. These variables were, however, not significantly correlated ( $r = .080$ ). They were retained as separate academic performance variables.

Two method of learning variables showed multicollinearity at pre-test measurement: strategic, systematic regulation and strategic approach to studying ( $r = .721$ ). Overall, the regulation and the approaches to studying variables were strongly intercorrelated. Principal components analysis with varimax rotation showed three components with eigenvalues  $> 1$ , together explaining 73.76 % of the variance. Component I referred to a strategic approach to studying based on achieving motivation and strategic, systematic self-regulation of learning (STRATSR1). Component II could be interpreted as a surface approach to studying based on fear of failure and incompetence to regulate learning (SURFINC1), and Component III referred to a deep approach to studying based on interest in ideas and self-regulation of learning (DEEPSR1). The factor scores were used as pre-test method of learning variables in the analyses. At post-test measurement, approximately the same pattern occurred. Again, principal components analysis was conducted and factor scores were computed (STRATSR2, SURFINC2, and DEEPSR2).

Among the perceived self-efficacy variables, there was multicollinearity between self-efficacy in self-reflection and self-efficacy in performing self-regulation ( $r = .73$ ), between self-efficacy in self-reflection and self-efficacy in task analysis ( $r = .77$ ), between self-efficacy in self-reflection and self-efficacy in accuracy of self-knowledge ( $r = .77$ ), and between self-efficacy in task analysis and self-efficacy in accuracy of self-knowledge ( $r = .83$ ). Therefore, these variables were aggregated by using their arithmetic mean, forming the new variable self-efficacy in self-regulated learning.

*Background Characteristics of Participating, Drop-out, and Non-Participating  
Students*

Because the students were free to decide whether or not to participate in the self-regulated learning program, they were not randomly assigned to our groups of interest. It was therefore important to examine possible patterns in background characteristics of non-participating students, drop-out students, and students who attended the full program, before proceeding with the analyses.

A direct discriminant function analysis was performed using all continuous pre-test variables as predictors of membership in the three groups (age, study result in secondary education, results on the entrance examination, and method of learning variables).

Table 3

*Means, Standard Deviations, F and  $\eta^2$  Values for all Continuous Pre-Test Variables According to Participation*

	Full participation ( <i>n</i> = 38)		Drop-out ( <i>n</i> = 33)		No participation ( <i>n</i> = 60)		<i>F</i>	$\eta^2$
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Age	18.08	0.43	18.09	0.29	18.15	0.51	0.362	
Study result in secondary education	77.76	5.87	74.62	5.46	75.30	6.86	2.650*	.040
Knowledge of and insight in sciences	14.02	1.82	14.00	1.84	11.30	1.72	0.427	
Information processing	13.02	1.34	12.60	1.33	12.79	1.33	0.885	
STRATSR1	.16	0.89	.01	0.93	- .13	1.09	0.956	
SURFNC1	.10	1.15	.02	0.87	- .05	0.96	0.279	
DEEPSR1	.11	0.88	- .18	0.97	.00	1.07	0.746	

\*  $p < .100$

Two discriminant functions were calculated, with a combined  $\chi^2 (14) = 13.033$ ,  $p = .524$ . This implied that there was no function that could reliably separate the three

groups: the groups did not significantly differ from each other on a linear combination of relevant continuous pre-test variables. Separate  $F$ 's indicated that there was a meaningful, but not significant difference between the groups on study result in secondary education,  $F(2,128) = 2.650, p = .075$ .

There were three categorical pre-test variables: freshman or not, sex, and primary learning style. Because only a small number of students had an active experimentation or reflective observation primary learning style, these categories were joined.

Separate  $\chi^2$ 's were computed to check whether the categorical variables were associated with participation in the program. There were no significant associations between freshman or not and participation,  $\chi^2(2) = 1.26, p = .531$ , and between primary learning style and participation,  $\chi^2(4) = 4.29, p = .368$ . There, however, was a meaningful, though not significant, association between sex and participation,  $\chi^2(2) = 5.01, p = .082$ . Male students tended to participate less than could be expected, and female students tended to participate more than could be expected.

### *Effects of Participation and Individual Differences on Academic Performance*

A 3 x 2 x 3 x 2 between-subjects MANCOVA was performed on the three academic performance variables: total exam score, first aid and communication, and exploration and Studium Generale. Adjustment was made for study result in secondary education. Independent variables were participation, and the individual differences factors sex, primary learning style, and freshman or not. Box's test indicated that there was homogeneity of variance-covariance matrices,  $F(60, 2893.14) = 1.043, p = .387$ .

Wilk's criterion was used to evaluate significance. The covariate study results in secondary education provided a significant adjustment to the combined academic performance variables,  $F(3, 96) = 8.348, p < .000$ . There was a large association between this covariate and the combined dependent variables, with partial  $\eta^2 = .207$ . Univariate  $F$ 's, however, revealed that this covariate only provided a significant adjustment to the dependent variable total exam score,  $F(1, 98) = 23.879, p < .000$ , partial  $\eta^2 = .196$ . It provided a meaningful but rather small adjustment to the

dependent variable first aid and communication,  $F(1,98) = 2.895$ ,  $p = .092$ , partial  $\eta^2 = .029$ .

Table 4

*Means, Standard Deviations and F Values for the Academic Performance Variables According to Participation, Sex, Primary Learning Style and Freshman or Not.*

	Participation							
	Full participation ( <i>n</i> = 38)		Drop-out ( <i>n</i> = 32)		No participation ( <i>n</i> = 53)			
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>F</i>	$\eta^2$
Total exam score <sup>a</sup>	13.44	2.92	13.67	3.92	14.02	3.15	0.562	
First aid and communication	13.46	1.19	13.47	1.34	13.11	1.37	1.495	
Exploration and Studium Generale	13.72	1.17	13.07	1.52	13.68	1.59	0.908	
	Sex							
	Male ( <i>n</i> = 38)		Female ( <i>n</i> = 85)					
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			<i>F</i>	$\eta^2$
Total exam score	15.01	3.06	13.19	3.24			0.321	
First aid and communication	13.05	1.39	13.43	1.26			0.644	
Exploration and Studium Generale	12.89	1.53	13.82	1.35			4.883**	.047

*(table continues)*



	Primary learning style							
	Concrete experience + Reflective observation ( <i>n</i> = 16)		Abstract conceptualization ( <i>n</i> = 72)		Active experimentation ( <i>n</i> = 35)			
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>F</i>	$\eta^2$
Total exam score	14.95	2.54	13.54	3.47	13.65	3.14	1.495	
First aid and communication	13.22	1.20	13.39	1.32	13.20	1.37	2.966*	.057
Exploration and Studium Generale	13.09	1.29	13.48	1.53	13.84	1.37	1.098	
	Freshman?							
	Yes ( <i>n</i> = 110)		No ( <i>n</i> = 13)					
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			<i>F</i>	$\eta^2$
Total exam score	13.82	3.29	13.11	3.24			0.173	
First aid and communication	13.26	1.25	13.73	1.71			2.454	
Exploration and Studium Generale	13.49	1.51	13.92	1.00			0.449	

a. Total exam score has reversed meaning: lower scores imply higher final exam scores.

\*  $p < .100$ . \*\*  $p < .05$ .

There was no significant effect of participation on the combined academic performance variables when adjusted for study result in secondary education,  $F(6, 192) = .941, p = .467$ . Also the individual differences factors had no significant effect

on the combined academic performance variables when adjusted for study result in secondary education. There were no significant interaction effects.

Separate  $F$ 's also showed no significant effect of participation on the separate academic performance variables after adjustment for study result in secondary education.

Our first hypothesis, stating that students who attended the full self-regulated learning program would have higher final exam results than the drop-out and the non-participating students, must therefore be rejected.

The separate  $F$ 's however revealed that female students scored significantly higher than male students on exploration and Studium Generale after adjustment for study result in secondary education,  $F(1, 98) = 4.883, p = .029$ . This was a rather moderate effect, with partial  $\eta^2 = .047$ . Second, they indicated that primary learning style had a meaningful effect on first aid and communication after adjustment for study result in secondary education,  $F(2, 98) = 2.966, p = .056, \eta^2 = .057$ . Pairwise comparisons showed that students with a thinking primary learning style tended to have a higher First aid and communication score than students with a feeling or watching primary learning style, who had approximately the same scores.

Finally, it is important to know that for these academic performance variables, non-random drop-out occurred: 7 students did not participate in the examinations. They were all students who did not attend the self-regulated learning program.

### *Effects of Participation and Individual Differences on Method of Learning and Perceived Self-Efficacy*

Method of learning and perceived self-efficacy were both assessed during the post-test session. However, only 59 students out of 132 attended this session. Therefore, patterns in this missing data were examined before testing the effect of participation on these variables.

### *Participants Post-Test Session*

59 students out of 132 attended the post-test session during which perceived self-efficacy and method of learning were assessed. A dummy variable was constructed, participation post-test session versus no participation post-test session, to test for patterns in these missing data.

First, it was examined whether these two groups of students equally participated in the self-regulated learning program. The majority of the participants in the post-test session (about 64%) attended the full program. In other words, only 20% of the students who did not participate in the self-regulated learning program and 27% of the drop-out students attended the post-test session, while all students who completed the program were present. It was therefore important to examine whether the group of non-participating and drop-out students who attended the post-test session ( $n = 21$ ) was representative for the whole group of non-participating and drop-out students.

Table 5

*Means, Standard Deviations and F Values for all Continuous Pre-Test Variables According to Participation Post-Test*

	Participation post-test ( $n = 21$ )		No participation post-test ( $n = 72$ )		$F$	$\eta^2$
	$M$	$SD$	$M$	$SD$		
Age	18.00	.45	18.17	.44	2.281	
Study result secondary education	77.52	6.82	74.34	6.10	4.199**	.040
Knowledge of and insight in sciences	13.92	1.92	14.27	1.72	0.633	
Information processing	12.82	1.38	12.69	1.32	0.153	
STRATSR1	-.09	1.05	-.07	1.03	0.003	
SURFNC1	-.14	.96	.01	.92	0.437	
DEEPSR1	.09	.80	-.11	1.09	0.602	

\*\*  $p < .05$

A direct discriminant function analysis was performed on the sub-sample of non-participating and drop-out students ( $n = 93$ ) using all continuous pre-test variables as predictors of “post-test session participation or not” (age, study result secondary education, results on the entrance examination, method of learning variables). One discriminant function was calculated, with a combined  $\chi^2 (7) = 8.290, p = .308$ . This implied that this function could not reliably separate both groups. Separate F’s indicated that there was a significant difference between the groups on the variable study result secondary education,  $F(1, 91) = 4.199, p = .043, \eta^2 = .044$ . The drop-out and non-participating students who attended the post-test session had higher study results in secondary education than the drop-out and non-participating students who did not attend the post-test session.

There were three categorical pre-test variables: freshman or not, sex, and primary learning style. Separate  $\chi^2$ ’s were computed to check whether they were associated with participation in the post-test session. There was no association with freshman or not,  $\chi^2 (1) = .043, p = .836$ , and primary learning style,  $\chi^2 (2) = .818, p = .664$ . However, participation in post-test session was significantly associated with sex,  $\chi^2 (1) = .6300, p = .012$ . Female students participated more than could be expected, male students participated less than could be expected.

In conclusion, the group of non-participating and drop-out students who attended the post-test session was not entirely representative for the whole group of non-participating and drop-out students. They had relatively high results in secondary education, and female students were overrepresented.

### *Effects of Participation and Individual Differences on Method of Learning*

The method of learning variables of interest were STRATSR2 (strategic approach to studying based on achieving motivation and strategic, systematic self-regulation of learning at post-test measurement), SURFINC2 (surface approach to studying based on fear of failure and incompetence to regulate learning at post-test measurement), and DEEPSR2 (deep approach to studying based on interest in ideas and effective self-regulation in study activities at post-test measurement). Because these variables were uncorrelated factors resulting from varimax rotation, performing MANCOVA on these

variables was superfluous. Three separate 3x2x3x2 ANCOVAs were performed with participation, sex, primary learning style, and freshman or not as fixed factors, and the relevant pre-test method of learning variable (STRATSR1, SURFINC1, DEEPSR1) as covariate. Table 6 summarizes the results of these analyses.

Table 6

*Means, Standard Deviations and F Values for the Method of Learning Variables According to Participation, Sex, Primary Learning Style, and Freshman or Not*

	Participation						<i>F</i>	$\eta^2$
	Full participation ( <i>n</i> = 38)		Drop-out ( <i>n</i> = 9)		No participation ( <i>n</i> = 12)			
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
STRATSR2	.20	0.90	- .08	1.27	- .56	0.93	2.065 <sup>+</sup>	.090
SURFINC2	.07	1.10	.30	0.70	- .47	0.72	2.184 <sup>+</sup>	.094
DEEPSR2	.10	0.99	- .23	0.49	- .14	1.31	4.409**	.174
	Sex						<i>F</i>	$\eta^2$
	Male ( <i>n</i> = 10)		Female ( <i>n</i> = 49)					
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>				
STRATSR2	- .67	0.95	.14	0.96	7.979***	.160		
SURFINC2	- .56	0.80	.11	1.00	.902			
DEEPSR2	.20	1.22	- .04	0.96	2.405	.054		
<i>(table continues)</i>								

(table continues)

Primary learning style							
	Concrete experience + Reflective observation ( <i>n</i> = 7)		Abstract conceptualization ( <i>n</i> = 37)		Active experimentation ( <i>n</i> = 15)		
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>F</i> $\eta^2$
STRATSR2	.15	0.87	-.08	1.04	.14	0.99	2.296
SURFINC2	-.16	0.63	-.08	1.05	.28	1.01	1.042
DEEPSR2	-.31	0.97	.14	0.98	-.21	1.05	3.291**    .135
Freshman?							
	Yes ( <i>n</i> = 52)		No ( <i>n</i> = 7)				
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>F</i>		$\eta^2$
STRATSR2	-.07	0.95	.56	1.22	0.261		
SURFINC2	-.02	1.03	.13	0.73	0.030		
DEEPSR2	.00	1.01	-.03	1.00	0.268		

<sup>+</sup>  $p < .150$ . \*  $p < .100$ . \*\*  $p < .05$ . \*\*\*  $p < .01$ .

### STRATSR2.

Levene's test indicated that there was homogeneity of variances,  $F(15, 43) = .981$ ,  $p = .490$ . The covariate STRATSR1 significantly adjusted the dependent variable STRATSR2,  $F(1,42) = 15.602$ ,  $p < .000$ . Partial  $\eta^2$  was .271.

After adjustment for the covariate, there was a significant main effect of sex on STRATSR2,  $F(1,42) = 7.979$ ,  $p = .007$ . This could be considered as a large effect, with partial  $\eta^2 = .160$ . Pairwise comparison of adjusted marginal means indicated that female students scored significantly higher on STRATSR2 than male students.

Participation in the self-regulated learning program did not have a significant effect on STRATSR2 after adjustment,  $F(2,42) = 2.065$ ,  $p = .140$ . However, effect size was medium, partial  $\eta^2 = .090$ . Pairwise comparisons of adjusted marginal means showed that the difference in STRATSR2 between students who attended the full

program and students who did not participate was meaningful ( $p = .094$ ).  $d$  for this particular contrast was .78, indicating a rather large effect. This result is in support of our second hypothesis, stating that the participating students would be more likely to report a method of learning incorporating self-regulated learning.

Next, there was a significant interaction effect of participation and primary learning style on STRATSR2 after adjustment,  $F(3,42) = 3.632$ ,  $p = .020$ , partial  $\eta^2 = .206$ . Comparison of adjusted cell means and examination of the profile plot (Figure 3) suggested that in the group of students who participated in the full program, students with different primary learning styles obtained approximately the same STRATSR2 scores. In the other groups, the differences between the various primary learning styles were larger.

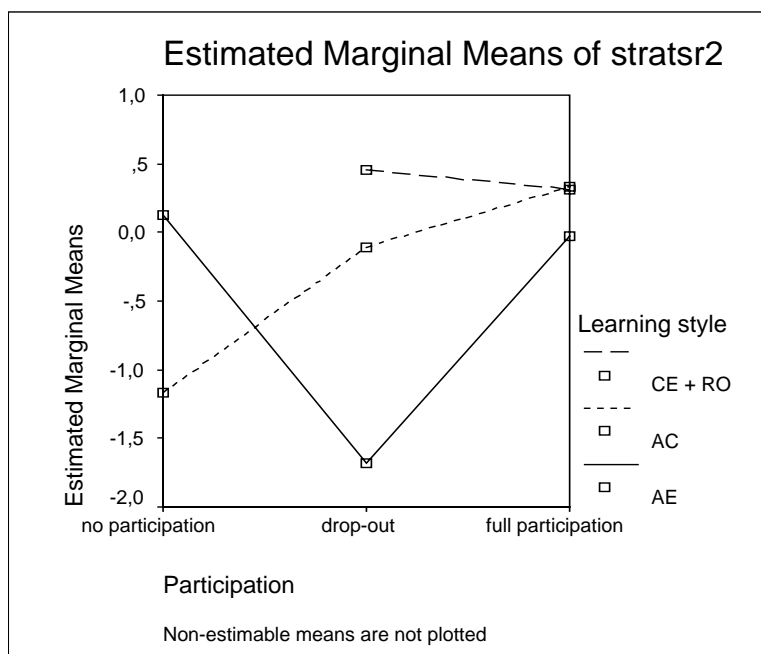


Figure 3. Profile plot of the interaction effect of participation and primary learning style on STRATSR2

### *SURFINC2.*

Levene's test indicated that there was homogeneity of variances,  $F(15, 43) = .909, p = .561$ . The covariate SURFINC1 significantly adjusted the dependent variable SURFINC2,  $F(1,42) = 54.760, p < .000$ . Partial  $\eta^2$  was .566.

After adjustment for the covariate, there were no significant main or interaction effects of the factors on SURFINC2. There however seemed to be a medium effect of participation,  $F(2,42) = 2.184, p = .125$ . Partial  $\eta^2$  was .094.

Examination of adjusted marginal means showed that the drop-out students had the highest scores on SURFINC2, followed by the students who participated in the full self-regulated learning program. The students who did not participate had the lowest scores. Especially the contrast between drop-out students and students who did not participate was meaningful,  $d$  was 1.08.

### *DEEPSR2.*

Levene's test indicated that there was homogeneity of variances,  $F(15, 43) = 1.191, p = .315$ . The covariate DEEPSR1 significantly adjusted the dependent variable DEEPSR2,  $F(1,42) = 4.259, p = .045$ . The association with the dependent variable was however not very large, with partial  $\eta^2 = .092$ .

After adjustment for the covariate, there were significant main effects of participation and of primary learning style on DEEPSR2.

For participation,  $F(2,42) = 4.409, p = .018$ , with partial  $\eta^2 = .174$ . This is indicative of a large effect. Examination of adjusted marginal means indicated that the students who participated in the full program had the highest scores on DEEPSR2 after adjustment, followed by the drop-out students. The students who did not participate obtained the lowest scores.  $d$  for the contrast between participating and non-participating students was .72 indicating a medium to large effect. This result supports our hypothesis that the participating students would be more likely to report a method of learning incorporating self-regulated learning.

For primary learning style,  $F(2,42) = 3.291, p = .047$ . Partial  $\eta^2$  was .135, which is indicative of a large effect. Examination of adjusted marginal means indicated that the highest scores on DEEPSR2 after adjustment were obtained by students with an



abstract conceptualization primary learning style. The lowest scores were obtained by students with a doing primary learning style. The students with a feeling or watching primary learning style fell between these two groups.

There were two large and significant interaction effects on DEEPSR2 after adjustment for the covariate: of participation and sex, and of participation and primary learning style.

For the interaction effect of participation and sex on DEEPSR2,  $F(2,42) = 4.955$ ,  $p = .012$ , with partial  $\eta^2 = .191$ .

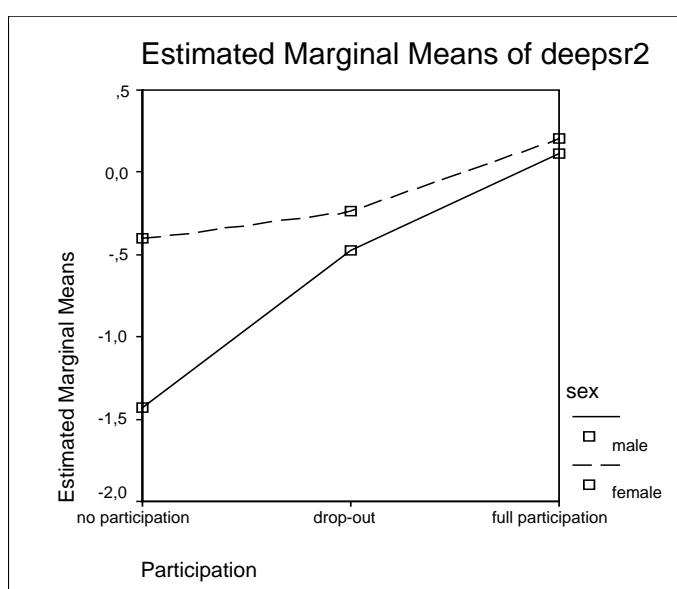


Figure 4. Profile plot of the interaction effect of participation and sex on DEEPSR2

The profile plot (Figure 4) showed that overall, female students had higher DEEPSR2 scores. However, for students who participated in the full program, the DEEPSR2 scores of male and female students did not strongly differ. The difference is slightly larger for drop-out students, but the in the group of non-participating students, the difference between male and female students is largest.

For the interaction effect of participation and primary learning style,  $F(3,42) = 5.201$ ,  $p = .004$ , and partial  $\eta^2 = .271$ .

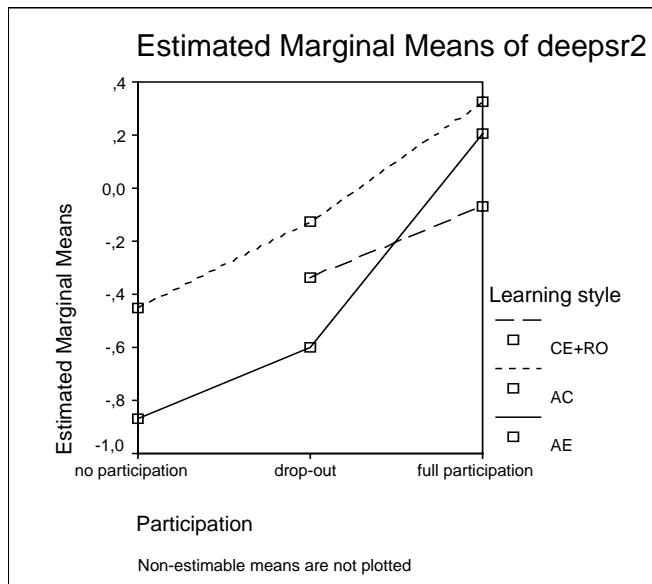


Figure 5. Profile plot of the interaction effect of participation and primary learning style on DEEPSR2

Overall, students with an abstract conceptualization primary learning style scored higher than students with a concrete experience or reflective observation primary learning style, who in turn scored higher than students with an active experimentation primary learning style. However, the profile plot showed that in the group of students who participated in the full program, this order changed: the students with an active experimentation primary learning style scored almost as high on DEEPSR2 as the students with an abstract conceptualization primary learning style.

#### *Effects of Participation and Individual Differences on Perceived Self-Efficacy*

A 3x2x3x2 between-subjects MANOVA was performed on four dependent variables representing perceived self-efficacy (SE): general learning efficacy, self-efficacy in self-regulated learning (SRL), and self-efficacy in academic performance (self-efficacy in achieving 14 to 15 on biochemistry, and self-efficacy in achieving 700 to 799 as total exam score). Independent variables were participation, sex, primary learning style, and freshman or not.

Table 7

*Means, Standard Deviations and F Values for the Perceived Self-Efficacy Variables According to Participation, Sex, Primary Learning Style, and Freshman or Not*

	Participation							
	Full participation ( <i>n</i> = 35)		Drop-out ( <i>n</i> = 9)		No participation ( <i>n</i> = 11)			
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>F</i>	$\eta^2$
General learning efficacy	75.94	10.14	74.2 2	7.69	81.81	14.71	2.347 <sup>+</sup>	.107
SE in SRL	68.94	8.58	61.8 3	12.66	61.36	9.53	12.740****	.395
SE in achieving 14-15 on biochemistry	33.31	21.18	28.8 9	15.36	30.90	27.37	0.188	
SE in achieving 700-799 as total exam score	26.46	20.62	23.3 3	17.32	29.09	30.81	0.257	
	Sex							
	Male ( <i>n</i> = 10)		Female ( <i>n</i> = 45)					
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			<i>F</i>	$\eta^2$
General learning efficacy	79.30	12.67	76.29	10.64			3.065*	.073
SE in SRL	66.80	8.77	66.14	10.33			0.309	
SE in achieving 14-15 on biochemistry	44.00	22.21	29.47	20.57			2.071	
SE in achieving 700-799 as total exam score	28.00	24.85	26.13	21.81			0.472	

*(table continues)*

	Primary learning style							
	Concrete experience + Reflective observation ( <i>n</i> = 7)		Abstract conceptuali- zation ( <i>n</i> = 36)		Active experimenta- tion ( <i>n</i> = 12)			
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>F</i>	$\eta^2$
General learning efficacy	80.00	5.77	76.41	11.29	76.25	12.63	1.229	.153
SE in SRL	70.62	10.57	65.04	9.05	67.38	12.25	3.515**	
SE in achieving 14-15 on biochemistry	27.14	21.38	33.42	21.32	31.08	23.15	0.051	
SE in achieving 700-799 as total exam score	22.86	18.90	27.67	23.24	25.00	21.95	1.272	
	Freshman?							
	Yes ( <i>n</i> = 49)				No ( <i>n</i> = 6)			
	<i>M</i>	<i>SD</i>		<i>M</i>	<i>SD</i>		<i>F</i>	$\eta^2$
General learning efficacy	76.45	11.39		80.00	6.32		0.346	
SE in SRL	65.66	10.30		71.13	5.31		0.152	
SE in achieving 14-15 on biochemistry	32.88	21.70		25.83	19.60		0.011	
SE in achieving 700-799 as total exam score	26.24	22.82		28.33	17.22		1.202	

<sup>+</sup>  $p < .150$ . \*  $p < .100$ . \*\*  $p < .05$ . \*\*\*  $p < .01$ . \*\*\*\*  $p < .001$

Box's test indicated that there might be a problem with the homogeneity of variance-covariance matrices,  $F(30, 1114.631) = 2.055$ ,  $p = .001$ . Therefore, Pillai's criterion

was used instead of Wilk's Lambda to evaluate significance (Tabachnick & Fidell, 1996).

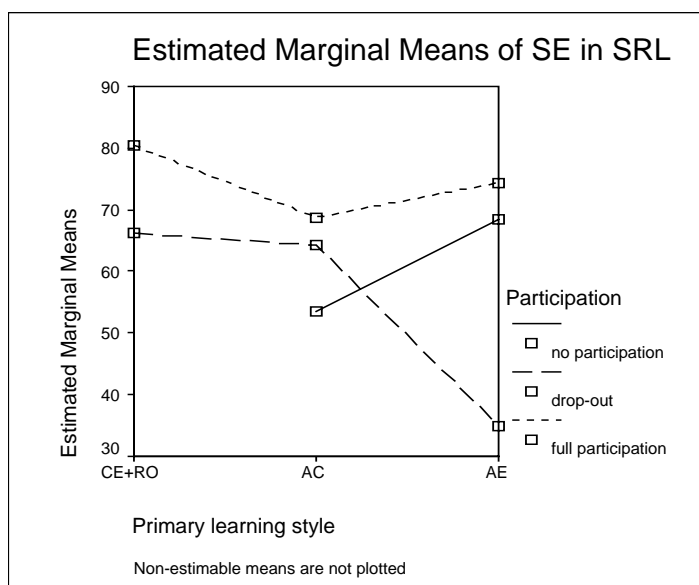
The combined perceived self-efficacy variables were significantly affected by participation,  $F(8,74) = 4.143$ ,  $p < .000$ , partial  $\eta^2 = .309$ ; sex,  $F(4,36) = 2.144$ ,  $p = .095$ , partial  $\eta^2 = .192$ ; primary learning style,  $F(8,74) = 1.820$ ,  $p = .087$ , partial  $\eta^2 = .164$ ; and the interaction effect of participation and primary learning style,  $F(12,114) = 3.398$ ,  $p < .000$ , partial  $\eta^2 = .263$ .

Separate  $F$ 's more specifically showed that there was a large and significant effect of participation on self-efficacy in self-regulated learning,  $F(2,39) = 12.740$ ,  $p < .000$ . Partial  $\eta^2$  was .395. Pairwise comparisons indicated that students who participated in the full program had the highest level of self-efficacy in self-regulated learning, followed by the students who did not participate and the drop-out students. The participating students' self-efficacy in self-regulated learning significantly increased compared to the first assessment at the start of the self-regulated learning program,  $M_{\text{session 1}} = 65.13$ ,  $t(36) = 2.234$ ,  $p = .032$ . Standardized mean differences ( $d$ ) for the contrasts between participating and non-participating students and between participating and drop-out students were .83 and .66 respectively, indicative of medium to large effects. These results imply that our hypothesis that participating students would have a higher level of perceived self-efficacy than the drop-out and the non-participating students applies to self-efficacy in self-regulated learning.

Also primary learning style had a significant effect on self-efficacy in self-regulated learning,  $F(2, 39) = 3.515$ ,  $p = .039$ . Partial  $\eta^2$  was .153, indicative of a large effect. Students with a concrete experience or reflective observation primary learning style had a higher level of self-efficacy in self-regulated learning than the students with an active experimentation primary learning style and students with an abstract conceptualization primary learning style, who had approximately the same level of self-efficacy in self-regulated learning.

Both independent variables exercised a large and significant interaction effect on self-efficacy in self-regulated learning,  $F(3, 39) = 3.790$ ,  $p = .018$ , partial  $\eta^2 = .226$ . The profile plot (Figure 6) showed that the students with an active experimentation primary

learning style who dropped out had very low scores on self-efficacy in self-regulated learning.



*Figure 6.* Profile plot of the interaction effect of participation and primary learning style on self-efficacy in self-regulated learning.

Last, self-efficacy in self-regulated learning was meaningfully affected by the interaction of participation and sex,  $F(2, 39) = 2.538, p = .092$ . Partial  $\eta^2$  was .115. Overall, the students who fully participated in the self-regulated learning program had a higher level of self-efficacy in self-regulated learning than the students who did not participate, who in their turn had a higher level of self-efficacy in self-regulated learning than the drop-out students. The profile plot (Figure 7) indicated that this order lasted for female students, but in the group of male students, it were the non-participating students who showed the lowest level of self-efficacy in self-regulated learning. The male drop-out students scored almost as high as the male participating students.

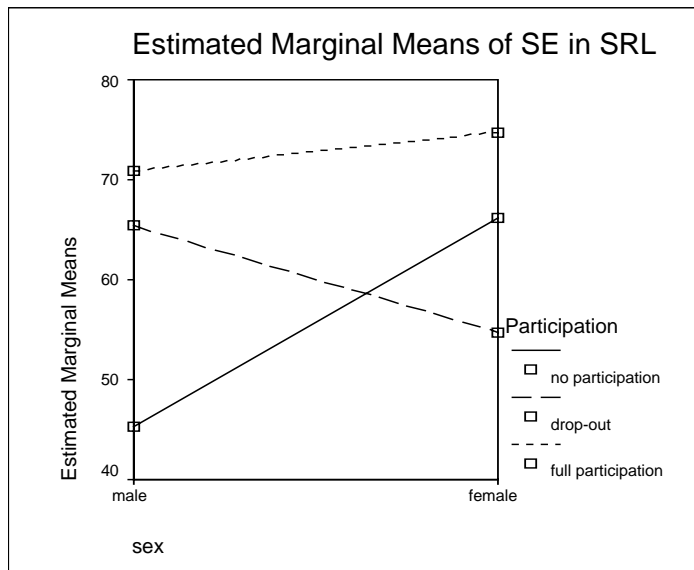


Figure 7. Profile plot of the interaction effect of participation and sex on self-efficacy in self-regulated learning.

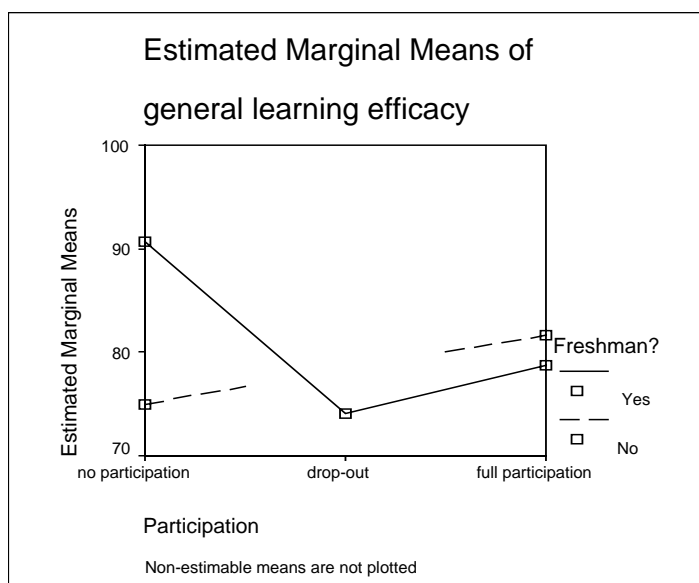
Separate  $F$ 's further showed that participation had a meaningful and relatively large effect on general learning efficacy,  $F(2, 39) = 2.347$ ,  $p = .109$ , partial  $\eta^2 = .107$ . Pairwise comparisons indicated that students who participated had a lower level of general learning efficacy than the students who did not participate, but a higher level of general learning efficacy than the drop-out students. This result suggests that our hypothesis that participating students would have a higher level of perceived self-efficacy than the drop-out and the non-participating students is not applicable to general learning efficacy.

Also sex had a meaningful effect on general learning efficacy,  $F(1, 39) = 3.065$ ,  $p = .088$ . Partial  $\eta^2$  was .073, a medium effect. Male students tended to have a higher level of general learning efficacy than female students.

There was a significant interaction effect of participation and the variable freshman or not on general learning efficacy,  $F(1, 39) = 4.584$ ,  $p = .039$ , with partial  $\eta^2 = .105$ .

Overall, students who did not participate tended to have the highest level of general learning efficacy. The profile plot (Figure 8) indicated that for the students who were not freshmen, this was not the case: those who did not participate had a low level of

general learning efficacy. Those who participated had a higher level of general learning efficacy than the participating freshman students.

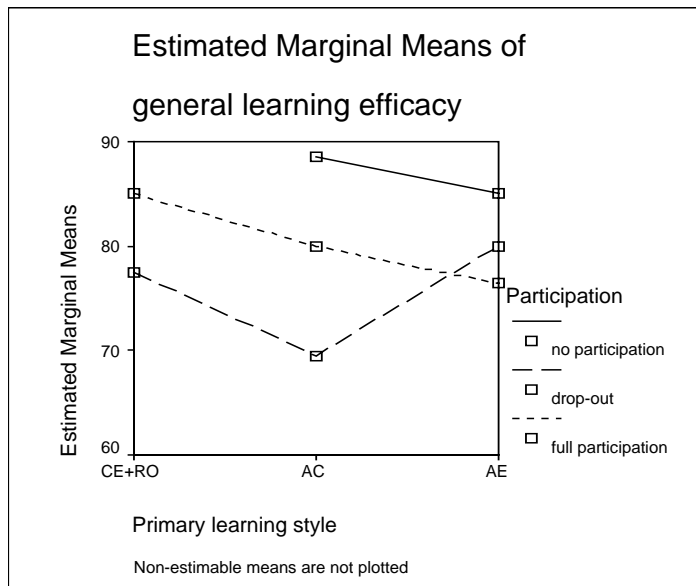


*Figure 8.* Profile plot of the interaction effect of participation and freshman or not on general learning efficacy.

Lastly, there was a meaningful and large interaction effect of participation and primary learning style on general learning efficacy,  $F(3, 39) = 2.363$ ,  $p = .086$ , partial  $\eta^2 = .154$ .

Overall, drop-out students tended to have the lowest level of general learning efficacy. The profile plot (Figure 9) showed that drop-out students with an active experimentation primary learning style were an exception. Their general learning efficacy level was higher than that of participating students with an active experimentation primary learning style.





*Figure 9.* Profile plot of the interaction effect of participation and primary learning style on general learning efficacy.

Finally, there were no significant main or interaction effects of participation and the individual differences factors on self-efficacy in academic performance. Our hypothesis that participating students would have a higher level of perceived self-efficacy than the drop-out and the non-participating students therefore does not apply to self-efficacy in academic performance.

## Discussion and Conclusions

The aim of this study was to investigate whether a program that was developed to support self-regulated learning in university students had an effect on the students' academic performance, method of learning and perceived self-efficacy. The students who attended the full program were compared with those who did not participate and those who dropped out during the course of the year. The results are discussed in relation to the conceptual framework that grounded the program.

### *Effects of the Self-Regulated Learning Program*

First, the study showed that, contrary to our predictions, the self-regulated learning program had no effect on the students' final exam results. The participating students did not obtain significantly better final grades than the non-participating and the drop-out students. However, in the group of non-participating students, the final exam results might have been artificially enhanced. Seven of these students stopped studying before the end of the academic year. It could be expected that if they would have participated in the examinations, the mean exam result of the non-participating students would have been lower and the contrast with the results of the participating students would consequently have been larger.

Second, the self-regulated learning program did have an effect on the students' method of learning. Our hypothesis that students who participated in the program would be more likely to report a method of learning incorporating self-regulated learning was confirmed. The participating students reported a more strategic approach to studying, based on achieving motivation and strategic, systematic regulation of learning. They also had a deeper approach to studying than the non-participating students, based on interest in ideas and self-regulation of learning. This was, however, not reflected in a lower level of surface approach, based on fear of failure and incompetence to regulate learning. A first explanation can be found in the students' metacognitive beliefs. Possibly, these participating students still remained somewhat uncertain about their method of studying and their ability to regulate, just because they were fully aware of what is involved. This is similar to the ironical effects of self-

awareness, investigated in social psychology, which imply that every conscious attempt to control behavior, is attended by the fear to fail (Brehm, Kassin, Fein, & Mervielde, 2000). Also the learning environment could play a role: medical education is a very demanding environment, with high standards of excellence. It is generally accepted that this stimulates need for achievement, which is known to be related to fear of failure (Gross, 1992).

Lastly, the program also had an effect on aspects of the participating students' perceived self-efficacy. Their self-efficacy in self-regulated learning increased over the course of the year. The program however did not have an effect on self-efficacy in academic performance. This might be explained by the students' limited knowledge of the learning environment. These first-year students did not yet have experience with the specific form of integrated final examinations typical of medical education at Ghent University, to base their academic efficacy judgments on. The program did also not provide clear information on this issue, so the participating students did not have an advantage on that part.

As to general learning efficacy, there was an effect of participation, but it were the non-participating students who gave themselves the highest ratings. They were very confident about their capacity to learn, probably the reason why they did not participate in the first place. For the participating students, the ironical effect of self-awareness might also here have been in play: the program made the students aware of the complexities of learning and of their own strengths and weaknesses, which might have made them more reserved in reacting on the decisive statement "When I work hard enough, I can actually learn everything".

Overall, these results confirm the domain-specificity of perceived self-efficacy. According to Bandura (1986, 2001; see also Pajares, 1996) the efficacy belief system is a differentiated set of beliefs linked to distinct realms of functioning. Self-regulated learning was the aim of the program, and participants reported increased self-efficacy, but only within the domain of self-regulated learning.

Following current knowledge about self-regulation and self-efficacy (Bandura, 1989; Boekaerts, 1997; Pajares, 1996; Schunk & Zimmerman, 1998; Zimmerman, 2000; Zimmerman & Schunk, 2001), we had high expectations about the beneficial

effects on academic performance of a self-regulated method of learning and the accompanying beliefs of self-efficacy. However, in this study, the effect of the program on these variables did not translate to better exam results for the participating students.

Probably the most plausible explanation lies in the students' prior knowledge. It is well-known that domain-specific prior knowledge strongly influences academic learning and performance (Alexander, 1992; Boekaerts, 1996; Vanderstoep, Pintrich, & Fagerlin, 1996; Winne, 2001). The large association between the covariate study results in secondary education and final exam results confirms this effect. All students in our study have passed an entrance examination, so they can be considered as well-prepared students, who have approximately the same starting level of declarative, procedural, and conditional knowledge in the domains of physics, chemistry, biology, and mathematics. The fact that self-regulatory strategy instruction did not have an additional effect on academic performance for the participating students might be due to this ceiling effect of prior knowledge. Also Hattie et al. (1996) observed a ceiling effect in university-level populations of high ability. In this group, more positive attitudes towards their study did not necessarily translate into performance outcomes.

Another explanation often found in the literature is that a deep, strategic, self-regulated method of learning does not necessarily lead to better learning outcomes if the learning environment, and more specifically the assessment procedure, does not emphasize and reward this way of learning (Entwistle & Tait, 1990; Vermunt & Van Rijswijk, 1988). Although at Ghent University, assessment in first-year medicine is partly based on permanent evaluation of work in problem-based learning tutorials and practical training sessions, the final (multiple-choice) examinations still emphasize and reward pure reproduction of knowledge.

Overall, the effects that have been found were above average. Hattie et al. (1996) reported an average effect size ( $d$ ) of .16 for effects of interventions on study skills and .48 for effects of interventions on affect. We obtained effect sizes of .78 and .72 for effects on method of learning, and .83 for the effect on self-efficacy in self-regulated learning. Knowing that the typical effect size in educational interventions is .40 (Hattie, 1992), these are striking figures.

Finally, it seems that the drop-out students need special attention. Up to now, we compared the students who attended the full self-regulated learning program with the non-participating and the drop-out students as if the latter groups did not differ from each other. This was however not the case. The results show that the drop-out students had the highest level of surface approach to studying based on fear of failure and incompetence to regulate learning at the end of the academic year. There was a large contrast with the non-participating students, who had the lowest score on this method of learning variable. Also for general learning efficacy, there was a large contrast, with the drop-out students having the lowest scores. Following the literature on self-efficacy and approaches to studying, these drop-out students must be considered as at risk of failure (Tait & Entwistle, 1996). It is striking that an intervention that should especially support these students, loses them over the course of the program. These students may not have felt very comfortable monitoring their behavior, reflecting about their own studying, talking about their method of learning with others, and so on (Paris & Paris, 2001). This might have caused them to quit the program.

### *Individual Differences*

A particular strength of this study is that we also included individual differences factors in the analyses to shed light on the full complexity of the self-regulated learning process as emphasized in the conceptual framework.

By including the individual differences factors sex, primary learning style, and freshman or not in the design, some interesting interaction effects were revealed. These variables moderated the effect of participation in the program.

First, there was an interaction effect of participation and sex, indicating that while female students overall tended to use a deeper approach to studying based on effective self-regulation than male students, this difference was reduced for male students who attended the full self-regulated learning program.

There also were interaction effects of participation and primary learning style. A first interaction effect indicated that in the group of students who participated in the full

program, students with different primary learning styles reached approximately the same level of strategic self-regulated learning, while for drop-out and non-participating students, the differences between the various primary learning styles remained larger. A second interaction effect concerned the deep approach to studying based on effective self-regulated learning: overall, students with an abstract conceptualization primary learning style scored higher than students with a concrete experience of reflective observation primary learning style, who in turn scored higher than students with an active experimentation primary learning style. However, the students with an active experimentation primary learning style who attended the program reached almost the same level as the students with an abstract conceptualization primary learning style.

A last interaction effect showed that while overall, non-participating students tended to have the highest level of general learning efficacy, this was not the case in the group of students who were no freshmen. In this group, it were the students who attended the full program who had the highest level of general learning efficacy.

These interaction effects suggest that the self-regulated learning program was able to abridge differences that were related to personal characteristics of the students. Participants from groups that tended to fall behind in some respects (male students, students with an active experimentation primary learning style, non-freshmen students) apparently took advantage of their participation. All this is in support of Zimmerman's (2002) statement that students' self-regulation can be a way to compensate for individual differences.

When we look at the main effects of the individual differences factors, it appears that sex is an important variable.

First of all, female students were diligent participants in our study: they were overrepresented in the post-test session and in the program as a whole. This is in line with the experiences of Zeegers and Martin (2001), who also observed that the attendees of their self-directed learning tutorials were predominantly female. This might be explained by the fact that male students more often have a non-academic learning orientation than female students (Severiens & ten Dam, 1997), which is at its turn related to the observation from research into the underachievement of boys that

boys tend to develop an anti-school, so called “laddish” culture (Jackson, 2002; Salisbury & Rees, 1999).

Further, female students scored significantly higher than male students on the course exploration and Studium Generale. This course aims at attitude formation by focusing on ethical principles and the social role of doctors and could be considered as the most “female” aspect of the first-year medicine curriculum. Female students also had a more strategic approach to studying based on achieving motivation and strategic, systematic self-regulation of learning. Also in other research, gender differences in the use of self-regulated learning strategies favoring female students have been reported (Pajares, 1996).

Overall, sex-role socialization seems to be the most plausible explanation for these differences (Bügel, 1991): being a well-organized, strategic, diligent student, to become an ethical, socially committed doctor, is more in line with a female than with a male sex-role.

Also gender differences in self-efficacy could be observed. Male students reported the highest level of general learning efficacy. As to self-efficacy in self-regulated learning, there was an interaction effect showing that female students who dropped out had a lower level of self-efficacy in self-regulated learning than female students who did not participate in the program, while for male students, the drop-out students had a higher level of self-efficacy in self-regulated learning than the non-participating students. This might suggest that male students who dropped out of the program felt confident that they were able to self-regulate, while, on the contrary, female students who dropped out were unsure about their ability to self-regulate.

Pajares and Schunk (Pajares, 1996; Schunk & Pajares, 2002) confirm that similar gender differences in self-efficacy are often reported (Bügel, 1991), but warn that it is possible that they are due to response bias: boys and girls use a different “metric” when providing confidence judgments. Boys tend to be more “self-congratulatory” in their responses whereas girls tend to be more modest, which at its turn can be a function of gender orientation, the stereotypic beliefs about gender that students hold.

### *Limitations*

A first limitation of this study relates to the decision to use self-report measures to assess method of learning. In the light of the result that a reported self-regulated method of learning did not translate in better academic outcomes, the possibility that these self-reports do not reveal what students actually do, limits our interpretive power. Did the participating students really incorporate self-regulated learning in their study method, or did they report it because they were aware that it was the aim of the program they attended? And how can we be sure that the non-participating students really to a lesser extent used self-regulatory strategies? Also the grain size of these measures might have been too large to be able to say exactly on which aspects of self-regulated learning the program had an effect. According to Veenman et al. (2003), process measures like thinking-aloud protocols or traces (see Winne & Jamieson-Noel, 2002) can more adequately reflect the study process and thus are said to be stronger predictors of study results. On the other hand, even these measures intervene in the environment and affect the learning process (Winne & Perry, 2000). Since it takes a lot of time to collect and analyze these protocols, they also pose practical problems.

Another limitation of the study was that, as a result of selective admission, first-year medical students are not representative for the whole first-year university population. This might not only have caused a ceiling effect, it also limits the generalizability of our results. Whether this really has to be considered as a problem is however open to debate: in this study, self-regulated learning is explicitly defined as determined by the triarchic interaction between person, environment, and behavior (Schunk, 2001; Zimmerman, 1989, 2000). This process and all attempts to foster it, must therefore always be understood within its unique context. Nevertheless, it would still be interesting to replicate this study in another, not pre-selected and more heterogeneous student group.

When a replication is considered, it might also be interesting to investigate the long-term effects of the program. In this study, only short-term effects have been examined. It would be interesting to know if the participants' advantage on method of



learning and perceived self-efficacy lasts over time and whether or not an effect on academic outcomes yet occurs in later years of their studies.

In general, to be able to get a full understanding of the effects of the program, the interrelationships between the method of learning, perceived self-efficacy, academic performance and individual differences variables need further investigation. Also qualitative data on the students appraisal of the program, on their reasons to drop out, ect. need to be examined. Only in this manner, the complex dynamics of an intervention to stimulate self-regulated learning can be revealed.

### *Implications*

This study has practical as well as theoretical implications. Because our self-regulated learning program was developed and implemented in an ecologically valid environment, our results can on the one hand contribute to the optimization of educational, in this case academic counseling, practice. They can inform further development and amelioration of similar programs. For example, we learnt that the students who drop out of an elective program tend to feel very unconfident about their self-regulated learning abilities. The program might even have discouraged these students. More effort apparently has to be made to motivate particularly this group of possibly at risk students (on the importance of motivating adult students, see Volet, 1991).

Optimization of educational practice can also be expected because the program was developed in partnership with the academic counselor of the Faculty of Medicine and Health Sciences, in this way contributing to the professionalization of this practitioner.

On the other hand, also progress in theory building has been made. The results of this study corroborate the knowledge that self-regulated learning can be taught by providing adequate instructional support. More specifically, they support the contention that elective counseling programs outside the normal teaching context can be effective if they are set up as relational interventions based on an integrative conceptual framework and the instructional principles of social learning, direct instruction, realistic context and content, and metacognitive awareness. In addition,

this study stresses that the effects of these programs can only be fully understood if the interactions with individual characteristics and the learning environment are also taken into account. Also for this purpose, the integrative conceptual framework showed to be crucial.

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## Chapter 4

### **The Social Cognitive Dynamics of Self-Regulated Learning in First-Year Medical Students: Predictors of Perceived Self-Efficacy, Method of Learning, and Academic Performance\***

*This study examines how the dynamics that are set out in the social cognitive model of self-regulated learning manifest themselves in the study processes of first-year medical students. Core person and behavior variables were assessed. Multiple regressions were used to examine which variables have the highest predictive value for perceived self-efficacy, method of learning (including self-regulated learning), and academic performance. Especially the behavioral self-regulation feedback loop between method of learning and perceived self-efficacy could be clearly distinguished. The key role of self-efficacy was confirmed. By using a differentiated set of self-efficacy beliefs, a refined picture of their antecedent and consequent variables was revealed. Individual differences in sex, age, learning style, and prior and domain knowledge, were other relevant elements in the prediction of the dependent variables.*

Self-regulated learning (SRL) refers to those forms of learning that are metacognitively guided, at least partly intrinsically motivated, and strategic (Winne, 2001). Although the many theoretical perspectives on self-regulated learning emphasize different features, Zimmerman (2001) proposes the following general definition: “Students are self-regulated to the degree that they are metacognitively, motivationally, and behaviorally active participants in their own learning process. These students self-generate thoughts, feelings, and actions to attain their personal learning goals” (p. 5). Research has clearly demonstrated that students who employ self-regulated approaches to learning achieve more and are more satisfied with their work. Self-regulatory processes lead to an

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increase in the students' motivation and to success in school (Boekaerts, 1997; Schunk & Zimmerman, 1998; Zimmerman & Schunk, 2001).

In this study, we want to examine whether and how the dynamics that are set out in the social cognitive model of self-regulated learning manifest themselves in the study processes of first-year medical students. This social cognitive perspective of self-regulated learning, as summarized in Figure 1, is one of the dominant theoretical perspectives on self-regulated learning (Puustinen & Pulkkinen, 2001; Zimmerman & Schunk, 2001). It offers a lucid general framework for understanding this complex interactive process.

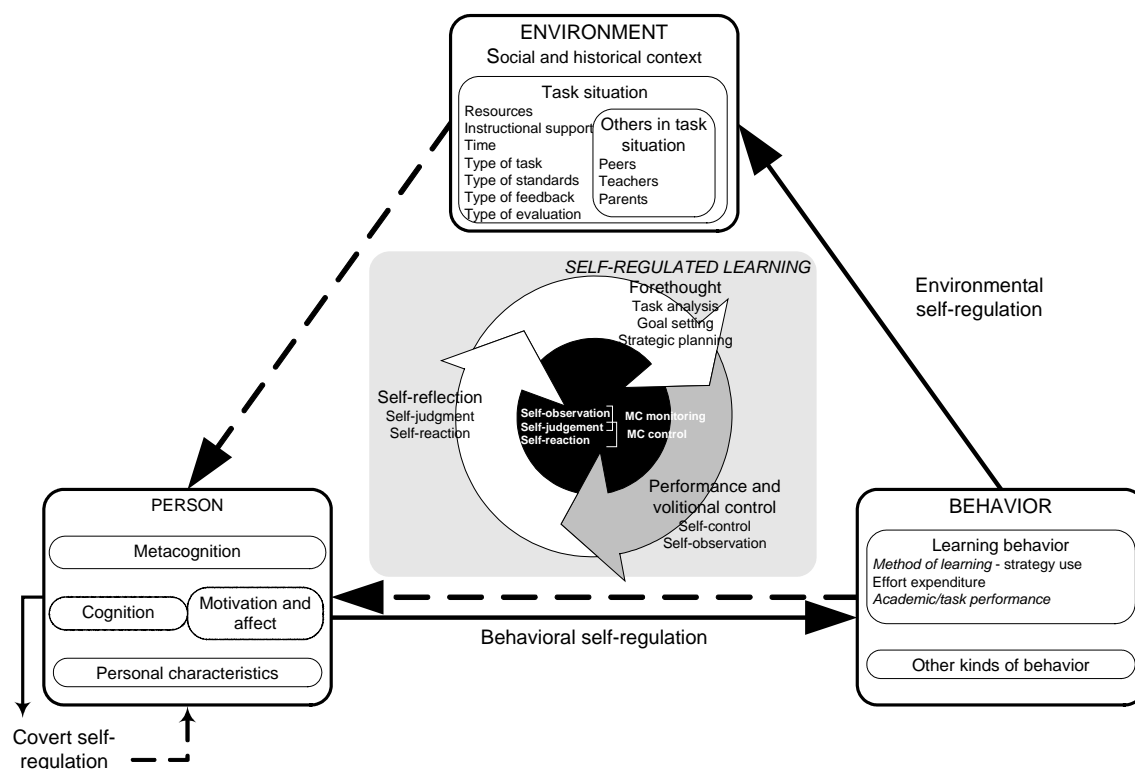


Figure 1. The social cognitive model of self-regulated learning

According to social cognitivists (Schunk, 2001; Zimmerman, 1989, 1995, 2000), self-regulated learning consists of three self-oriented feedback loops: behavioral self-regulation, environmental self-regulation, and covert self-regulation. The different self-regulatory processes and accompanying beliefs fall into three

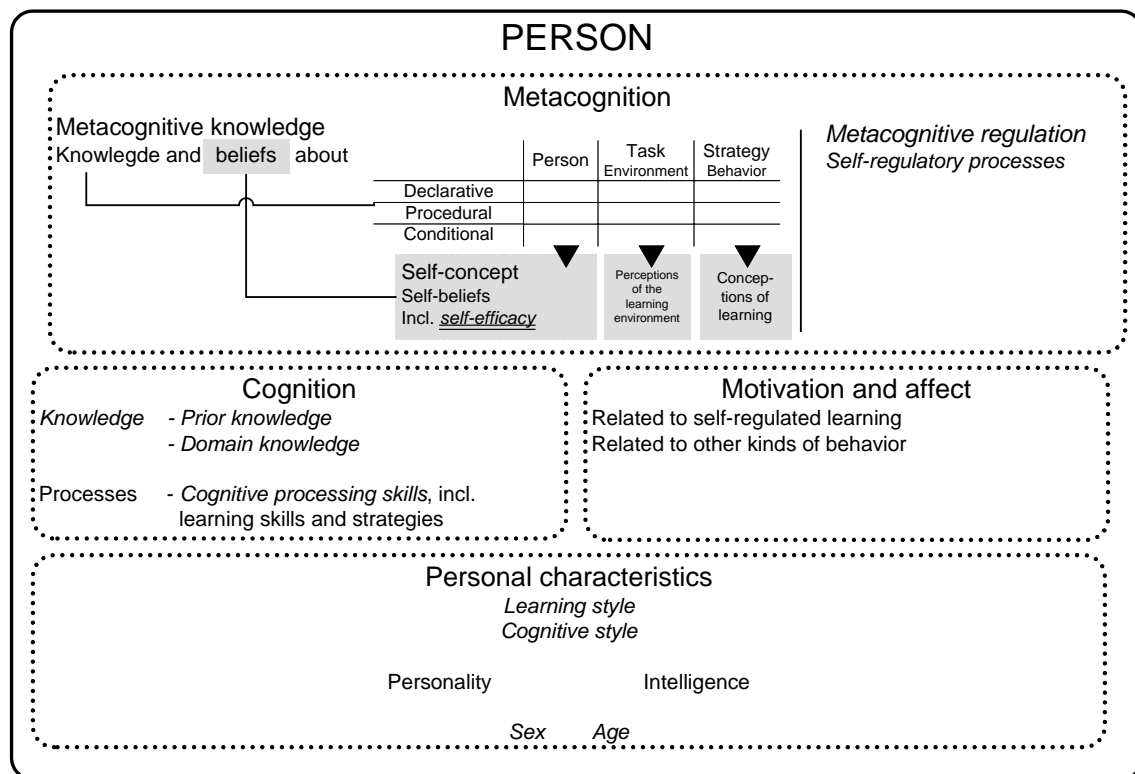
cyclical phases: forethought, performance and volitional control, and self-reflection. Furthermore, of all self-regulatory processes, self-observation, self-judgment, and self-reaction are considered to be the key subprocesses of self-regulation. They interact with each other in a reciprocal fashion (Zimmerman, 1989; Schunk, 2001).

A particularly interesting feature of social cognitive theory is that it embeds these self-regulatory processes within a broader system of triarchic interactions between personal, behavioral and social-environmental factors (Schunk, 2001; Zimmerman, 1989, 2000). In the further description of these factors we have integrated elements from the theory on (meta)cognition, (self-regulated) learning, and motivation.

First, the *environmental factors* can relate to the task situation or to others in the task situation (Corno, 2001). Elements of the task situation that can influence or might be influenced by self-regulated learning are the available resources, the instructional support, time allocation, the type of task, the type of standards, the type of feedback, and the type of evaluation (Schunk, 2001; Winne, 2001). Relevant others in the task situation are peers, teachers, and parents. In general, these environmental factors are crucial because they define the extent to which students have the freedom and opportunity to self-regulate.

*Behavioral factors* include learning behavior such as method of learning (strategy use), effort expenditure, and academic or task performance. It is, however, also important to pay attention to other kinds of behavior (sleeping habits, hobbies, etc.) that can stimulate or hamper self-regulated learning.

Figure 2 zooms in on the various *personal factors* and processes relating to self-regulation.



*Figure 2. Personal factors and processes relating to self-regulated learning*

Within these personal factors and processes, which are all interrelated, more and less stable elements can be assumed. Among the more stable personal characteristics are cognitive style and learning style. Others are sex, age, personality, and intelligence. The less stable, more context-sensitive elements can roughly be sub-divided into cognition, motivation and affect, and metacognition.

Cognition comprises a student's base of prior knowledge and domain knowledge on the one hand, and his or her base of cognitive processing skills on the other. The latter also includes the learning skills and strategies that he or she has mastered.

Motivation refers to the will to self-regulate and to learn. Affect refers to all kinds of feelings that accompany and influence self-regulated learning. Also motivation for other behavior than studying, and feelings that have other sources, can affect and be affected by self-regulation. Motivation and affect are strongly determined by the metacognitive beliefs a student holds (Bandura, 1997; Boekaerts, 1995, 1996; Paris, Byrnes, & Paris, 2001; Pintrich & De Groot, 1990).

Metacognition receives the bulk of the attention in the recent literature on learning. It is generally assumed to have two components: metacognitive knowledge and metacognitive regulation or control (Brown, 1987; Hacker, 1998; Schraw, 2001). The two are closely related and feed each other recursively. Metacognitive regulation refers to the self-regulatory processes central to self-regulated learning. Metacognitive knowledge was originally defined by Flavell as “that segment of one’s stored world knowledge that has to do with people as cognitive creatures and with their diverse cognitive tasks, goals, actions, and experiences” (Flavell, 1979, p. 906). In his later work, he broadened this definition to include knowledge and beliefs, about anything psychological, including emotions, motives, etc. (Flavell, 1987). This metacognitive knowledge is commonly classified according to two dimensions. The first dimension is Flavell’s (1979, 1987) distinction between knowledge of person variables, of task variables, and of strategy variables. The second dimension is the distinction between declarative, procedural, and conditional knowledge (Schraw & Moshman, 1995; Schraw, 2001). Because people’s levels of motivation, affective states, and actions are based more on what they believe than on what is objectively true (Bandura, 1997), the believe-aspect of metacognitive knowledge is very important. For social cognitivists, perceived self-efficacy is the key self-belief affecting learning. It refers to people’s beliefs in their capabilities to produce desired effects by their actions. These beliefs are constructed from four principal sources of information: enactive mastery experiences, vicarious experiences, social influences, and physiological and affective states (Bandura, 1997). In social cognitive theory, change in self-efficacy is considered the main outcome of feedback (dotted arrow in Figure 1): it serves as a sort of thermostat that regulates strategic efforts to acquire knowledge and skill. Self-efficacy is known to affect behavior in several ways: it influences the choices individuals make and the course of actions they pursue; it determines their level of effort, persistence, and resilience; and influences individuals’ thought patterns and emotional reactions. As a result, self-efficacy beliefs are strong determinants and predictors of the level of accomplishment that individuals finally attain (Bandura, 1989; Pajares, 1996). Zimmerman added that a high level of self-efficacy is associated with better quality learning strategies, more self-monitoring, and finally, higher academic achievement



(Zimmerman, 2000). In comparison with these self-beliefs, metacognitive beliefs about environmental or behavioral variables receive little attention in the literature on self-regulation. In the research on approaches to learning, however, it was found that students' perceptions of academic learning environments are important mediators of the effects of these environments on study behavior (Entwistle & Tait, 1990). Also students' conceptions of learning ("What do you mean by learning?"), which can be seen as metacognitive beliefs about learning behavior developed through experiences of teaching and studying, influence the way in which they actually learn (Marton, Beaty, & Dall'Alba, 1993; Marton, Hounsell & Entwistle, 1997).

Within the context of academic counseling in first-year medical education, we had the opportunity to inquire about some of these core person and behavior variables that are said to be affecting and affected by self-regulated learning, namely prior and domain knowledge, cognitive processing skills, sex, age, cognitive style, learning style, perceived self-efficacy, method of learning (including self-regulated learning), and academic performance. These variables are italicized in Figure 1 and Figure 2.

To test the dynamics that are set out in social cognitive theory, the following research questions were investigated.

1. How are the person and behavior variables, as measured at the start of the academic year, interrelated?
2. Which of these antecedent variables are the best predictors of students' perceived self-efficacy at the end of the academic year? We hypothesize that prior and domain knowledge, and method of learning as measured at the start of the academic year, will be the strongest predictors, for they best reflect the students' previous learning experiences.
3. Which of the person and behavior variables are the best predictors of students' method of learning, including self-regulated learning, at the end of the academic year? According to the social cognitive model, perceived self-efficacy should play a crucial role, next to method of learning measured at the start of the academic year.
4. To what extent do these person and behavior variables predict academic performance at the end of the academic year? Following the theory,

perceived self-efficacy and method of learning should make a significant contribution.

Correlational analysis and multivariate regression were used.

## Method

### *Participants*

Data were collected within the context of an academic counseling program at the Faculty of Medicine and Health Sciences at Ghent University. Informed consent was obtained and anonymity of data-processing was guaranteed. All first-year medical students ( $N = 145$ ) were invited to the assessment sessions, which were planned following on their normal courses. 132 students (92.3 % of total) participated in a first assessment session at the start of the academic year. Their ages varied between 17 and 26, with a mean of 18.2. The gender distribution was 32% male and 68% female.

To mobilize the students for participation in a second assessment session at the end of the academic year, this session was explicitly announced in a preceding lesson. 59 students attended this session (40.7% of total). Their age varied between 17 and 19, with a mean of 18.05. Gender distribution was 17% male and 83% female. The analyses in this study were conducted on this sub-sample. However, this sub-sample was not entirely representative for the whole group: female students were overrepresented, and the students who participated in the second assessment session reported a higher study result in secondary education than the students who did not participate in the second assessment session,  $F(1,129) = 9.619$ ,  $p = .002$ . This information has to be taken into account when interpreting further results.

### *Instruments*

#### *Person Variables*

##### *Background information – Questionnaire.*

A questionnaire was developed to inquire about relevant background information during the first assessment session: age, sex, studies last year (to see if they were

freshmen or not), self-reported study result in secondary education (mean end-examination score on 100), as indicator of prior knowledge, and results on the Flemish admission examination.

The latter admission examination has been introduced in Flanders in 1997 to restrict entrance to medical education. It assesses scientific knowledge and insight in the fields of physics, chemistry, biology, and mathematics on the one hand, and information processing skills on the other. These information processing skills are tested with a case-based assessment of information acquisition on the one hand, and four specific tests, namely cognitive reasoning, visual information processing, memory and pattern recognition, on the other (Lievens, Coetsier, Janssen, & Decaesteker, 2001). In this study the score (on 20) for knowledge of and insight in sciences is considered as an indicator of domain knowledge, and the score (on 20) for information processing is considered as an indicator of cognitive processing skills.

#### *Cognitive style – Group Embedded Figures Test (GEFT).*

Witkin's field dependence/independence (FD/I) was chosen to operationalize cognitive style, because it proves to be the primordial cognitive style model in the field (see Desmedt & Valcke, 2004).

The Group Embedded Figures Test (Witkin, Oltman, Raskin & Karp, 1971) was used to measure this variable. It is a 20-item paper- and pencil speed test in which respondents have to find a simple figure in a more complex figure. The GEFT comprises three sections: the first section contains 7 very simple items (2 minutes), and both the second and third section contain 9 more difficult items (5 minutes each). A student's test score is the total number of simple forms correctly traced in the second and third sections combined. High GEFT scores indicate a highly field independent cognitive style.

The reliability of this instrument was investigated in the sample of students who participated in the first assessment session ( $n = 132$ ). For section two,  $K-R\ 20 = .63$  and for section three,  $K-R\ 20 = .66$ . These are acceptable reliability scores. When internal consistency was computed for the two sections together,  $K-R\ 20 = .76$ , which can be considered as good.

*Learning style - Learning Style Inventory (LSI, Version 3).*

A Dutch translation of the third version of the Learning Style Inventory (Kolb, 1999) was developed using the parallel blind technique with the researcher as one of the translators (Behling & Law, 2000). It was administered during the first assessment session. The LSI is a 12-item questionnaire that measures a student's relative preference for concrete experience, reflective observation, abstract conceptualization, and active experimentation by asking them to rank four sentence endings that correspond to these four different ways of learning.

Table 2 lists the Cronbach's  $\alpha$  reliability coefficients of the translated version of the LSI-1999 in our sample of participants in the first assessment session ( $n = 132$ ).

Table 2

*Reliability of the Dutch Translation of the LSI-1999*

	$\alpha$
Concrete experience (CE)	.75
Reflective observation (RO)	.65
Abstract conceptualization (AC)	.77
Active experimentation (AE)	.73

These reliability scores seem to be acceptable. Because the LSI is an ipsative measure, the interpretation of these  $\alpha$  – scores is, however, not straightforward. Applying the usual correlation-based analysis techniques for psychometric evaluation with ipsative scores yields results that are difficult to interpret. They have to be considered as an artefact of the ipsative scoring method (Anastasi & Urbina, 1997; Cornwell & Dunlap, 1991; Henson & Hwang, 2002; Pickworth, 2000).

To be able to appropriately analyze the LSI scores, an alternative statistical procedure was applied: the original LSI scores were transformed following the procedure that was proposed by Cornwell and his colleagues (Cornwell & Dunlap, 1991; Cornwell & Manfreda, 1994). By using only an individual's first rank order of the final LSI ipsative scores, a nominal variable was defined, named primary learning style, indicating a preference for one of the four learning modes. According to

Cornwell et al., this nominal variable can be used successfully in theory building and testing: because the final ipsative score is calculated as the sum of 12 separate ipsative items, this final score should be more reliable than the individual scores.

*Perceived self-efficacy.*

A self-efficacy scale was developed following Bandura's "Guide for constructing self-efficacy scales" (2001). It was administered during the second assessment session.

The scale consists of 33 items and is divided into four parts. The students have to respond to each item on a 0-100 scale. Part one consists of one statement that taps general learning efficacy, namely "When I work hard enough, I can actually learn everything". Part two consists of 21 items that ask for self-efficacy in self-regulated learning (3 items per sub-process: task analysis, goal setting, strategic planning, self-observation, self-control, self-judgment, and self-reaction). Part three comprises 12 items referring to self-efficacy in accuracy of self-knowledge. And lastly, in part four, tapping self-efficacy in academic performance, the students are asked which study results they think they can achieve, for one specific course (biochemistry) and for all courses together. Each possible range of scores (4-5, 6-7, ... , 16-17, 18 or more) has to be judged on a 0-100 scale. This part consists of 18 items.

The psychometric properties of this self-efficacy scale were examined with data from a sub-sample of students who attended one of the academic counseling sessions ( $n = 67$ ). Item analysis was conducted separately for the four parts of the self-efficacy scale. Before that, non-discriminating items were eliminated.

First, Item 1, tapping general learning efficacy, had  $M = 77.95$ ,  $SD = 14.62$  and a range of 70. This indicates that this item was sufficiently able to differentiate among students with varying learning efficacy.

Second, principal components analysis of the 21 items asking about self-efficacy in the various sub-processes of self-regulated learning resulted in five orthogonal components with eigenvalue  $> 1$ . Results of the scree test suggested focusing only on the first three components, which explained 57.66% of the variance. Component I was called self-efficacy in performing self-regulated learning, because it refers to self-efficacy in goal-setting, strategic planning, and self-control, which are core sub-

processes of self-regulated learning. This sub-scale had Cronbach's  $\alpha = .88$ . Component II loaded high on the items about self-efficacy in task analysis. Cronbach's  $\alpha$  was .76. Component III referred to the self-reflection sub-processes of self-regulated learning. This sub-scale had Cronbach's  $\alpha = .85$ . The sub-scale means were used.

Third, Cronbach's  $\alpha$  for the self-efficacy in accuracy of self-knowledge sub-scale was .84. The mean scale-score was used.

Last, the self-efficacy in academic performance part showed to be difficult to complete for the students. While the instruction was that each possible range of scores had to be judged on a 0-100 scale, some students just checked off one range of scores, others wanted to make sure that the sum of their replies equaled 100, and so forth. This resulted in a lot of missing values. It was decided to retain the two items with the smallest number of missing values and the largest standard deviations as separate variables: self-efficacy in achieving 14 to 15 (on 20) on biochemistry, and self-efficacy in achieving 700 to 799 (on 1000) as total exam score.

## *Behavior*

### *Method of learning.*

Two instruments were used to assess method of learning, namely the Leuven Executive Regulation Questionnaire (LERQ), which focuses on self-regulation, and the Approaches and Study Skills Inventory for Students (ASSIST), which focuses on the broader concept of approach to studying. These instruments were administered during the first and the second assessment session.

Both the LERQ and the ASSIST are self-report measures of general learning behavior. They measure self-regulated learning and approach to studying as an aptitude, rather than as an event. Self-report questionnaires aggregate over or abstract some quality of learning based on multiple learning events, and de-emphasize contextual and temporal variability. A problem therefore is that they do not reveal what learners actually do (as contended by a.o. Veenman, Prins & Verheij, 2003; Winne & Jamieson-Noel, 2002). They only provide information about learner's memories and interpretations of their actions and their explanations of cognitive and metacognitive processes. On the other hand, self-report measures are the most

frequently used measurement protocols, mainly because they are efficient: economical in terms of labor and relatively fast and inexpensive to score (Patrick & Middleton, 2002; Perry, 2002; Winne & Perry, 2000).

The Leuven Executive Regulation Questionnaire (Minnaert, 1996) is a 63-item self-report questionnaire designed to investigate whether, to what extent, and how students regulate their study activities in higher education. Students are requested to respond to statements that relate to nine regulation activities (goal-setting, orienting, planning, monitoring, testing, diagnosing, on-line regulating, evaluating, and reflecting). Each of the statements has to be judged on a five-points scale. In the first assessment session the LERQSO, a reformulation of the LERQ in terms of studying in secondary education (Masui, 2002), was used. The LERQ was used in the second assessment session. Both questionnaires were used in the original language versions.

Minnaert (1996) reports a factor analysis resulting in five orthogonal scales. The first scale (23 items) is interpreted as effective self-regulation in study activities (process and content). The second scale (12 items) reflects incompetence to regulate study activities, partially due to a lack of metacognitive knowledge about studying in higher education. The third scale (16 items) reveals procrastination of regulating own study activities combined with a passive, field dependent regulation. The fourth scale (8 items) is interpreted as strategic, systematic regulation of study activities with a focus on planning and process monitoring; the fifth scale (4 items) refers to active, field dependent regulation of study activities.

After missing values were completed by applying the mean substitution technique, reliability and validity of this instrument was examined in our sample of first assessment session participants ( $n = 132$ ). All LERQSO scales, except the fifth scale ( $\alpha = .52$ ), showed good internal consistency. Cronbach's  $\alpha$ 's ranged between .79 and .83. Factor analyses were applied to investigate the factorial validity of this instrument. Three of the five LERQSO scales could be clearly recognized in the factor solution: the effective self-regulation scale, the incompetence to regulate scale, and the strategic, systematic regulation scale. We decided to retain these three scales for further analyses. Sum scores were used.

The Approaches and Study Skills Inventory for Students (Entwistle, Tait & McCune, 1999; “Scoring key”, 2003; Tait & Entwistle, 1996; Tait, Entwistle & McCune, 1998) is a 52-item self-report questionnaire to investigate approaches to studying.

The students have to respond to the items on a five-point scale. It is an extensively trialed and validated instrument, with a long history of development work (for an overview, see Tait, Entwistle, & McCune, 1998). A Dutch version of the instrument was developed for this study, using the parallel blind technique with the researcher as one of the translators (Behling & Law, 2000).

The inventory distinguishes three approaches to studying, each consisting of various 4-item sub-scales. The deep approach comprises the sub-scales seeking meaning, relating ideas, use of evidence, and the motive “interest in ideas”. The strategic approach consists of the sub-scales organized studying, time management, alertness to assessment demands, monitoring effectiveness, and achieving motivation. The surface apathetic approach comprises the sub-scales unrelated memorizing, lack of purpose, syllabus boundness, and the motive “fear of failure”. Sum scores are used (“Scoring key”, 2003). According to Entwistle (2000) a combination of deep and strategic approach, without any elements of the surface, apathetic approach, is generally associated with successful academic performance.

After missing values were completed by applying the mean substitution technique, we examined reliability and validity of this instrument in our sample of first assessment session participants ( $n = 132$ ). Reliability analysis indicated that the three main scales of the ASSIST showed good internal consistency. Cronbach’s  $\alpha$ ’s ranged from .73 to .86. The developers of this instrument (Tait, Entwistle, & McCune, 1998) considered .50 as the acceptable minimum  $\alpha$  for the sub-scales. All sub-scales, except the “using evidence” sub-scale ( $\alpha = .17$ ), reached this critical value. Cronbach’s  $\alpha$ ’s ranged from .50 to .82. The three original main scales could be recognized in factor analysis at sub-scale level. Confirmatory factor analysis showed that the original factor structure fitted the data relatively well. There was no good fit,  $\chi^2 (62, N = 132) = 140.36$ ,  $p = .000$ , GFI = .87, CFI = .85, RMSEA = .10, but the GFI and CFI could be



considered as reasonably high. Also all parameter estimates were significant and had values consistent with the theory.

*Academic performance.*

The students’ final exam results were obtained from the faculty administration. The information included the separate scores (on 20) for each course bloc (cell 1, cell 2, cell 3, health and society, infection and defence, information processing, first aid and communication, exploration and Studium Generale), and a total exam score on 1000.

Table 2 gives an overview of the procedure.

Table 2.

*Procedure*

1st assessment session <i>n</i> = 132	2nd assessment session <i>n</i> = 59	Final examinations <i>n</i> = 145
Beginning of October	End of May	June
Background information GEFT LSI LERQSO ASSIST	LERQ ASSIST Perceived self-efficacy	Academic performance

## Results

### *Data Screening*

Prior to analysis, all variables were examined for accuracy of data entry, missing values, outliers, normality, and multicollinearity according to the procedure described by Tabachnick and Fidell (1996). Randomly missing data were estimated using mean or mode substitution. Cases with standardized scores in excess of 3.29 were considered as univariate outliers. These cases were deleted or their raw score was changed into a score that was one unit smaller or larger than the next most extreme score in the distribution. Examination of Mahalanobis distances revealed no multivariate outliers.

Normality of the variables was assessed by examining the values of skewness and kurtosis. The variables GEFT-score, total exam score and cell 3 were significantly negatively skewed. Transformations were applied to normalize these variables:  $NEWX = LG10(K-X)$  for the substantial negative skewness of GEFT-score, and  $NEWX = SQRT(K-X)$  for the moderate negative skewness of total exam score and cell 3. For further interpretation it is important to keep in mind that these transformed variables got reversed meaning, e.g. a high score on total exam score implied low final exam results.

Multicollinearity was examined separately for the method of learning variables, the perceived self-efficacy variables, the academic performance variables, and the remaining person variables. A correlation of .70 or more was considered indicative of multicollinearity.

There was multicollinearity among the academic performance variables: the students' exam results for the different courses were highly correlated with each other and with the total exam score. Principal components analysis with varimax rotation was conducted to examine whether it was possible to reduce the number of academic performance variables. Two components had eigenvalues  $> 1$ , together explaining 68.61% of the variance.

Component I comprised the exam results that were highly correlated with the total exam score: cell 1, cell 2, cell 3, infection & defence, health and society, and

information processing. Total exam score was used as representative variable for this group of academic performance variables.

Component II consisted of first aid and communication, and exploration and Studium Generale. These variables were however not significantly correlated ( $r = .080$ ). They were retained as separate academic performance variables.

Two method of learning variables showed multicollinearity in the group of students who attended the first assessment session: strategic, systematic regulation and strategic approach to studying ( $r = .721$ ). Overall, the regulation and approaches to studying variables were strongly intercorrelated. Principal components analysis with varimax rotation showed three components with eigenvalues  $> 1$ , together explaining 73.76 % of the variance.

Component I referred to a strategic approach to studying based on achieving motivation and strategic, systematic self-regulation of learning (STRATSR1). Component II could be interpreted as a surface approach to studying based on fear of failure and incompetence to regulate learning (SURFINC1), and Component III referred to a deep approach to studying based on interest in ideas and effective self-regulation in study activities (DEEPSR1). Factor scores were used. In the data from the second assessment session, approximately the same pattern occurred. Again, principal components analysis was conducted and factor scores were computed (STRATSR2, SURFINC2, and DEEPSR2).

Among the perceived self-efficacy variables, there was multicollinearity between self-efficacy in self-reflection and self-efficacy in performing self-regulation ( $r = .73$ ), between self-efficacy in self-reflection and self-efficacy in task analysis ( $r = .77$ ), between self-efficacy in self-reflection and self-efficacy in accuracy of self-knowledge ( $r = .77$ ), and between self-efficacy in task analysis and self-efficacy in accuracy of self-knowledge ( $r = .83$ ). Therefore, these variables were aggregated by using their arithmetic mean, forming the new variable self-efficacy in self-regulated learning.

Lastly, for correlational analysis and multiple regression require continuous variables, dummy variables were created for the categorical variables sex and primary learning style. One dummy variable sufficed for sex: 1 = female, 0 = male. Two

dummy variables were created for primary learning style: AC (1 = preference for abstract conceptualization, 0 = no preference for abstract conceptualization) and AE (1 = preference for active experimentation, 0 = no preference for active experimentation). Only a small group of students had a reflective observation or concrete experience primary learning style ( $n = 7$ ): these categories were joined and were thus referred to by a zero-value for the two dummy variables.

#### *Correlations among Person and Behavior Variables at the Start of the Academic Year*

Table 3 shows the bivariate correlations for all variables that were assessed at the start of the academic year. Only the significant correlations are discussed below.

The results show that study result in secondary education was positively related to the result on the knowledge of and insight in sciences part of the entrance examination. Knowledge of and insight in sciences was negatively related to age: older students reported a lower result on this part of the entrance examination.

Cognitive style was positively related to the students' score on the information processing part of the entrance examination. Cognitive style also appeared to be related to learning style: there was significantly positive relationship between field independency and the abstract conceptualization primary learning style, and a significantly negative relationship with the active experimentation primary learning style. Logically, both primary learning style preferences were negatively correlated.

Age also seemed to matter when it came to primary learning style: there was a negative relationship between age and preference for abstract conceptualization. Preference for abstract conceptualization was also negatively related to sex, with female students showing a lower preference for this primary learning style.

As to the method of learning variables, a deep approach to studying based on interest in ideas and effective self-regulation in study activities was negatively correlated with a preference for active experimentation. A surface approach to studying based on fear of failure and incompetence to regulate learning at the start of the academic year was negatively correlated with field independency. There was a

positive relationship with age: older students tended to have higher scores on this method of learning variable.

Table 3

*Bivariate Correlations for all Variables Assessed at the Start of the Academic Year*

Variable	1	2	3	4	5	6	7	8	9	10
1 Study result in secondary - education										
2 Knowledge of and insight in sciences	.334**	-								
3 Information processing	-.134	-.110	-							
4 Sex	.170	-.004	-.050	-						
5 Age	-.191	-.279*	-.214	.188	-					
6 GEFT-score <sup>a</sup>	-.040	-.078	-.300*	.093	.206	-				
7 Abstract conceptualization	-.025	.070	.051	-.249*	-.311**	-.312**	-			
8 Active experimentation	.035	.054	-.047	.151	.200	.331**	-.749***	-		
9 STRATSR1	-.011	.150	-.181	.045	.199	.126	-.026	.146	-	
10 DEEPSR1	.083	.078	-.51	-.054	-.073	-.081	.206	-.227*	-.075	-
11 SURFINC1	-.178	-.172	.066	.195	.235*	.238*	-.072	.080	.101	.039

\*  $p < .05$ . \*\*  $p < .01$ . \*\*\*  $p < .001$ . (1-tailed)

a. GEFT-score has reversed meaning.

### *Predictors of Perceived Self-Efficacy*

Since our sample was relatively small, all effects with a significance level up to  $\alpha = .100$  and having medium to large effect size ( $\beta$  and  $sr^2$ ) were considered interesting in the discussion of the multiple regression analyses below (for the prediction of perceived self-efficacy, method of learning, and academic performance). This enabled us to uncover potentially meaningful and valuable effects that were not significant, but that might have yielded more significant results if there were only more subjects in the study (Kramer & Rosenthal, 1999; Olejnik & Algina, 2000). Consequently, prespecified significance levels for the regression tables were:  $^+ p \leq .100$ ,  $^* p < .100$ ,  $^{**} p < .05$ ,  $^{***} p < .01$ ,  $^{****} p < .001$ .

First, four standard multiple regressions were performed with successively general learning efficacy, self-efficacy in self-regulated learning, and self-efficacy in academic performance (2 variables) as dependent variable. Each time, the predictors were study result in secondary education, results on the entrance examination, sex, age, cognitive style, primary learning style, and method of learning as measured at the start of the academic year. Afterwards, the intercorrelations between the perceived self-efficacy variables were examined.

#### *General Learning Efficacy*

Multiple regression with general learning efficacy as dependent variable showed that general learning efficacy was not reliably predicted by the antecedent variables:  $R$  for regression was not significantly different from zero,  $F(11,46) = 1.402$ ,  $p = .204$ . The model only explained 25% of the variance in this sample. Adjusted  $R^2$  was .072.

#### *Self-Efficacy in Self-Regulated Learning*

Table 4 displays the correlations between the predictors and self-efficacy in self-regulated learning ( $r$ ), the unstandardized regression coefficient ( $B$ ) and intercept, the standardized regression coefficient ( $\beta$ ), the semipartial correlations ( $sr^2$ ),  $R^2$ , and adjusted  $R^2$ .

Table 4

*Summary of Simultaneous Regression Analysis for Variables Predicting Self-Efficacy in Self-Regulated Learning*

Variable	<i>r</i>	<i>B</i>	$\beta$	$sr^2$
Study result in secondary education	.093	-3.358E <sup>-02</sup>	-.021	.000
Knowledge of and insight in sciences	.048	-0.288	-.054	.002
Information processing	-.079	0.631	.082	.005
Sex	-.030	-0.446	-.017	.000
Age	.234	2.588	.113	.010
GEFT-score <sup>a</sup>	.203	5.891	.154	.019
Abstract conceptualization	-.172	-6.963**	-.339	.044
Active experimentation	.066	-5.033	-.218	.019
STRATSR1	.450	5.331*****	.511	.224
DEEPSR1	.095	2.166*	.186	.031
SURFINC1	-.386	-4.733*****	-.490	.197
Intercept = 20.073			$R^2 = .528$	
			Adj. $R^2 = .416$	
			$R = .727*****$	

\*  $p < .100$ . \*\*  $p < .05$ . \*\*\*  $p < .01$ . \*\*\*\*\*  $p < .001$ .

a. GEFT-score has reversed meaning.

R for regression was significantly different from zero,  $F(11,46) = 4.686$ ,  $p < .000$ . Four of the antecedent variables contributed significantly to the prediction of self-efficacy in self-regulated learning. The most important predictors were strategic



approach to studying based on achieving motivation and strategic, systematic self-regulation of learning (22.4% of the variance), having a positive effect, and surface approach to studying based on fear of failure and incompetence to regulate learning (19.7% of the variance), having a negative effect. Next, there were abstract conceptualization, having a negative effect on self-efficacy in self-regulated learning, and deep approach to studying based on interest in ideas and effective self-regulation in study activities, having a positive effect. A total of 52.8% of the variability in self-efficacy in self-regulated learning was explained by the antecedent variables.

### *Self-efficacy in Academic Performance*

#### *Self-efficacy in achieving 14 to 15 (on 20) on biochemistry.*

Table 5 displays the correlations between the predictors and self-efficacy in achieving 14 to 15 on biochemistry ( $r$ ), the unstandardized regression coefficient ( $B$ ) and intercept, the standardized regression coefficient ( $\beta$ ), the semipartial correlations ( $sr^2$ ),  $R^2$ , and adjusted  $R^2$ .

$R$  for regression almost reached significance at the .05 level,  $F(11,45) = 1.952$ ,  $p = .057$ . Two of the antecedent variables contributed significantly to the prediction of self-efficacy in achieving a good result in biochemistry: study result in secondary education had a positive effect and explained 6.1% of the variance, while sex, more specifically being female, had a negative effect and explained 6.8% of the variance. Altogether, in this sample, 32.3% of the variability in self-efficacy in achieving 14 or 15 (on 20) in biochemistry was predicted by the antecedent variables.

Table 5

*Summary of Simultaneous Regression Analysis for Variables Predicting Self-efficacy in Achieving 14 to 15 (on 20) on Biochemistry*

Variables	<i>r</i>	<i>B</i>	$\beta$	$sr^2$
Study result in secondary education	.314	0.996**	.281	.061
Knowledge of and insight in sciences	.280	1.902	.162	.020
Information processing	.059	3.173	.194	.032
Sex	-.277	-16.068**	-.282	.068
Age	-.052	2.930	.056	.003
GEFT-score <sup>a</sup>	.042	9.693	.113	.011
Abstract conceptualization	.147	-.198	-.004	.000
Active experimentation	-.114	-4.098	-.081	.003
STRATSR1	.156	3.747	.159	.022
DEEPSR1	.154	2.633	.104	.010
SURFINC1	-.282	-3.471	-.173	.025
Intercept = -158.291			$R^2 = .323$	
			Adj. $R^2 = .158$	
			$R = .568^*$	

\*  $p < .100$ . \*\*  $p < .05$ . \*\*\*  $p < .01$ . \*\*\*\*  $p < .001$ .

a. GEFT-score has reversed meaning.

*Self-efficacy in achieving 700-799 (on 1000) as total exam score.*

Self-efficacy in achieving 700-799 (on 1000) at the end of the academic year was not reliably predicted by the antecedent variables. R for regression was not significantly different from zero,  $F(11,45) = 1.576$ ,  $p = .139$ . The model only explained 27.8% of the variance in this sample. Adjusted  $R^2$  was .102.

*Intercorrelations*

Table 6 displays the intercorrelations between the four perceived self-efficacy variables. General learning efficacy is positively correlated with self-efficacy in self-regulated learning. It is however not significantly correlated with the variables representing self-efficacy in academic performance. Self-efficacy in self-regulated learning is positively correlated with the self-efficacy in academic performance variables, with the relationship with self-efficacy in achieving 700-799 (on 1000) as total exam score being strongest. The self-efficacy in academic performance variables are also strongly intercorrelated.

Table 6

*Intercorrelations Between the Four Perceived Self-Efficacy Variables*

Variables	1	2	3	4
1 General learning efficacy	-			
2 Self-efficacy in self-regulated learning	.232**	-		
3 Self-efficacy in achieving 14 to 15 (on 20) on biochemistry	.168	.256**	-	
4 Self-efficacy in achieving 700-799 (on 1000) as total exam score	-.016	.366***	.385***	-

\*\*  $p < .05$ . \*\*\*  $p < .01$ .

### *Predictors of Method of Learning*

Three standard multiple regressions were performed with successively STRATSR2 (strategic approach to studying based on achieving motivation and strategic, systematic self-regulation of learning), DEEPSR2 (deep approach to studying based on interest in ideas and effective self-regulation in study activities), and SURFNC2 (surface approach to studying based on fear of failure and incompetence to regulate learning) as dependent variable. Each time, the predictors were study result in secondary education, results on the entrance examination, sex, age, cognitive style, primary learning style, method of learning as measured at the start of the academic year, general learning efficacy, self-efficacy in self-regulated learning, and self-efficacy in academic performance (2 variables).

#### *Strategic Approach to Studying Based on Achieving Motivation and Strategic, Systematic Self-Regulation of Learning (STRATSR2)*

Table 7 displays the correlations between the predictors and STRATSR2 ( $r$ ), the unstandardized regression coefficient ( $B$ ) and intercept, the standardized regression coefficient ( $\beta$ ), the semipartial correlations ( $sr^2$ ),  $R^2$ , and adjusted  $R^2$ .

$R$  for regression was significantly different from zero,  $F(15,39) = 5.347$ ,  $p < .000$ . Five antecedent variables contributed significantly to the prediction of STRATSR2. The most important predictors was STRATSR1 (9.1% of the variance), having a positive effect, followed by general learning efficacy (7.3% of the variance), having a negative effect. Next, being female also had a positive effect on STRATSR2: sex explained 7.2% of the variance. Self-efficacy in achieving 700-799 as total exam score had a negative effect on STRATSR2 (5.7% of the variance), while self-efficacy in self-regulated learning had a positive effect (4.5% of the variance).

Lastly, two variables made a meaningful additional contribution to the prediction of STRATSR2: age and result on the knowledge of and insight in sciences part of the entrance examination had a positive effect, each explaining about 2.5% of the variance.

Table 7

*Summary of Simultaneous Regression Analysis for Variables Predicting STRATSR2*

Variables	<i>r</i>	<i>B</i>	$\beta$	$sr^2$
Study result in secondary education	.071	-4.276E <sup>-03</sup>	-.026	.000
Knowledge of and insight in sciences	.181	9.902E <sup>-02</sup> *	.188	.025
Information processing	-.244	-3.219E <sup>-02</sup>	-.042	.001
Sex	.320	.812***	.317	.072
Age	.278	.462*	.187	.024
GEFT-score <sup>a</sup>	.198	2.825E <sup>-02</sup>	.007	.000
Abstract conceptualization	-.138	-5.381E <sup>-02</sup>	-.026	.000
Active experimentation	.114	-.224	-.093	.004
STRATSR1	.597	.433***	.410	.091
DEEPSR1	-.061	-9.200E <sup>-02</sup>	-.173	.005
SURFINC1	-.018	-.172	-.080	.015
General learning efficacy	-.228	-3.108E <sup>-02</sup> ***	-.342	.073
Self-efficacy in self-regulated learning	.460	3.304E <sup>-02</sup> **	.331	.045
Self-efficacy in achieving 14 to 15 on biochemistry	.097	7.750E <sup>-03</sup>	.166	.017
Self-efficacy in achieving 700-799 as total exam score	.056	-1.322E <sup>-02</sup> **	-.294	.057
Intercept = -9.299				$R^2 = .673$
				Adj. $R^2 = .547$
				$R = .820$ ****

\*  $p < .100$ . \*\*  $p < .05$ . \*\*\*  $p < .01$ . \*\*\*\*  $p < .001$ .

a. GEFT-score has reversed meaning.

Altogether, in this sample, 67.3% of the variability in strategic approach to studying based on achieving motivation and strategic, systematic regulation of learning at the end of the academic year was predicted by the antecedent variables.

*Deep Approach to Studying Based on Interest in Ideas and Effective Self-Regulation in Study Activities (DEEPSR2)*

Table 8 displays the correlations between the predictors and DEEPSR2 ( $r$ ), the unstandardized regression coefficient ( $B$ ) and intercept, the standardized regression coefficient ( $\beta$ ), the semipartial correlations ( $sr^2$ ),  $R^2$ , and adjusted  $R^2$ .

Table 8

*Summary of Simultaneous Regression Analysis for Variables Predicting DEEPSR2*

Variables	$r$	$B$	$\beta$	$sr^2$
Study result in secondary education	.106	-7.037E <sup>-03</sup>	-.042	.001
Knowledge of and insight in sciences	.026	-.117	-.215	.033
Information processing	-.198	-.239**	-.302	.059
Sex	-.111	-.119	-.045	.001
Age	-.151	-.629*	-.248	.043
GEFT-score <sup>a</sup>	-.142	-.592	-.141	.013
Abstract conceptualization	.228	.223	.105	.004
Active experimentation	-.179	3.082E <sup>-02</sup>	.013	.000
STRATSR1	.373	.375**	.346	.065
DEEPSR1	-.174	.412***	.348	.099
SURFINC1	.342	-1.506E <sup>-02</sup>	-.015	.000
General learning efficacy	.090	1.972E <sup>-02</sup>	.211	.028

(table continues)

Variables	<i>r</i>	<i>B</i>	$\beta$	<i>sr</i> <sup>2</sup>
Self-efficacy in self-regulated learning	.343	1.164E <sup>-02</sup>	.113	.005
Self-efficacy in achieving 14 to 15 on biochemistry	.048	-8.275E <sup>-03</sup>	-.173	.018
Self-efficacy in achieving 700-799 as total exam score	.358	1.468E <sup>-02</sup> **	.317	.067
Intercept = 14.373				
$R^2 = .548$				
Adj. $R^2 = .374$				
$R = .740^{***}$				

\*  $p < .100$ . \*\*  $p < .05$ . \*\*\*  $p < .01$ . \*\*\*\*  $p < .001$ .

a. GEFT-score has reversed meaning.

R for regression was significantly different from zero,  $F(15,39) = 3.151$ ,  $p = .002$ . Five antecedent variables contributed to the prediction of DEEPSR2. The most important predictor was DEEPSR1 (9.9% of the variance), followed by self-efficacy in achieving 700 to 799 as final exam result and STRATSR1, respectively accounting for 6.7% and 6.5% of the variance. All these predictors had a positive effect on DEEPSR2. The results on the information processing part of the entrance examination and age had a negative effect on DEEPSR2.

Altogether, in this sample, 54.8% of the variability in deep approach to studying based on interest in ideas and effective self-regulation in study activities at the end of the academic year was predicted by the antecedent variables.

#### *Surface Approach to Studying Based on Fear of Failure and Incompetence to Regulate Learning (SURFINC2)*

SURFINC2 could be reliably predicted by the antecedent variables: R for regression was significantly different from zero,  $F(15,39) = 5.020$ ,  $p < .000$ . However, the only variable significantly contributing to the prediction of SURFINC2 was SURFINC1: it explained 13.8% of the variance. Altogether, in this sample, 65.9% of the variability in

surface approach to studying based on fear of failure and incompetence to regulate learning at the end of the academic year was predicted by the antecedent variables.

### *Predictors of Academic Performance*

Three standard multiple regressions were performed with successively total exam score, first aid and communication, and exploration and Studium Generale as dependent variable. Each time, the predictors were study result in secondary education, results on the entrance examination, sex, age, cognitive style, primary learning style, general learning efficacy, self-efficacy in self-regulated learning, self-efficacy in academic performance (2 variables), and method of learning as measured at the end of the academic year.

#### *Total Exam Score*

Table 9 displays the correlations between the predictors and EXTOT, the unstandardized regression coefficient ( $B$ ) and intercept, the standardized regression coefficient ( $\beta$ ), the semipartial correlations ( $sr^2$ ) and  $R^2$ , and adjusted  $R^2$ .

$R$  for regression was significantly different from zero,  $F(15,39) = 2.101$ ,  $p = .032$ . Three antecedent variables meaningfully contributed to the prediction of total exam score: self-efficacy in achieving 700-799 as total exam score accounted for 5.5% of the variance, the result on the knowledge and insight in sciences part of the entrance examination explained 4.7% of the variance, and self-efficacy in self-regulated learning accounted for 4% of the variance. All these predictors had a positive effect on total exam score. Altogether, in this sample, 44.7% of the variability in total exam score was predicted by the antecedent variables.



Table 9

*Summary of Simultaneous Regression Analysis for Variables Predicting Total Exam Score*

Variables	<i>r</i>	<i>B</i>	$\beta$	$sr^2$
Study result in secondary education	-.334	-3.777E <sup>-02</sup>	-.078	.004
Knowledge of and insight in sciences	-.452	-.415*	-.268	.047
Information processing	.101	0.349	.154	.014
Sex	.055	0.192	.025	.000
Age	.134	0.708	.098	.006
GEFT-score <sup>a</sup>	.076	1.984	.165	.017
Abstract conceptualization	-.063	-1.488	-.244	.022
Active experimentation	-.095	-1.761	-.250	.027
General learning efficacy	-.204	-3.271E <sup>-02</sup>	-.122	.008
Self-efficacy in self-regulated learning	-.323	-9.827E <sup>-02</sup> +	-.335	.040
Self-efficacy in achieving 14 to 15 on biochemistry	-.335	-9.294E <sup>-03</sup>	-.068	.003
Self-efficacy in achieving 700-799 as total exam score	-.408	-4.137E <sup>-02</sup> *	-.313	.055
STRATSR2	-.149	7.048E <sup>-02</sup>	.024	.000
DEEPSR2	-.162	.475	.166	.015
SURFINC2	.216	-.508	-.164	.014
Intercept = 15.173				$R^2 = .447$
				Adj. $R^2 = .234$
				$R = .668^{**}$

<sup>+</sup>  $p \pm .100$ . \*  $p < .100$ . \*\*  $p < .05$ . \*\*\*  $p < .01$ . \*\*\*\*\*  $p < .001$ .

a. GEFT-score has reversed meaning.

### *First Aid and Communication*

The antecedent variables did not reliably predict the students' exam score on first aid and communication. R for regression was not significantly different from zero,  $F(15,39) = 0.834, p = .636$ .

### *Exploration and Studium Generale*

The antecedent variables did not reliably predict the students' exam score on exploration and Studium Generale. R for regression was not significantly different from zero,  $F(15,39) = 1.011, p = .464$ .

### *Overview of Meaningful and Significant Correlations and Regression Paths*

Figure 3 gives a visual overview of the meaningful and significant correlations and regression paths that were found in this study. Please note that this figure should not be confused with the output of model testing through structural equation modeling.

The path diagram illustrates the structural equation model (SEM) for the study. The variables and their standardized path coefficients are as follows:

- Demographic and Background Variables:**
  - Study result in secondary education: .334 (to Knowledge of and insight in sciences)
  - Knowledge of and insight in sciences: -.268 (to Total exam score)
  - Information processing: -.279 (to Sex), -.300 (to Age), -.249 (to GEFT-score), -.235 (to Active experimentation)
  - Sex: -.281 (to General learning efficacy), -.282 (to Self-efficacy in self-regulated learning), -.282 (to Self-efficacy in achieving 14-15 on biochemistry), -.282 (to Self-efficacy in achieving 700-799 as total exam score)
  - Age: .317 (to General learning efficacy), .302 (to Self-efficacy in self-regulated learning), .302 (to Self-efficacy in achieving 14-15 on biochemistry), .302 (to Self-efficacy in achieving 700-799 as total exam score)
  - GEFT-score: -.311 (to Abstract conceptualization), -.312 (to Active experimentation)
  - Abstract conceptualization: -.331 (to Active experimentation), -.339 (to Self-efficacy in self-regulated learning)
  - Active experimentation: -.749 (to SURFINC1)
- Learning Efficacy Variables:**
  - General learning efficacy: .317 (to STRATSR2), .187 (to DEEPSR2), .232 (to Self-efficacy in self-regulated learning)
  - Self-efficacy in self-regulated learning: .410 (to STRATSR2), .294 (to DEEPSR2), .256 (to Self-efficacy in achieving 14-15 on biochemistry), .366 (to Self-efficacy in achieving 700-799 as total exam score)
  - Self-efficacy in achieving 14-15 on biochemistry: .346 (to STRATSR2), .348 (to DEEPSR2), .385 (to SURFINC2)
  - Self-efficacy in achieving 700-799 as total exam score: .331 (to STRATSR2), .335 (to DEEPSR2), .521 (to SURFINC2)
- Exam Scores and Outcomes:**
  - STRATSR1: .511 (to STRATSR2), .186 (to DEEPSR2), -.490 (to SURFINC2)
  - DEEPSR1: .186 (to STRATSR2), .366 (to DEEPSR2), -.490 (to SURFINC2)
  - SURFINC1: .227 (to SURFINC2)
  - STRATSR2: .342 (to Total exam score)
  - DEEPSR2: .313 (to Total exam score)
  - SURFINC2: .521 (to Total exam score)
- Other Variables:**
  - First aid and communication: .317 (to SURFINC2)
  - Exploration and Studium Generale: .317 (to SURFINC2)

## Discussion and Conclusions

The aim of this study was to examine whether and how the dynamics that are described within the framework of the social cognitive model of self-regulated learning, manifest themselves in data from first-year medical students. Correlational analysis and multivariate regression were used.

### *Interrelationships Between Person and Behavior Variables at the Start of the Academic year*

Our first question concerned the interrelationships between the variables that were measured at the start of the academic year. Several relationships were found.

First, there was an evident overlap between the prior knowledge and the domain knowledge of the medical students: their study results in secondary education were positively related to their scores on the knowledge of and insight in sciences part of the admission examination. The students' score on the information processing part of the entrance examination was positively related to cognitive style. This is not surprising: the entrance examination partly measures the same basic cognitive processing skill as the GEFT, namely pattern recognition (Lievens et al., 2001).

Cognitive style was also related to learning style: students with a preference for abstract conceptualization were more field independent, while students with a preference for active experimentation were rather field dependent. Although Highhouse and Doverspike (1987) found no significant correlations between the LSI-1985 and the GEFT in psychology students, Kolb did set field independency and abstract conceptualization on the same line in his theory (Kolb, 1984, p. 165). Our results confirm his supposition. The results further show that there was a relationship between learning style and sex: female students had a lower preference for abstract conceptualization than male students. This is in line with the results obtained in Kolb's normative comparison group (Learning Style Inventory, 2003), and by Katz (1988) and Severiens and ten Dam (1997).

As to method of learning at the start of the academic year, a deep approach to studying based on interest in ideas and effective self-regulation in study activities was

negatively related to the active experimentation primary learning style. Although this seems acceptable, it contradicts the results of Cano-Garcia and Justicia-Justicia (1994), who did not find any significant correlations between the sub-scales of the LSI and the ASI (a precursor of the ASSIST) in a sample of 991 university students.

Students with a surface approach to studying based on fear of failure and incompetence to regulate learning were less field independent. This confirms Joughin's (1992) hypothesis that there might be potential contradictions between self-directed learning and field-dependency. No further evidence on this relationship is yet available.

Finally, we saw that older students, actually in this sample students aged 19, had a lower preference for abstract conceptualization and a more surface approach to studying based on fear of failure and incompetence to regulate learning. In our particular context, these 19 year old students were all non-promoted students, who repeated their first year in medical school. Although correlational analysis does not allow pointing out cause and effect, a disadvantageous pattern in the dynamics between person, behavior, and learning environment can be observed in these students, which might explain their backlog.

### *Predictors of Perceived Self-Efficacy*

The second research question was which of the antecedent person and behavior variables are the best predictors of students' perceived self-efficacy at the end of the academic year. We hypothesized that prior and domain knowledge, and method of learning as measured at the start of the academic year, would be the strongest predictors.

A central observation was that this was different for the different types of perceived self-efficacy. General learning efficacy and self-efficacy in achieving 700-799 as total exam score were not reliably predicted by the antecedent person and behavior variables.

Self-efficacy in self-regulated learning was best predicted by method of learning. It was positively affected by having a strategic approach to studying based on achieving

motivation and strategic, systematic regulation of learning, and negatively by having a surface approach to studying based on fear of failure and incompetence to regulate learning. Also a preference for abstract conceptualization had a negative effect on self-efficacy in self-regulated learning.

Self-efficacy in achieving a good result in biochemistry was best predicted by prior knowledge and by sex, with female students reporting lower self-efficacy in achieving a good result in biochemistry.

Based on these results, the hypothesis that prior and domain knowledge, and method of learning as measured at the start of the academic year, would be the strongest predictors of perceived self-efficacy, cannot be rejected. It however needs further refinement.

We observed that prior knowledge – and in extension domain knowledge, since we know that both are correlated – only predicted self-efficacy in achieving a good final result in one specific course. Apparently, domain-specific learning experiences influence domain-specific self-efficacy. On the other hand, method of learning had an impact on self-efficacy in self-regulated learning: both refer to level of proficiency in generic self-regulatory strategies.

These conclusions confirm Bandura's assertion that the efficacy belief system is a differentiated set of beliefs that are task and situation specific and that are linked to distinct realms of functioning (Bandura, 1986, 2001; Pajares, 1996).

The impact of sex on self-efficacy in achieving a good result in biochemistry is in line with the gender differences summarized by Pajares and Schunk (Pajares, 1996; Schunk & Pajares, 2002). They warn, however, that it is possible that these gender differences can be due to response bias: boys and girls use a different “metric” when providing confidence judgments. Boys tend to be more “self-congratulatory” in their responses whereas girls tend to be more modest. Also gender orientation, which refers to the stereotypic beliefs about gender that students hold, might be in play, with female students reporting lower self-efficacy in a field that is often considered as a male domain.

Finally, we also saw that learning style affected self-efficacy. Since most research focuses on the predictive value of self-efficacy rather than on the sources of

efficacy, similar results could not be found. This stresses the need for more investigations to trace the genesis and development of self-efficacy beliefs, in which not only social and environmental, but also personal variables are taken into account (Pajares, 1996).

### *Predictors of Method of Learning*

The third research question was which of the person and behavior variables are the best predictors of the students' method of learning, including self-regulated learning, at the end of the academic year. We hypothesized that perceived self-efficacy would play a crucial role, next to method of learning at the start of the academic year.

First, adopting a surface approach to studying based on fear of failure and incompetence to regulate learning at the end of the academic year was significantly predicted solely by having this method of learning at the start of the academic year.

Next, various person and behavior variables significantly contributed to the prediction of a strategic approach to studying based on achieving motivation and strategic, systematic regulation of learning at the end of the academic year. This method of learning as measured at the start of the academic year was the most important predictor. Moreover, several variables had an additional effect. Domain knowledge and age both had a small positive effect. Sex had a considerable effect, with female students reporting a more strategic approach to studying based on achieving motivation and strategic, systematic regulation of learning at the end of the academic year. This is in line with previous research indicating that gender differences in the use of self-regulated learning strategies typically favor female students (Pajares, 1996). Zimmerman and Martinez-Pons (1990), for example, show that in a sample of high school students, girls report significantly more record keeping and monitoring, environmental structuring, and goal setting and planning than boys. Mattick, Dennis, and Bligh (2004) report that in first-year medical students, female students have significantly higher "effort management" and "organized studying" scores on an adaptation of the ASSIST.

Self-efficacy in self-regulated learning had a positive effect on strategic approach to studying based on achieving motivation and strategic, systematic regulation of learning: students who felt confident about their capacity to self-regulate also reported a corresponding method of learning.

On the other hand, general learning efficacy and self-efficacy in achieving 700-799 as total exam score both had a negative effect. Students who felt confident about their general learning capacity to a lesser extent reported a strategic approach to studying based on achieving motivation and strategic, systematic regulation of learning. They were apparently less concerned about achieving the highest possible grades and strategically planning, organizing, and monitoring their studying.

Students with a high level of self-efficacy in achieving 700-799 as total exam score were apparently engaged in deep learning, based on interest in ideas combined with effective self-regulation in study activities. These dynamics clearly illustrate the “thermostat” function of self-efficacy central to social cognitive theory, and support the observation that high self-efficacy helps to create feelings of serenity in approaching difficult tasks and activities (Pajares, 1996). Self-efficacy in achieving 700-799 as total exam score was only one of the predictors of a deep approach to studying based on interest in ideas and effective self-regulation in study activities at the end of the academic year learning. The most important predictor was the pre-test of this method of learning. But also a strategic approach to studying based on achieving motivation and strategic, systematic regulation of learning at the start of the academic year had a positive effect. Apparently, for first year medical students, a certain level of strategic, systematic regulation of learning was a prerequisite for the development of deep learning based on effective self-regulation in study activities. Based on literature on expertise (Chi, Glaser, & Farr, 1988; Ertmer & Newby, 1996) we can hypothesize that as students develop more expertise in strategic, systematic regulation skills, these skills become more automated and more efficient, by which these students can focus more on active engagement in understanding the main ideas of the course. It seems that more research is needed to explore the development from conscious, systematic regulation to more automated and efficient self-regulation.



Two predictors had a negative effect on deep approach to studying based on interest in ideas and effective self-regulation in study activities at the end of the academic year: age, and result on the information processing part of the admission examination.

In conclusion, the hypothesis that perceived self-efficacy and method of learning at the start of the academic year would play a crucial role in the prediction of method of learning at the end of the academic year, can be acknowledged. However, again the results show that self-efficacy must be seen as a differentiated concept. The different types of self-efficacy had different effects on method of learning, which confirms the observation that only if efficacy assessments are tailored to the criterial task - in this case, reporting a method of learning incorporating self-regulation - prediction is enhanced (Pajares, 1996). An interesting finding was that self-efficacy in achieving 700-799 as total exam score led to a lower concern about systematic and strategic regulation, but to a stronger engagement in deep learning based on effective self-regulation in study activities. Zimmerman's general statement (2000) that a high level of self-efficacy is associated with better quality learning strategies, more self-monitoring, and so on, can therefore not be rejected, but certainly needs further refinement in terms of different forms of self-efficacy and different levels of automation of self-regulated learning skills. Qualitative research into self-regulated learning offers opportunities to reveal the details of these processes (Patrick & Middleton, 2002).

These results also add to the typology of non-promoted students. These older students tended to be more strategic at the end of the academic year, but they did not adopt a more deep approach to studying based on interest in ideas. Probably, achieving the highest possible grades through strategic, systematic regulation was the main concern of these students because succeeding this year was their primary goal. This explanation endorses the importance of trying to understand students' personal beliefs, motives and strivings to interpret their behavior. It is the phenomenological view on (self-regulated) learning that particularly focuses on this qualitative understanding (see for example Marton, Hounsell & Entwistle, 1997; McCombs, 2001; Paris, Byrnes & Paris, 2001).

### *Predictors of Academic Performance*

The last, but for many educators probably the most crucial question, was to what extent these person and behavior variables could predict academic performance at the end of the academic year. It was hypothesized that perceived self-efficacy and method of learning would make a significant contribution.

Total exam score was used as the central indicator of academic performance in this study. All person and behavior variables together explained 44.7% of the variance in this variable. The most important predictor was self-efficacy in achieving 700-799 as total exam score. This again underlines the fact that reasonably precise judgments of efficacy matched to a specific outcome afford the greatest prediction of behavioral outcomes (Bandura, 1986). Domain knowledge, as measured by the knowledge of and insight in sciences part of the entrance examination, was the second important predictor. This corroborates previous results that domain-specific prior knowledge strongly influences academic learning and performance (Alexander, 1992; Boekaerts, 1996; Vanderstoep, Pintrich, & Fagerlin, 1996; Winne, 2001) but also confirms the findings that performances are generally better predicted by self-efficacy than by prior attainment (Pajares, 1996). Also self-efficacy in self-regulated learning added meaningfully to the prediction of total exam score. This is in line with Schunk's findings that students' judgment of their capability that they can learn the material required in the domain in question, their so called "self-efficacy for learning", relates positively to performance (Schunk, 1996).

However, none of the method of learning variables as measured at the end of the academic year had a significant effect on total exam score.

With respect to the prediction of total exam score, the hypothesis that both perceived self-efficacy and method of learning would make a significant contribution, therefore, did only partly hold. Self-efficacy in achieving 700-799 as total exam score and self-efficacy in self-regulated learning indeed directly affected total exam score. However, the effect was not mediated by method of learning.

Relying on the literature on self-regulation (Boekaerts, 1997; Schunk & Zimmerman, 1998; Zimmerman & Schunk, 2001) and approaches to studying

(Entwistle, 2000), we had high expectations as to the beneficial effects on academic performance of a method of learning incorporating self-regulation.

Probably the most plausible explanation for the fact that this hypothesis did not hold in this study lies in the students' domain knowledge. It is well-known that domain-specific prior knowledge strongly influences academic learning and performance (Alexander, 1992; Boekaerts, 1996; Vanderstoep, Pintrich, & Fagerlin, 1996; Winne, 2001). Also in this study, it was a strong predictor of academic performance. All students in our study passed an entrance examination, so they can be considered as "good" students, who have a high starting level of declarative, procedural, and conditional knowledge in the domains of physics, chemistry, biology, and mathematics. Next, also perceived self-efficacy, which is known to lead to an increased level of effort, persistence, and resilience (Bandura, 1989; Pajares, 1996), was a strong predictor of academic performance. Within this group of selected first-year medical students, academic performance was apparently more determined by domain-knowledge and hard work, than by study method. It would be interesting to investigate if this pattern holds in later years of their study, or whether the students reporting a study method incorporating self-regulation will benefit in the long run.

Another explanation often found in the literature is that a deep, strategic, self-regulated method of learning does not necessarily lead to better learning outcomes if the learning environment, and more specifically the assessment procedure, does not emphasize and reward this way of learning (Entwistle & Tait, 1990; Vermunt & Van Rijswijk, 1988). Although at Ghent University, assessment in first-year medicine is partly based on continuous evaluation of work in problem-based learning tutorials and practical training sessions, the final (multiple-choice) examinations still emphasize and reward pure reproduction of knowledge. It would be interesting to investigate in more detail what the relationship is between method of learning and the different assessment requirements (quantity/quality, reproduction/transformation, etc.). For example, Minbashian, Huon & Bird (2004) investigated why a deep approach to studying did not lead to higher grades in short-essay exams. They found out that students who use a high level of deep approach fail to consistently achieve higher exam grades because of deficiencies in the quantity of their responses, rather than because of the insensitivity

of exams to students' understanding of the study material. More research is needed, however, to fully understand these specific interactions between method of learning, the assessment procedure and the broader learning environment.

Lastly, an explanation might also be found in the decision to use self-report measures to assess method of learning. These self-reports might not reveal what students actually do. According to Veenman et al. (2003), process measures like thinking-aloud protocols or traces (see Winne & Jamieson-Noel, 2002) can more adequately reflect the study process and thus are said to be stronger predictors of study results. On the other hand however, it is known that even these measurement procedures, especially thinking-aloud protocols, do not measure "real" learning, because they interfere with the learning process (Winne & Perry, 2000). Also practically, it takes a lot of time to collect and analyze these protocols, which was not possible within the context of this study.

The other academic performance variables, the scores on first aid and communication, and exploration and Studium Generale, were not significantly predicted by any of the person and behavior variables at all. This might be explained by the fact that the social-cognitive model of self-regulated learning, and most of the variables that were assessed, were conceptualized within the context of traditional academic studying. The predictor still having the highest impact on performance in first aid and communication was showing a preference for the active experimentation primary learning style. This not only sounds reasonable, but knowing that Kolb's learning styles were developed within the context of adult education against the background of experiential learning (Kolb, 1984), it is not surprising that exactly this variable adds to the prediction of results on a professional skills course.

### *Limitations*

Limitations of the present study are mainly related to the characteristics of the research sample. A major limitation was that this sample was actually too small to perform multiple regression. It was definitely too small to perform path analysis through structural equation modelling, which would have been the ideal technique to test the

model of self-regulated learning. On the other hand, because effect size and sample size both independently determine significance (Kramer & Rosenthal, 1999), we can be confident that the effects found in this small sample, would certainly all have been significant if the sample had been larger.

Further, our sample was a convenience sample, which limits the generalizability of the results. Whether this really has to be considered as a problem remains open to debate: the model of self-regulated learning explicitly incorporates the broader social, historical, and educational context in the explanation of self-regulated learning. Self-regulated learning is explicitly defined as context-specific. What we have examined here are the dynamics between person and behavior variables affecting and affected by self-regulated learning, within the context of first-year medical education at a Flemish university, which can be considered as a very demanding learning environment, and for which the students are selected through an admission examination. Nevertheless, it would be interesting to replicate this study in another context, with a less select group of students.

### *Conclusion*

In sum, this study shows that the dynamics that are set out in the social cognitive model of self-regulated learning do manifest themselves in data from first-year medical students. We have been able to disclose this complex interactive process within an ecologically valid context. Especially the behavioral self-regulation feedback loop between method of learning and perceived self-efficacy could be clearly distinguished. The key role of perceived self-efficacy was confirmed. A particular strength of this study was that by using a differentiated set of self-efficacy beliefs, a more refined picture of their antecedent and consequent variables within the process of self-regulated learning could be revealed. Also individual differences and differences in prior/domain knowledge, which have often been overlooked in previous research (Minnaert, 1996), were shown to be relevant elements in the prediction of self-efficacy, method of learning and academic performance.

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## Chapter 5

### **In Search of Theoretical and Empirical Foundations for the “Learning Style Awareness” Hypothesis as Guiding Principle for Educational Applications of Learning Styles in University Education\***

*Educational applications of learning styles traditionally follow guidelines based on the so-called “matching-hypothesis”. Since this approach is criticized for various reasons, fostering students’ learning style awareness within the context of self-regulated learning is often seen as a possibly more fruitful application, especially in the context of university education. However, this “learning style awareness” hypothesis still lacks sound theoretical and empirical foundations. In this article, we first develop a theoretical process model for explaining the expected effect of learning style awareness on the learning process. Secondly, we report the results of an experiment to empirically test these theoretical assumptions within the context of academic counseling. A learning style version, based on Kolb’s learning style model, and a standard version of an intervention to promote self-regulated learning in first year medical students are compared, entertaining high expectations of the effect of learning style awareness on the students’ ability to self-regulate. The results show that none of the theoretical assumptions can be accepted. It appears that the students did not consider the learning style information as particularly relevant for understanding and regulating their own learning. The literature offers possible explanations for these unexpected results. Overall, the conclusion must be that the impact of learning style awareness on the quality of learning must be reconsidered and certainly not be overestimated.*

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Although different conceptions of “learning style” exist, the concept can be generally described as “the way an individual sets about learning something” (Adey, Fairbrother, Wiliam, Johnson, & Jones, 1999). According to the theoretical orientation that is at the heart of the learning styles research (Desmedt & Valcke, 2004), learning styles must be seen as consistent and relatively stable individual differences in the way people learn. It is stressed that there is no “good” or “bad” learning style, and that it is of prime importance that education meets the specific strengths and weaknesses of learners. Educational applications of learning styles traditionally follow guidelines based on the so-called “matching-hypothesis”. This hypothesis builds on aptitude-treatment-interaction (ATI) research (see Cronbach & Snow, 1977), and states that if a teacher matches instruction to the individual learning styles of his or her students, the latter will perform better, or at least they will appreciate the instruction to a higher extent.

The problems with this educational application of learning styles are however manifold. First, there seems to be little reliable empirical evidence that consistently supports the matching-hypothesis (Adey et al., 1999; Furnham, 1995; Moran, 1991; Reynolds, 1997; Sadler-Smith, 2001; Stahl, 1999; Stellwagen, 2001). Second, the original ATI-researchers (Cronbach & Snow, 1977) actually never had the intention to prescribe generally applicable matching-guidelines (Boekaerts, 2002). They explicitly warned for such oversimplifications. Third, the rigid application of matching-guidelines not only leads to practical and organizational problems (Dixon, 1985), especially at university, it also raises ethical questions (Messick, 1984; McKeachie, 1995; Adey et al., 1999). When one decides to capitalize on the strengths of a student’s learning style, this implies that the weaknesses remain undeveloped, and vice versa. If one acknowledges that the “stability” of the learning style concept and the psychometric quality of many learning style measures are questionable (Rayner & Riding, 1997; Reynolds, 1997; Sadler-Smith, 2001; Stahl, 1999; Stellwagen, 2001), how can one justify such a decision? Zimmerman (2002) observed that in spite of matching, the curriculum remained too narrow and inflexible to accommodate the psychological needs of all students.

Finally, we see that since the 70s, the period in which research into educational applications of learning style took a start, the dominant conceptions of learning and education have clearly altered. The student is held more responsible for his or her own learning process. Through the acquisition of metacognitive knowledge, skills and strategies, students have to be able to self-regulate their learning process. Seen in the light of the recent developments in the field of self-regulated learning (see Boekaerts, Pintrich & Zeidner, 2000; Zimmerman & Schunk, 2001), the idea of “matching-guidelines for teachers” becomes rather outdated. Zimmerman (2002) explicitly considers students’ self-regulation as a way to compensate for individual differences in learning: one has to “... focus ... on what students need to know about themselves in order to manage their limitations during efforts to learn. Although teachers also need to know a student’s strengths and limitations in learning, their goal should be to empower their students to become self-aware of these differences” (p. 65). Stimulating learning style awareness in students could therefore be an important element in fostering self-regulated learning. Along this line, another, more fruitful, educational application of the learning style concept at university might be developed.

Within the learning style literature, some authors have suggested that promoting awareness of and reflection on one’s own learning style could improve the learning process (Dixon, 1985; Moran, 1991; Rayner & Riding, 1997; Riding & Rayner, 1998; Sadler-Smith, 2001). Messick (1984) was the first to give a definition of what he called “self-matching” with regard to cognitive style: “By increasing student awareness of cognitive styles and their implications for learning ... we might expand students purviews about the range of alternative thinking strategies, encompassing not only those strategies that are congenial to their styles but those that are uncongenial as well” (p. 69).

However, this “learning style awareness” hypothesis still lacks sound theoretical and empirical foundations. At a theoretical level, the idea that learning style awareness has a positive effect on the learning process seems to be generally accepted as a self-evident conception. No attempts have as yet been made to develop a process model which explains why this could be a reasonable hypothesis. Since the learning style research is notorious for it’s a-theoretical, “common sense” based claims (see

Grigorenko & Sternberg, 1995; Moran, 1991), it is of utmost importance that this theoretical process model is developed first.

At the empirical level, research into the effects of learning style awareness is still scarce and remains mostly unpublished (Andrew, Pheiffer, Green, & Holley, 2002; Carns & Carns, 1991; Carry, 1999; Cook, 1991; Ehrhard, 2000; Labour, 2002; Lacina, 1991; McLaughlin, 1996; Nickles, 2003; O'Phelan, 1994; Raviotta, 1989; Sandiford, MacDonald, Robinson, Davenport, Elliot, & Hicks, 2002). The studies that are available generally do not include a clear control group, or do not allow for the isolation of the effect of learning style awareness from the effects of the broader intervention.

In this article, we try to meet these two lacunae regarding the hypothesis that stimulating learning style awareness can improve learning.

In the first part of this contribution, we develop a hypothetical process model for explaining the expected surplus value of learning style awareness for the learning process. In the second part of the text, we report a design experiment which was set up to empirically test these theoretical assumptions with a view to educational applications at university.

## Part I – Process model

The central question in this part of the text is: what happens when a student learns about learning styles in general and about the characteristics of his or her personal learning style in particular? Based on cognitive psychology, research on metacognition, theories about self-regulated learning, and theories about the self, a hypothetical process model is constructed.

### *Self-Regulated Learning*

We situate this process model within the broader framework of social cognitive theory of self-regulated learning (Schunk, 2001; Zimmerman, 1989, 1995, 2000). Figure 1 summarizes this perspective on self-regulated learning.

According to social cognitivists (Schunk, 2001; Zimmerman, 1989, 1995, 2000), self-regulated learning consists of three self-oriented feedback loops: behavioral self-regulation, environmental self-regulation, and covert self-regulation. The different self-regulatory processes and accompanying beliefs fall into three cyclical phases: forethought, performance or volitional control, and self-reflection. Of all these self-regulatory processes, self-observation, self-judgment, and self-reaction are considered to be the key sub processes of self-regulation. They interact with each other in reciprocal fashion (Zimmerman, 1989; Schunk, 2001). Comparably, in Winne's model (1998, 2001), the processes of metacognitive monitoring and metacognitive control are the hubs of self-regulated learning. A characteristic feature of social cognitive theory is that it embeds these self-regulatory processes within a larger triarchic system that also includes personal, behavioral and social-environmental factors. The model was chosen in particular because this triarchic system clearly represents how the surplus value of learning style awareness in the self-regulated learning process can be realized: a student becomes aware of his or her learning style, by which he or she can adapt the environment and/or behavior to manage his or her limitations and to optimize the learning process. Zimmerman (2000) almost literally describes this process: "The planning and selection of strategies requires cyclical adjustments because of fluctuations in covert personal, behavioral, and environmental components. No self-regulatory strategy will work equally well for all persons, and few, if any strategy will work optimally for a person on all tasks or occasions" (p. 14).

The grey dotted arrows in the figure represent the key elements of the hypothetical process model. In short, it is hypothesized that learning style awareness enhances metacognitive knowledge about the person factor in learning. Reflection on and awareness of one's own learning style contributes to the development of the self-concept. The learning style framework provides a language that enables verbal expression and cognitive representation of individual differences in learning on the one hand, and of the own strengths and weaknesses on the other. As a result of these intertwined developments, the student becomes more motivated and is more able to engage in more precise metacognitive monitoring, which enhances his or her ability to self-regulate. These key elements are further explained below.

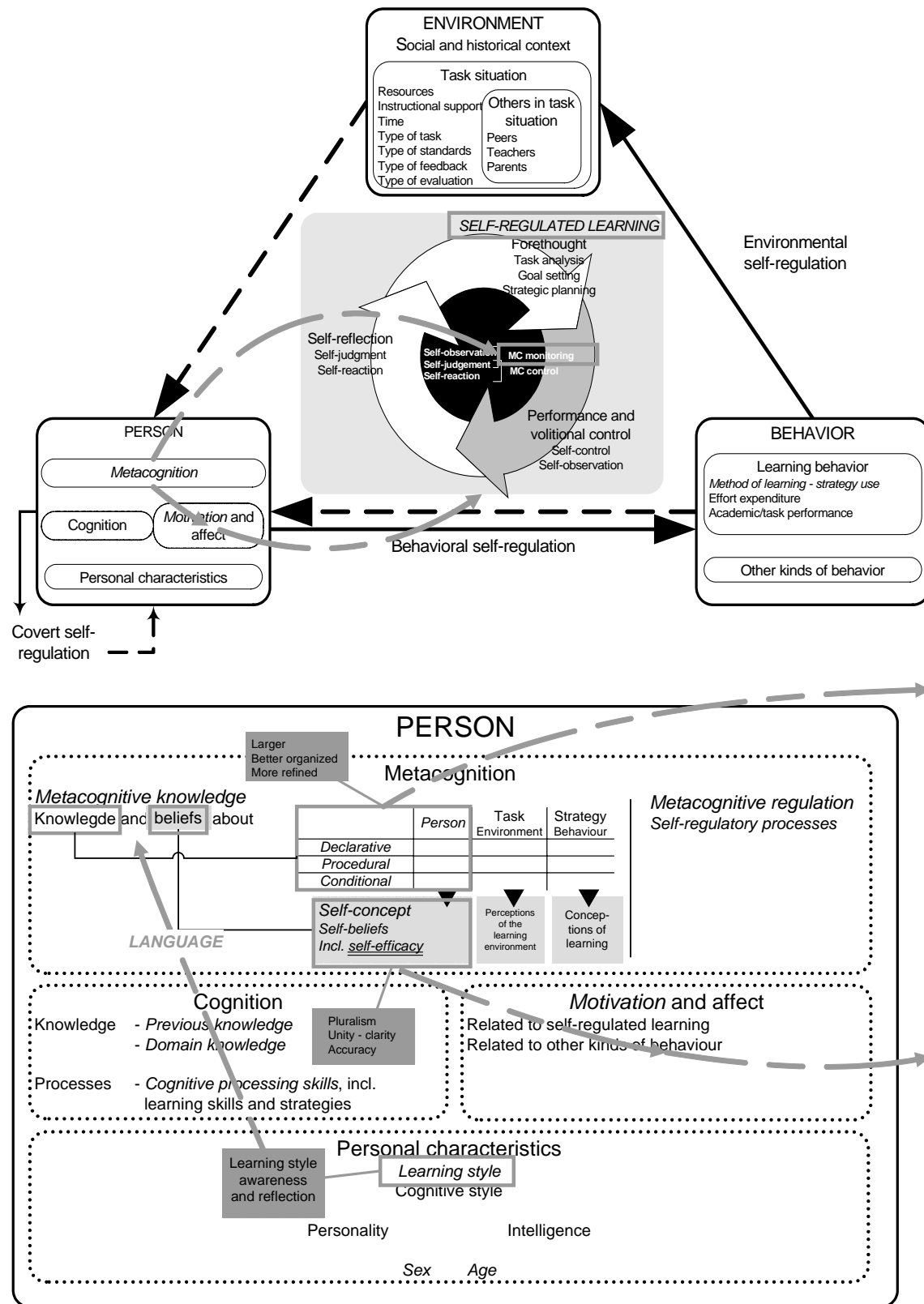


Figure 1. Social cognitive model of self-regulated learning. The bottom part of the figure shows the person factor in learning in more detail.

## *Metacognitive Knowledge*

### *Knowledge*

Knowledge about learning styles in general and about one's own learning style in particular, forms part of one's metacognitive knowledge. More specific, the knowledge concerns the so called intra-individual and interindividual differences in the person factor in learning: "everything that you can come to believe about the nature of yourself and other people as cognitive processors" (Flavell, 1979, p. 907). Flavell distinguished this form of metacognitive knowledge next to metacognitive knowledge of task variables and metacognitive knowledge of strategy variables. Overall, metacognitive knowledge can include declarative (e.g. "What is my learning style?"), procedural (e.g. "How does a person with a certain learning style process information?"), and conditional (e.g. "Under which environmental conditions does a person with a particular learning style learn best?") elements (Schraw & Moshman, 1995; Schraw, 2001).

It is assumed that when learning style awareness is stimulated, a student's metacognitive knowledge base somehow undergoes changes. A student basically acquires a language to talk and think about individual differences in learning. The student develops a psychological tool (Kozulin, 1998) to describe and understand his or her personal way of learning.

Since Flavell argued that metacognitive knowledge is not fundamentally different from other knowledge stored in long-term memory (Flavell, 1979), these changes in metacognitive knowledge can be described from a cognitive psychology framework:

First of all, the student's network of metacognitive knowledge of the person factor in learning enlarges. He or she acquires more knowledge about individual differences in learning in general and about his or her own personal way of learning in particular.

Since the learning style information forms a coherent theory, this information is represented as a schema. This is an economically organized knowledge structure, to which also the already available metacognitive knowledge can be linked. This economical representation makes the information readily accessible, information

processing more efficient, and provides a framework for recognizing new instances of information. Thus the student's network of metacognitive knowledge of the person factor in learning gets better organized.

At the same time, the learning style information enables the student to make more accurate discriminations in the domain of intra-individual and interindividual differences in learning. In this way, the network of metacognitive knowledge becomes more complex and more refined (based on Ashcraft, 1998; Gagné, Yekovich, & Yekovich, 1993; Winne, 2001).

### *Beliefs – Self-concept*

Knowledge of one's learning style not only consists of descriptive, objective information, but also has valence attached to it: What are my strengths and weaknesses in learning? How do I prefer to learn? Learning style awareness is therefore expected to also affect the subjective beliefs one holds about oneself as a learner, one's self-concept.

Most scholars conceptualize the self as a theory that must be cognitively constructed. The self-concept is not innate, but is developed by the individual through interaction with the environment and reflecting on that interaction (Harter, 1999).

Carver and Scheier (1998) mention that self-awareness has an effect on the development of more elaborated and firmly anchored self-concepts. The self-concept develops greater pluralism and greater unity in its structure (Harter, 1999; Campbell, Assanand, & Di Paula, 2003). By learning about learning style, the number of self-aspects within the student's self-concept enlarges (pluralism). On the other hand, learning to know oneself in terms of learning style also imposes greater unity on the self-concept. Self-concept clarity, or the extent to which the contents of the self-concept are clearly and confidently defined, internally consistent, and temporally stable, increases.

Furthermore, awareness of and reflection on learning style can contribute to the accuracy of self-knowledge (Nelson, Kruglanski, & Jost, 1998) because the self-concept becomes more empirically valid, better reflecting reality.

### *Self-Regulation*

It is assumed that the evolutions learning style awareness brings about in the student's metacognitive knowledge have a positive effect on the student's ability to self-regulate his or her learning process. The principle of reactivity, defined by Zimmerman (2002), simply states that students' metacognitive awareness of particular aspects of their functioning enhances their self-control. We hypothesize that metacognitive monitoring and the motivation generated by the self-concept play a mediating role.

### *Metacognitive Monitoring*

The developments in metacognitive knowledge have implications for the student's ability to metacognitively monitor the learning process. Through the fact that the student acquires more, better organized (unity) and more refined (pluralism) metacognitive knowledge and beliefs he or she becomes more able to self-judge what is known and not known. Self-evaluation becomes more accurate (Demetriou et al., 1999). Higher levels of reflective awareness make it possible for learners to metacognitively assess the validity and usefulness of their thoughts, feelings, and actions in a given learning context (McCombs, 2001). Carver and Scheier (Carver & Scheier, 1998) would say that "the comparators ability to detect differences between input and reference value increases".

Within Winne's framework of self-regulated learning (Winne, 1996; Winne, 2001) metacognitive knowledge functions as conditional knowledge for cognitive tactics. Cognitive tactics are schema's that are presented as rules in IF-THEN form. Tactics can have multiple IFs that specialize or differentiate behavior. Such a schema of IFs is conditional knowledge. The developments in metacognitive knowledge explained above are expected to result in more complex conditional knowledge. This complexity of conditional knowledge influences how students metacognitively monitor their learning and whether they identify occasions for applying cognitive tactics and strategies. Complex schemas of conditional knowledge allow tactics to be very discriminating about the contexts in which the actions assembled in them are enacted. Therefore, the more discriminating one's conditional knowledge, the more



detailed one's rules for classifying conditions, the higher the precision of comparisons that monitoring generates between products and standards and the greater the capacity to regulate one's learning (Winne, 1996; Winne, 2001).

### *Self-Concept and Self-Regulation*

According to McCombs (McCombs, 2001) the development of the self-concept is assumed to be one of the fundamental phenomena that explain the development of self-regulation. Its basic role in the learning process is generating motivation, as a function of evaluating the personal meaningfulness and relevance of learning activities relative to individual goals and beliefs about one's competencies and abilities.

From another line of research we learn that self-development, i.e. greater pluralism and unity, tends to enhance psychological adjustment (Campbell, Assanand & Di Paula, 2003). We expect this psychological well-being to be beneficial for the self-regulated learning process as well.

## Part II – Design Experiment

The aim of this experiment was to empirically test the expected surplus value of learning style awareness in the self-regulated learning process, as explained by the process model. At the same time, we wanted to explore whether the “learning style awareness” hypothesis can offer perspectives for educational applications of learning styles in university education, more specifically within the context of academic counseling.

### *Design*

An experiment was set up, with pre- and post-test, and three groups. During the academic year 2002-2003, an academic counseling program with a focus on self-regulated learning was organized for the first year medical students at the Faculty of Medicine and Health Sciences at Ghent University. The program was practically elaborated in collaboration with the faculty's academic counselor. Two versions of this program were developed. The control group received a standard self-regulated

learning program, without explicit information on learning styles. The experimental group participated in a self-regulated learning program in which learning style awareness was a central feature. The third, reference group did not participate in the program.

### *The Intervention: Two Versions of a Self-Regulated Learning Program*

#### *Conceptual Framework*

The social cognitive model of self-regulated learning (Schunk, 2001; Zimmerman, 1989, 1995, 2000) was used as a general conceptual framework to develop both versions of the program. This model clearly shows that self-regulated learning is a very complex interactive process. Without losing clarity, it gives an encompassing view on the topic. Adhering to this framework compelled us to equally pay attention to the various cognitive, metacognitive, motivational and affective sub-processes of self-regulated learning in developing the program, which preserved us from the one-sidedness that various authors observed in other study skills interventions (Hattie, Biggs, & Purdie, 1996; Kaldeway & Korthagen, 1994; Simpson, Hynd, Nist, & Burrell, 1997). The model could also be easily explained to the students.

#### *Common Instructional Approach in the Two Versions of the Program*

Both versions of the self-regulated learning program were set up as elective counseling programs, next to the normal teaching context. While the content of the program was based on the social-cognitive framework, the instructional approach used during the program sessions integrated four general characteristics that often reoccur in the literature on self-regulatory strategy instruction, thus creating a specific learning environment.

First, the program built on small group interaction. The maximum group size was 15. This reflected Zimmerman's conviction that self-regulated learning is social: each self-regulatory process or belief can be learned from instruction or modeling by parents, teachers, coaches and peers, who all form important elements of the learning environment (Zimmerman, 2002). It also gave ample opportunity for "reflective

discourses” about how to use strategies appropriately and to learn effectively (Paris & Paris, 2001), without telling students what to do or what strategies should be applied. The dynamics of small groups instruction allowed for an inductive approach, starting from problems raised by the students.

Secondly, the program consisted of direct instruction (Hattie et al., 1996; Lapan, 2002; Simpson et al., 1997). Each program session had clear instructional goals, and structured and sequential materials were provided. The self-regulatory strategies were explained to the students, and they were told for which types of tasks, for which types of learners, and why they were helpful. Various examples were used. As such, the students were stimulated to acquire declarative, procedural and conditional metacognitive knowledge, which was expected to make it more likely that they would transfer the strategies to other learning tasks. The students also had ample opportunity to practice the strategies, after which feedback was provided.

Third, although the strategy instruction was not embedded in the teaching context, real learning tasks and assignments were used. The self-regulatory strategies were taught within a realistic context and content area, always referring to the demands of the curriculum. (Hattie et al., 1996; Simpson et al., 1997).

Lastly, a high degree of learner activity and metacognitive awareness was promoted by asking questions to stimulate reflection (Hattie et al., 1996; Lapan, 2002).

### *The Learning Style Version of the Program*

The difference between the experimental and the standard version of the program was in the way the person factor in learning was addressed. The standard program was based on general reflection about personal characteristics and individual differences, without a given frame of reference. Personal strengths and weaknesses related to studying were reflected upon and discussed with fellow-students. In the experimental program, learning style awareness was explicitly promoted. In the first session, the students from the experimental group had to determine their own learning style, which was then thoroughly elaborated and discussed with fellow-students. These students’ personal learning style remained a point of reference during the whole program. The students learned to think about themselves (their strengths, weaknesses, preferences,

etc.) and about individual differences in learning in terms of learning style. They were stimulated to look at the evaluation of task and environmental factors and at the choice of study strategies from a learning style perspective.

Kolb's learning style model (Kolb, 1984; Kolb, 1999) was chosen as frame of reference for this experimental program. Kolb defines learning style as one's preferred mode of perceiving (Through concrete experience or abstract conceptualization?) and processing information (Through reflective observation or active experimentation?) in learning from experience. By combining these continua of learning modes, Kolb differentiates four learning styles: diverging, assimilating, converging, and accommodating. The Learning Style Inventory (LSI - first version: 1976) was developed to assess these learning styles. Each of these learning styles is considered to have its own strengths and weaknesses within a particular context. Whether a learning style is beneficial or not depends to a large extent on the demands of the learning environment. According to Kolb (1984), the ultimate object of personal development has to be integration: the learning skills of non-dominant learning modes have to be strengthened in order to be able to flexibly adapt to these demands. He states that a major step towards this goal is awareness of learning style.

There are two reasons why Kolb's model was selected. First, because it shows to be the most dominant model in the learning style literature, representative for the theoretical orientation that is at the heart of the learning styles research (Desmedt & Valcke, 2004; Henson & Hwang, 2002). The second reason is that the model and the accompanying inventory have strong face validity (Atkinson, 1991; Garner, 2000; Henson & Hwang, 2002). The four learning modes/styles and the results of Kolb's inventory are straightforward and very intelligible, and therefore easy to explain to students who are unfamiliar with learning styles.

However, it must be acknowledged that many authors have been very critical of Kolb's work. Garner (2000) for example, sees problems and inconsistencies in the theory behind Kolb's learning styles. This criticism can be countered with the argument that Kolb's model is one of the rare learning style models having a very elaborate theoretical background (see Kolb, 1984). Some other models lack any broader psychological or philosophical frame of reference altogether (Grigorenko &

Sternberg, 1995; Moran, 1991). More important is the criticism raised against the reliability and validity of the LSI (for an overview, see Atkinson, 1991; Henson & Hwang, 2002; Loo, 2002). The cause of these problems and a manner to cope with it will be discussed in the instruments section of this article. The final judgment of the critics is that the use of the LSI is only warranted for dialogical, rather than diagnostic purposes, as long as the user is mindful and open about the instrument's apparent limitations. Its use is appropriate to make the learning process explicit, increase learners' awareness, and stimulate personal development (Atkinson, 1991; Garner, 2000). That is the very purpose Kolb (1984, 1999) had in mind when he developed the LSI and it is the purpose for which it is used in the experimental self-regulated learning program.

### *The Program in Practice*

Both versions of the program consisted of four sessions, plus one evaluation session. Each session took 1.5 hours. They were planned throughout the academic year; the general aim was to guide the students through the self-regulated learning phases during the course of the year. Table 1 gives an overview of the planning and content of the sessions. It also shows how the sessions fitted in the social cognitive model of self-regulated learning.

The researcher and the counselor also mentored the program. They randomly assigned themselves to the various groups and sessions. A workbook was developed that served as a guideline/learning environment during the sessions. It was used by the mentors as a standardized scenario. The students could use it as a learning tool and reference book during studying. To guarantee the connection with the students' authentic learning environment, the program focused on studying for one specific course (general chemistry in the first semester - biochemistry in the second semester), and the students were stimulated to transfer the information to their study process as a whole.

Table 1

*Planning and Content of the Self-Regulated Learning (SRL) Program*

Session	Planning	Content	SRL Phase
Introduction and pre-test			
1	End of October	Introduction on SRL Analysis of learning environment and task demands Analysis of personal characteristics/ Learning style	Forethought
2	End of November Beginning of December	Goal setting Strategic planning Procrastination and fear of failure	Forethought
Exams January 2003			
3	February	Self-judgment: self-evaluation and causal attribution Self-reaction	Self-reflection
4	End of March Beginning of April	Study skills and strategies Stress management	Performance and volitional control
5	May	Evaluation of program by students	
Post-test			
Exams June 2003			

*Hypotheses*

Previous analyses into the effectiveness of the self-regulated learning program have generally shown that both versions had a beneficial effect on the learning process. All students who participated in the program were more likely to report a method of learning incorporating self-regulated learning (See Chapter 3).

It is hypothesized that the students in the learning style condition benefited more from the program than the students in the control condition. Learning style

awareness will have had a surplus effect on their ability to self-regulate, following the dynamics of the process model.

More specifically, the following hypotheses regarding the core elements of our theoretical process model were tested:

- Students in the learning style condition will report to a higher extent a method of learning incorporating effective metacognitive monitoring and self-regulated learning.
- Students in the learning style condition will have developed more and more refined metacognitive knowledge about the person factor in learning.
- Students in the learning style condition will have incorporated “learning styles” in their language when talking and thinking about learning.
- Students in the learning style condition will be more motivated and will report less fear of failure.
- Students in the learning style condition will report higher judgments of accuracy of self-knowledge.

In addition, we hypothesized that students in the learning style condition will show higher appraisal for and interest in the program, especially for the parts in which their personal learning style was explicitly addressed.

### *Participants*

All first-year medical students ( $N = 145$ ) were offered the opportunity to participate in the self-regulated learning program. It was agreed that students who attended the full program and the pre- and post-test, would receive two cinema tickets. Informed consent was obtained and anonymity of data-processing was guaranteed.

132 students (92.3 % of total) participated in the introductory pre-test session. After this introduction, 101 students engaged themselves to participate in the self-regulated learning program. They were assigned to 7 matched groups of 13 students on the average. Learning style was the matching variable, to obtain maximum diversity within the groups. An average group consisted of 6 students with an assimilating

learning style, 5 students with a converging learning style, 1 student with a diverging learning style, and 1 student with an accommodating learning style.

The eighth group consisted of 7 students who had already spent one or more years in higher education. These students were a priori assigned to the control condition. The 7 matched groups were randomly assigned to the experimental or the control condition.

Since participation was not compulsory, considerable drop-out occurred. This drop-out was however equally spread over the different groups and over the different learning styles. Overall, there were 38 students who participated in four or five sessions. Because the fifth session was an evaluation session, all these students were considered as students who attended the full program. 18 students attended the control version of the program, 20 attended the experimental version.

### *Instruments*

The variables that were measured are represented in italics in Figure 1.

#### *Learning style - Learning Style Inventory (LSI, Version 3)*

Learning style was assessed during the introductory pre-test session. A Dutch translation of the third version of the Learning Style Inventory (Kolb, 1999) was developed, using the parallel blind technique with the researcher as one of the translators (Behling & Law, 2000). The LSI is a 12-item questionnaire that measures a student's relative preference for concrete experience, reflective observation, abstract conceptualization, and active experimentation by asking them to rank four sentence endings that correspond to these four different ways of learning.

Table 2 lists the Cronbach's  $\alpha$  reliability coefficients of the translated version of the LSI-1999 in our sample of participants in the pre-test session ( $n = 132$ ).



Table 2

*Reliability of the Dutch Translation of the LSI-1999*

	$\alpha$
Concrete experience	.75
Reflective observation	.65
Abstract conceptualization	.77
Active experimentation	.73

These reliability scores are acceptable. Interpretation of these  $\alpha$  – scores is however not straightforward, because the LSI is an ipsative measure (Anastasi & Urbina, 1997; Cornwell & Dunlap, 1991; Henson & Hwang, 2002; Pickworth, 2000). Applying the usual correlation-based analysis techniques for psychometric evaluation with ipsative scores yields results that are difficult to interpret. They have to be considered as an artefact of the ipsative scoring method.

To be able to appropriately analyze the ipsative LSI scores, an alternative statistical procedure was applied: the original LSI scores were transformed following the procedure that was proposed by Cornwell and his colleagues (Cornwell & Dunlap, 1991; Cornwell & Manfreda, 1994). By using only an individual's first rank order of the final LSI ipsative scores, a nominal variable was defined, named primary learning style, indicating a preference for one of the four learning modes. According to Cornwell et al., this nominal variable can be used successfully in theory building and testing: because the final ipsative score is calculated as the sum of 12 separate ipsative items, this final score should be more reliable than the individual scores.

*Background Information – Questionnaire*

A questionnaire was developed to inquire about relevant background information during the introductory pre-test session: age, sex, studies last year (to see if they were freshmen or not), study result in secondary education, and results on the Flemish entrance examination. The latter comprised a score for knowledge of and insight in sciences and a score for information processing.

### *Method of Learning*

Two instruments were used to assess method of learning, namely the Leuven Executive Regulation Questionnaire (LERQ), which focuses on self-regulation, and the Approaches and Study Skills Inventory for Students (ASSIST), which focuses on the broader concept of approach to studying. These instruments were administered during the introductory pre-test session and during the post-test session.

#### *Leuven Executive Regulation Questionnaire (LERQ).*

The Leuven Executive Regulation Questionnaire (Minnaert, 1996) is a 63-item self-report questionnaire designed to investigate whether, to what extent, and how students regulate their study activities in higher education. Students are requested to respond to statements that relate to nine regulation activities (goal-setting, orienting, planning, monitoring, testing, diagnosing, on-line regulating, evaluating, reflecting). Each of the statements has to be judged on a five-point scale. As pre-test the LERQSO, a reformulation of the LERQ in terms of studying in secondary education (Masui, 2002), was used. Both questionnaires were used in original language version.

Minnaert (1996) reports a factor analysis resulting in five orthogonal scales. The first scale (23 items) is interpreted as effective self-regulation in study activities (process and content). The second scale (12 items) reflects incompetence to regulate study activities, partially due to a lack of metacognitive knowledge about studying in higher education. The third scale (16 items) reveals procrastination of regulating own study activities combined with a passive, field dependent regulation. The fourth scale (8 items) is interpreted as strategic, systematic regulation of study activities with a focus on planning and process monitoring, and the fifth scale (4 items) refers to active, field dependent regulation of study activities.

We examined reliability and validity of this instrument in our sample of pre-test session participants ( $n = 132$ ). All LERQSO scales, except the fifth scale ( $\alpha = .52$ ), showed good internal consistency. Cronbach's  $\alpha$ 's ranged between .79 and .83. Factor analyses were applied to investigate the factorial validity of this instrument. Three of the five LERQSO scales could be clearly recognized in the factor solution: the effective self-regulation scale, the incompetence to regulate scale, and the strategic,

systematic regulation scale. We decided to retain these three scales for further analyses. Sum scores were used.

*Approaches and Study Skills Inventory for Students (ASSIST.)*

The Approaches and Study Skills Inventory for Students (Entwistle, Tait, & McCune, 1999; “Scoring key”, 2003; Tait & Entwistle, 1996; Tait, Entwistle, & McCune, 1998) is a 52-item self-report questionnaire to investigate approaches to studying. The students have to respond to the items on a five-points scale. It is an extensively trialed and validated instrument, with a long history of development work (for an overview, see Tait, Entwistle, & McCune, 1998). It was translated in Dutch using the parallel blind technique with the researcher as one of the translators (Behling & Law, 2000).

The inventory distinguishes three approaches to studying, each consisting of various 4-item sub-scales. The deep approach comprises the sub-scales seeking meaning, relating ideas, use of evidence, and the motive interest in ideas. The strategic approach consists of the sub-scales organized studying, time management, alertness to assessment demands, monitoring effectiveness, and achievement motivation. The surface apathetic approach comprises the sub-scales unrelated memorizing, lack of purpose, syllabus boundness, and the motive fear of failure. Sum scores were used (“Scoring key”, 2003).

We examined reliability and validity of this instrument in our sample of pre-test session participants ( $n = 132$ ). Reliability analysis indicated that the three main scales of the ASSIST showed good internal consistency. Cronbach’s  $\alpha$ ’s ranged from .73 to .86. The developers of this instrument (Tait, Entwistle, & McCune, 1998) considered .50 as the acceptable minimum  $\alpha$  for the sub-scales. All sub-scales, except the “using evidence” sub-scale ( $\alpha = .17$ ), reached this ultimate value. Cronbach’s  $\alpha$ ’s ranged from .50 to .82. The three original main scales could be recognized in factor analysis at sub-scale level. Confirmatory factor analysis showed that the original factor structure fitted the data relatively well. There was no good fit,  $\chi^2 (62, N = 132) = 140.36, p = .000$ , GFI = .87, CFI = .85, RMSEA = .10, but the GFI and CFI could be considered as reasonably high. Also all parameter estimates were significant and had values consistent with the theory.

### *Metacognitive Knowledge – Written Assignment*

Metacognitive knowledge was assessed during the fifth session with a written assignment, which can be seen as a written version of the interview technique for measuring metacognition and self-regulated learning (De Groot, 2002; Schraw & Impara, 2000; Winne, 2000). The students were asked to give study advice to a fellow-student in a limited time of 15 minutes. To investigate the amount and quality of metacognitive knowledge, the metacognitive statements in these written protocols were coded according to the two dimensions described in the model of self-regulated learning.

The protocols ( $n = 33$ ) were coded by two independent coders. Inter-coder reliability was computed for 7 of these protocols (21% of the total sample). Percent agreement was 65.1 and Cohen's kappa was 0.45.

The variables of interest for this study were the total amount of metacognitive statements the students made regarding the person factor in learning and the amount of conditional metacognitive statements the students made regarding this person factor.

### *Language*

The written assignment was also used for tracing to what extent the students in the experimental condition adopted the learning style language in their vocabulary for talking about learning. The two independent coders counted how many times the students referred to "learning style" in general or to Kolb's four learning styles in particular.

### *Motivation*

Each approach to studying as explained above comprises a separate motivational sub-scale. A deep approach to studying is based on the motive interest in ideas, a strategic approach on achievement motivation, and a surface apathetic approach on fear of failure.

To be able to separately examine this motive component, these sub-scale scores were not included in the main scale scores.

### *Accuracy of Self-Knowledge – Self-Efficacy Scale*

In every session, the students were asked how confident they were that they could accurately judge their learning capabilities and their own strengths and weaknesses in learning. This came down to a judgment of self-efficacy in accuracy of self-knowledge. A self-efficacy scale was developed following Bandura's "Guide for constructing self-efficacy scales" (2001). The scale consisted of 12 items that were formulated as "To what extent can you...?". The students responded on a 0-100 scale. The psychometric properties of this self-efficacy scale were examined with data from the sub-sample of students who attended the first session ( $n = 67$ ). Cronbach's  $\alpha$  was .84. For further analysis the mean scale-score was used.

### *Appraisal of the program – Questionnaire and Group Interview*

The students' appraisal for the program was assessed in the fifth session with a short questionnaire and a more elaborate group interview.

The questionnaire consisted of two parts. The first part comprised 12 items that asked the students to judge the different aspects of the self-regulated learning program (the planning of sessions, the length of sessions,...) on a 0-10 scale (appraisal scores). In the second part, they had to rank order 12 topics of the different sessions according to how interesting they thought they were (interest scores).

The group interviews each lasted 40 minutes and were conducted by the researcher and the academic counselor. To make sure that these interviews would be free from "interviewer-error" and from "interviewee-error", the moderation method (Kwakman & Postema, 2000) was used as facilitation technique. The interview guideline can be found in Appendix. To more or less standardize the course of the interviews, the interviewers did not go deep into new topics raised by the students during the interview. The interviews were tape-recorded and full transcripts were made. The interviewers also took a picture of the way the students ordered and judged their responses.

An additional source of information about the students' appraisal for the program, were the phone interviews with the students who dropped out after the first session. An independent interviewer asked them to explain why they quit the program

after one session. The responses of 17 students (9 from the control condition, 8 from the learning style condition) could be collected. The interviews were tape-recorded and full transcripts were made.

### *Data Analysis*

Due to the small sample size, quantitative data analysis was limited to reporting descriptive statistics and testing mean differences using t-tests and univariate AN(C)OVAs. All dependent variables were tested separately. Effect sizes were computed to be able to uncover potentially interesting and valuable effects that are not significant, but that might have yielded more significant results if more subjects had been involved in the study (Kramer & Rosenthal, 1999; Olejnik & Algina, 2000). Cohen's *d* was used as effect size estimate. Effects with  $p < .05$  were considered significant; effects with  $p$  up to .20 and medium to large effect sizes were considered meaningful.

The students from Group 8, those who spent already one or more years in higher education, were excluded from the analyses, to avoid distortion of the results. Consequently,  $n$  for the control group became 13.

To check whether the experimental and the control group, in spite of matching and random assignment, were equivalent on relevant background and pre-test variables, this was tested before starting further analyses.

Qualitative analysis was used to process the group interviews. The interviews were reconstructed in mind maps, based on the transcripts, the response cards, and the photo's: one mind map per question and per group. MindGenius software was used. Each response as written on a card was considered as a code. These codes were initially ordered in categories according to the structure imposed by the students. Passages of the transcripts related to a particular code or category were saved as note with that code or category. For further analysis, the mind maps of all groups were integrated per question. Starting from the structure imposed by the students, similar categories were aggregated. Based on the transcripts, new codes and categories were added to capture new topics and themes.

The interviews with the drop-out students were processed using Atlas-ti. Bottom-up analysis was used to categorize the students' reasons for quitting the program.

## Results

### *Equivalence of Experimental and Control Group*

The results in Table 3 show that there was a significant difference between the experimental and the control group on the variable monitoring effectiveness. The experimental group also had meaningfully lower scores on study result in secondary education, strategic approach to studying, time management, and achievement motivation.

Table 3

*Means, Standard Deviations, t Values, and d Values for Background and Pre-Test Variables*

	Experimental condition (n = 20)		Control condition (n = 13)				
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>	<i>d</i>
Background							
Study result in secondary education	76.80	5.32	79.69	6.60	-1.388	.175	-.48
Knowledge of and insight in sciences	14.01	1.66	14.35	1.92	-0.531	.599	
Information processing	13.10	1.32	13.01	1.24	0.192	.849	
Self-regulation pre-test							
Effective self-regulation	64.45	10.02	61.69	9.96	0.774	.445	
Incompetence to regulate	23.70	6.76	21.46	9.93	0.772	.446	
Strategic, systematic regulation	22.50	5.01	23.46	4.27	-0.570	.573	

(table continues)

	Experimental condition ( <i>n</i> = 20)		Control condition ( <i>n</i> = 13)				
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>	<i>d</i>
Approaches to studying pre-test							
Deep approach	45.70	5.24	44.54	6.51	0.565	.576	
Seeking meaning	15.30	2.277	15.46	2.37	-0.196	.846	
Relating ideas	14.60	2.76	13.54	3.15	1.021	.315	
Strategic approach	55.50	9.13	59.46	6.53	-1.353	.186	-.50
Organised studying	13.70	3.85	13.61	3.04	0.067	.947	
Time management	13.60	4.26	15.38	2.36	-1.543	.133	-.52
Alertness to assessment demands	13.75	2.31	14.08	3.01	-0.352	.727	
Monitoring effectiveness	14.45	2.54	16.38	2.02	-2.305	.028	-.84
Surface approach	25.60	5.84	24.61	5.48	0.484	.632	
Lack of purpose	6.70	1.95	6.23	2.01	0.668	.509	
Unrelated memorising	9.65	3.17	9.15	3.31	0.432	.669	
Syllabus-boundness	9.25	2.17	9.23	2.17	0.025	.980	
Motivation pre-test							
Interest in ideas	15.90	1.71	15.69	1.49	0.357	.723	
Achievement motivation	14.10	2.77	15.46	2.02	-1.524	.138	-.56
Fear of failure	10.95	4.39	10.92	4.82	0.017	.987	

$\chi^2$ -tests showed that there were no significant differences between both groups on the variables sex,  $\chi^2 (1) = .045, p = .833$ , and primary learning style,  $\chi^2 (2) = 1.146, p = .564$ .

Consequently, when meaningful mean differences are found in further analyses, ANCOVA will be performed to ascertain if these differences can not be accounted for by the initial significant difference in monitoring effectiveness.



*Effects of Learning Style Awareness on Method of Learning  
Self-regulation.*

Table 4 indicates that there was a meaningful difference between the experimental group and the control group in strategic, systematic regulation of study activities with a focus on planning and process monitoring. There was a medium positive effect of participation in the learning style version of the program.

Table 4

*Means, Standard Deviations, t Values, and d Values for Self-Regulation*

	Experimental condition ( <i>n</i> = 20)		Control condition ( <i>n</i> = 13)		<i>t</i>	<i>p</i>	<i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Effective self-regulation	62.80	7.92	64.68	13.78	-0.498 <sup>a</sup>	.622	
Incompetence to regulate	26.10	6.75	24.98	8.89	0.409	.685	
Strategic, systematic regulation	26.95	3.56	24.89	3.77	1.584	.123	.56

<sup>a</sup>Levene's test for equality of variance: equal variances not assumed, with  $\alpha < .05$ .

ANCOVA was performed with post-test of strategic, systematic regulation of study activities as dependent variable, and monitoring effectiveness and pre-test of strategic, systematic regulation of study activities as covariates. The pre-test of strategic, systematic regulation of study activities provided a significant adjustment,  $F(1,29) = 15.178$ ,  $p = .001$ ,  $\eta^2 = .344$ . The covariate monitoring effectiveness did not significantly adjust the dependent variable,  $F(1,29) = 0.527$ ,  $p = .474$ ,  $\eta^2 = .018$ . The effect of condition remained,  $F(1,29) = 3.395$ ,  $p = .076$ ,  $\eta^2 = .105$ , and could be considered as medium to large.

These results support the hypothesis that students in the learning style condition would to a higher extent report a method of learning incorporating effective metacognitive monitoring and self-regulated learning.

*Approaches to Studying.*

Table 5

*Means, Standard Deviations, t Values, and d Values for Approaches to Studying*

	Experimental condition ( <i>n</i> = 20)		Control condition ( <i>n</i> = 13)		<i>t</i>	<i>p</i>	<i>d</i> <sup>a</sup>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Deep approach	42.65	5.84	45.39	5.20	-1.374	.179	(-.49)
Seeking meaning	14.70	2.39	16.07	1.45	-1.852	.074	(-.30)
Relating ideas	13.30	2.43	14.01	2.34	-0.829	.413	
Strategic approach	56.45	6.55	57.38	6.75	0.396	.695	
Organized studying	13.85	2.30	13.48	2.92	0.409	.685	
Time management	13.05	3.28	13.86	2.84	-0.730	.471	
Alertness to assessment demands	14.45	2.54	14.25	2.05	0.242	.810	
Monitoring effectiveness	15.10	2.17	15.80	1.42	-1.118	.272	
Surface approach	28.45	6.52	25.58	6.61			
Lack of purpose	7.70	2.79	5.70	2.02	2.224	.034	.82
Unrelated memorising	10.45	2.93	10.01	3.03	0.418	.679	
Syllabus-boundness	10.30	2.85	9.88	2.92	.413	.683	

<sup>a</sup> Values between brackets refer to effects that disappeared after relevant covariates were controlled for.

Table 5 shows that participating in the experimental condition had a significant and large positive effect on the variable lack of purpose. ANCOVA with post-test of lack of purpose as dependent variable, and monitoring effectiveness and pre-test of lack of purpose as covariates, indicated that only the pre-test of lack of purpose provided a meaningful adjustment,  $F(1,29) = 3.765$ ,  $p < .062$ ,  $\eta^2 = .115$ . The effect of condition however remained,  $F(1,29) = 3.285$ ,  $p = .080$ ,  $\eta^2 = .102$ .

There also were medium differences between the experimental and the control group on seeking meaning and deep approach to studying, in favor of the control group. A first ANCOVA with post-test of seeking meaning as dependent variable, and

monitoring effectiveness and pre-test of seeking meaning as covariates, however showed that this difference could be fully explained by differences in the covariates: for seeking meaning,  $F(1,29) = 25.580$ ,  $p < .000$ ,  $\eta^2 = .469$ , and for monitoring effectiveness,  $F(1,29) = 25.736$ ,  $p < .000$ ,  $\eta^2 = .470$ . The effect of condition disappeared,  $F(1,29) = 0.353$ ,  $p = .557$ ,  $\eta^2 = .012$ .

The same held for the differences in deep approach. A second ANCOVA with post-test of deep approach as dependent variable and monitoring effectiveness and pre-test of deep approach as covariates, indicated that also this difference could be fully explained by differences in the covariates: for deep approach,  $F(1,29) = 36.975$ ,  $p < .000$ ,  $\eta^2 = .560$ , and for monitoring effectiveness,  $F(1,29) = 15.431$ ,  $p < .000$ ,  $\eta^2 = .347$ . The effect of condition almost disappeared,  $F(1,29) = 1.473$ ,  $p = .235$ ,  $\eta^2 = .048$ .

For there were no significant or meaningful differences between the experimental and the control group on monitoring effectiveness or on the other aspects of a strategic approach to studying, these results do not support the hypothesis that students in the learning style condition would to a higher extent report a method of learning incorporating effective metacognitive monitoring and self-regulated learning.

### *Effects of Learning Style Awareness on Metacognitive Knowledge*

Table 6

*Means, Standard Deviations, t Values, and d Values for Metacognitive (MC) Knowledge about the Person Factor in Learning*

			Experimental condition ( $n = 17$ )		Control condition ( $n = 12$ )		$t$	$p$	$d$
			$M$	$SD$	$M$	$SD$			
MC knowledge about			0.94	1.56	1.75	1.48	-1.402	.172	-.53
person factor - Total									
MC knowledge about			0.29	0.59	0.75	0.75	-1.831	.078	-.67
person factor -									
Conditional									

Table 6 indicates that there were meaningful differences between the students from the experimental and the control condition in their metacognitive knowledge about the person factor in learning. Students from the learning style condition had lower scores than students from the control condition based on total metacognitive knowledge about the person factor in learning as well as on conditional metacognitive knowledge about the person factor in learning.

A first ANCOVA was performed with metacognitive knowledge of the person factor as dependent variable and monitoring effectiveness as covariate. The covariate monitoring effectiveness did not significantly adjust the dependent variable,  $F(1,26) = 0.136, p = .715, \eta^2 = .005$ . The effect of condition remained,  $F(1,26) = 2.025, p = .167, \eta^2 = .072$ , and could be considered as medium. Next, a second ANCOVA was performed with conditional metacognitive knowledge of the person factor as dependent variable and monitoring effectiveness as covariate. The covariate monitoring effectiveness significantly adjusted the dependent variable,  $F(1,26) = 6.415, p = .018, \eta^2 = .198$ , but also the effect of condition was significant,  $F(1,26) = 7.537, p = .011, \eta^2 = .225$ , and could be considered as large.

These results imply that the hypothesis that students in the learning style condition would have more and more refined metacognitive knowledge about the person factor in learning than students in the control condition, must be rejected.

#### *Effects of Learning Style Awareness on Language*

None of the students referred to “learning style” or to one of Kolb’s four learning styles in the study advice they wrote for a fellow-student. It seems that the hypothesis that students in the learning style condition would incorporate “learning styles” in their language to talk about learning must be rejected.

#### *Effects of Learning Style Awareness on Motivation*

Table 7 suggests that there was a medium to large difference between the experimental and the control group on achievement motivation at the end of the academic year. Students from the control group had higher scores than students from the experimental group.

Table 7

*Means, Standard Deviations, t Values, and d Values for Motivation*

	Experimental condition ( <i>n</i> = 20)		Control condition ( <i>n</i> = 13)				
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>	<i>d</i> <sup>a</sup>
Interest in ideas	15.30	3.08	15.60	1.39	-0.380 <sup>b</sup>	.707	
Achievement motivation	13.45	2.06	14.80	2.38	-1.727	.094	(-.61)
Fear of failure	12.05	4.66	11.46	4.91	.347	.731	

<sup>a</sup> Values between brackets refer to effects that disappeared after relevant covariates were controlled for.

<sup>b</sup> Levene's test for equality of variance: equal variances not assumed, with  $\alpha < .05$ .

However, when an ANCOVA was performed with achievement motivation as dependent variable, and monitoring effectiveness and the pre-test of achievement motivation as covariates, both covariates significantly adjusted the dependent variable,  $F(1,29) = 5.332$ ,  $p = .028$ ,  $\eta^2 = .155$  for monitoring effectiveness;  $F(1,29) = 4.254$ ,  $p = .048$ ,  $\eta^2 = .128$  for pre-test of achievement motivation, and the effect of condition disappeared,  $F(1,29) = 0.157$ ,  $p = .695$ ,  $\eta^2 = .005$ .

Based on these results, the hypothesis that students in the learning style condition would be more motivated and would report less fear of failure, must be rejected.

#### *Effects of Learning Style Awareness on Accuracy of Self-Knowledge*

Table 8 indicates that there was no significant difference between the experimental group and the control group on self-efficacy in accuracy of self-knowledge.

ANCOVA with monitoring effectiveness as covariate shows that the difference that existed, could be accounted for by the initial differences in monitoring effectiveness,  $F(1,30) = 5.430$ ,  $p = .027$ ,  $\eta^2 = .153$ . Condition had no effect at all,  $F(1,30) = 0.002$ ,  $p = .966$ ,  $\eta^2 = .000$ .

The hypothesis that students in the learning style condition would report higher judgments of accuracy of self-knowledge must therefore be rejected.

Table 8

*Means, Standard Deviations,  $t$  Values, and  $d$  Values for Self-Efficacy in Accuracy of Self-Knowledge*

	Experimental condition ( $n = 20$ )		Control condition ( $n = 13$ )		$t$	$p$	$d$
	$M$	$SD$	$M$	$SD$			
Self-efficacy in accuracy of self-knowledge	65.16	9.59	68.46	12.47	-0.859	.397	

#### *Effects of Learning Style Awareness on Appraisal of the Program*

##### *Appraisal scores.*

Table 9 indicates that the students who participated in the learning style version of the program expressed lower appraisal for many aspects of the program. There were large effects of condition on the students' appraisal of working in small groups, of the knowledge of the mentors, and of the usefulness of the program. There were medium effects of condition on the students' appraisal of the content of the workbook, of the way the program was logically constructed, of the exercises, and of the usefulness of the workbook.

ANCOVAs with monitoring effectiveness as covariate were performed to check whether these differences could not be accounted for by the initial difference between the groups on this variable. The results showed that monitoring effectiveness significantly adjusted the appraisal for the content of the workbook,  $F(1,26) = 5.165$ ,  $p = .032$ ,  $\eta^2 = .166$ , and the usefulness of the program,  $F(1,26) = 2.996$ ,  $p = .095$ ,  $\eta^2 = .103$ . The covariate had a meaningful effect on the appraisal of the exercises,  $F(1,26) = 1.946$ ,  $p = .175$ ,  $\eta^2 = .070$  and the usefulness of the workbook,  $F(1,26) = 1.764$ ,  $p = .196$ ,  $\eta^2 = .064$ . For all these variables, the effect of condition did not remain significant or meaningful.

Next, the covariate did not significantly adjust the appraisal for the small groups,  $F(1,26) = 0.112$ ,  $p = .741$ ,  $\eta^2 = .004$ , the appraisal for the knowledge of the mentors,  $F(1,26) = 1.021$ ,  $p = .321$ ,  $\eta^2 = .038$  and the logical construction of the program,  $F(1,26) = 0.031$ ,  $p = .862$ ,  $\eta^2 = .001$ . However, only the effects of condition on the appraisal for the small groups and the appraisal for the knowledge of the mentors remained respectively significant,  $F(1,26) = 5.503$ ,  $p = .027$ ,  $\eta^2 = .175$  and meaningful  $F(1,26) = 2.374$ ,  $p = .135$ ,  $\eta^2 = .084$ .

Table 9

*Means, Standard Deviations, t Values, and d Values for Appraisal of the Different Aspects of the Self-Regulated Learning Program*

Appraisal of	Experimental condition ( $n = 17$ )		Control condition ( $n = 12$ )		$t$	$p$	$d^a$
	$M$	$SD$	$M$	$SD$			
Content program	6.76	1.92	7.33	0.89	-0.952	.349	
Planning sessions	8.12	1.05	7.67	1.23	1.059	.299	
Content workbook	6.41	2.12	7.25	0.87	-1.464 <sup>b</sup>	.157	(-.52)
Small groups	8.59	1.23	9.50	0.52	-2.732 <sup>b</sup>	.012	-.96
Knowledge mentors	7.82	1.07	8.58	0.90	-2.001	.056	-.77
Usefulness program	5.00	2.47	6.41	1.24	-2.027 <sup>b</sup>	.054	(-.72)
Length sessions	6.65	2.06	6.33	1.56	0.445	.660	
Design workbook	7.53	1.54	7.33	1.07	0.379	.708	
Logical construction program	7.23	1.92	7.92	0.67	-1.351 <sup>b</sup>	.191	(-.47)
Exercises	6.29	1.45	7.00	0.95	-1.474	.152	(-.57)
Usefulness workbook	5.41	2.00	6.42	1.00	-1.781 <sup>b</sup>	.087	(-.63)
Teaching style mentors	7.65	1.66	8.17	0.94	-0.979	.336	

<sup>a</sup> Values between brackets refer to effects that disappeared after relevant covariates were controlled for.

<sup>b</sup> Levene's test for equality of variance: equal variances not assumed, with  $\alpha < .05$ .

A last observation is that for many of these appraisal variables, equal variances could not be assumed. The standard deviations tended to be larger in the experimental group, which indicates that in this learning style group, there was a larger variation of opinions regarding the appraisal of the program.

Overall, these results do not support the hypothesis that the students in the learning style condition would show higher appraisal for the program.

*Interest scores.*

Table 10

*Means, Standard Deviations, t Values, and d Values for Interest in the Different Topics of the Self-Regulated Learning Program*

Interest in	Experimental condition ( <i>n</i> = 17)		Control condition ( <i>n</i> = 12)		<i>t</i>	<i>p</i>	<i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Analysis of task demands	2.47	1.94	4.25	2.70	-2.069	.048	-.76
Analysis of resources in the learning environment	3.41	1.12	3.33	1.97	0.136	.893	
Analysis of personal characteristics/ Learning style	4.88	4.86	5.50	2.07	-0.468 <sup>a</sup>	.644	
Goal setting	6.70	2.20	7.42	2.91	-0.750	.460	
Strategic planning	8.59	2.57	8.58	2.94	0.005	.996	
Procrastination and fear of failure	6.65	2.83	8.08	3.65	-1.194	.243	
Self-reflection	7.47	2.87	6.17	3.71	1.067	.296	
Searching structure	7.23	3.33	7.58	2.47	-0.307	.761	
Study skills and strategies	8.47	2.90	7.83	3.27	0.553	.585	
Mnemonics	9.12	2.57	6.67	4.05	1.996	.056	.72
Technique-evaluation-matrix	4.82	2.50	4.50	3.55	.288	.775	
Stress management	7.82	3.52	8.64	3.38	-.605	.550	

a. Levene's test for equality of variances: equal variances not assumed, with  $\alpha < .05$



Table 10 indicates that overall, there were few differences between the experimental and the control group regarding interest in the different topics of the self-regulated learning program. There was no significant difference between both groups in interest for the topic analysis of personal characteristics (control group) or personal learning style (experimental group). Both groups however did not show equal variances for this variable: apparently, in the learning styles group, opinions were more divided.

There were two large differences between the experimental and the control group. Students from the control group expressed significantly higher interest in the topic analysis of task demands, while students from the experimental group expressed meaningfully more interest in mnemonics.

Two ANCOVAs were performed with monitoring effectiveness as covariate, to check whether these differences could not be accounted for by the initial difference between the groups on this variable. The results show that the covariate did not significantly adjust both interest scores: for interest in analysis of task demands,  $F(1,26) = 0.170$ ,  $p = .683$ ,  $\eta^2 = .007$ , and for interest in mnemonics,  $F(1,26) = 0.041$ ,  $p = .842$ ,  $\eta^2 = .002$ . The effect of condition on both interest scores remained rather large: for interest in analysis of task demands,  $F(1,26) = 3.156$ ,  $p = .087$ ,  $\eta^2 = .108$ , and for interest in mnemonics,  $F(1,26) = 3.657$ ,  $p = .067$ ,  $\eta^2 = .123$ .

Nevertheless, the hypothesis that students in the learning style condition would show higher interest in the parts of the program in which their personal learning style was explicitly addressed, could not be maintained.

#### *Interview data.*

In this article, we are particularly interested in what the students from the experimental group spontaneously said about the emphasis on learning styles throughout the program. Did they consider it as a good or rather uninteresting aspect of the program?

Apparently, the opinions were about equally divided. Some students said they found it interesting to get to know their learning style:

- *It confirmed my study method. It was good for my self-knowledge. I already knew how I studied, but I wasn't 100% sure. That is why I found it interesting to know whether I was a thinker or a dreamer or so. It confirms...*

Others did not judge it interesting. They found it rather useless and said that the topic returned too much throughout the program:

- *I didn't really need to know whether I was a thinker, dreamer,... I think I know myself. I also think I won't change myself or so because I know my learning style...*
- *Those "four different types" were not interesting to know.*

From the interviews with the drop-out students, we learned that the most important reasons for quitting the program after one session were "I'd rather use my time for studying", "I forgot/didn't know there was a session", "I couldn't come/planning difficulties", "Session 1 was not interesting". Table 11 shows that students who dropped out of the standard program equally mentioned all reasons for quitting. However, of the students who dropped out of the learning style program, the majority said they quit the program because they found session 1 not interesting.

Table 11

*Reasons for Quitting the Program after One Session by Condition*

	Experimental condition	Control condition
"I'd rather use my time for studying"	0	2
"I forgot/didn't know there was a session"	2	2
"I couldn't come/planning difficulties"	0	2
"Session 1 was not interesting"	6	3

## Discussion and Conclusions

The idea that learning style awareness has a positive effect on the learning process seems to be generally accepted as a self-evident conception. Since the traditional matching-approach did not yield the expected results, fostering students' learning style awareness is often seen as another, possibly more fruitful educational application of the traditional learning style models. However, this "learning style awareness" hypothesis still lacks sound theoretical and empirical foundations. The aim of this study was therefore twofold. First, to develop a theoretical process model for explaining the expected effect of learning style awareness on the learning process, and second, to empirically test these theoretical assumptions with a view to educational applications at university.

In the first part of this article, we developed a theoretical explanation for the expected surplus value of learning style awareness within the broader framework of self-regulated learning. Based on cognitive psychology, research on metacognition, theories about self-regulated learning, and theories about the self, we managed to write a plausible narrative. Five hypotheses regarding the core elements of the process model were subsequently put to the test in a design experiment reported in the second part of this article. A learning style version and a standard version of an intervention to promote self-regulated learning in first year medical students were compared, entertaining high expectations of the effect of learning style awareness on the students' ability to self-regulate.

The results show that none of the hypotheses can be accepted. The students whose learning style awareness was explicitly stimulated, did not have more and more refined metacognitive knowledge about the person factor in learning; they did not incorporate "learning styles" in their language to talk and think about learning; they were not more motivated and they did not report less fear of failure; they did not report higher judgments of accuracy in self-knowledge. Regarding to the hypothesis about their ability to self-regulate, the results are less unambiguous. The mean score of the learning styles group on strategic, systematic self-regulation of study activities with a focus on planning and process monitoring was higher than that of about 70% of the

students in the control group ( $d = .56$ ), but this difference was not statistically significant and was not corroborated by differences on the related strategic approach to studying. We therefore do not have sufficient evidence in support of our primary hypothesis that students in the learning style condition would to a higher extent report a method of learning incorporating effective metacognitive monitoring and self-regulated learning. Overall, the “learning style awareness” hypothesis and its expected value for educational applications at university are not empirically supported by the results of this study.

Throughout the results, we find indications that the students in the experimental condition had rather mixed feelings regarding the learning style information. From our qualitative outcomes, we learn that students who dropped out of the learning style version of the program often mentioned uselessness of the first session (i.e. the introductory session on learning styles) as the most important reason to quit. Interviews with the participants show that the opinions about this learning style information were divided: some found it interesting, others thought it was useless and boring. The quantitative information on appraisal of and interest in the program reflects this variation in opinions. The fact that the students from the learning style condition report significantly more “lack of purpose” at the end of the academic year than the students from the control condition, might ultimately reflect their opinion that the learning style information had questionable relevance. When we realize that the students did not experience the awareness of their personal learning style as the powerful tool to ameliorate their study method it is generally thought to be, it becomes very clear why learning style awareness did not have the effect we expected. This is in line with the knowledge from research from the phenomenological (McCombs, 2001) and phenomenographic tradition (Entwistle & Tait, 1990; Marton, Hounsell, & Entwistle, 1997), that the students’ beliefs and perceptions of the learning environment mediate the effects of this environment on behavior. These results strongly challenge the optimism about the students’ reaction on information about their own learning style awareness that is implicit in the writings of the learning style awareness advocates (Andrew, Pheiffer, Green, & Holley, 2002; Carns & Carns, 1991; Cook, 1991; Labour, 2002; Lacina, 1991; Nickles, 2003; Sandiford, MacDonald, Robinson,

Davenport, Elliot, & Hicks, 2002). Apparently, the students did not consider Kolb's learning styles as particularly relevant for understanding their own learning. Although the learning style information was explicitly contextualized and the students were stimulated to relate their learning styles to their concrete learning experiences, integration did not occur.

An explanation for these "unexpected" results can in the first place be found in our theory. When constructing the theoretical process model, we already realized that what we wrote is an optimistic story. We enlarged one specific sub-process in the model of self-regulated learning, meanwhile overlooking other critical features that could at the same time neutralize the expected effect of learning style awareness. The literature that supports the "learning style awareness" hypothesis also helps to explain why learning style awareness might not work.

First, from theories about the self, we learn that it is not very likely that the self-concept of a student, once he or she has reached a certain age, will drastically develop by learning about his or her personal learning style. Harter (1999) explains that the self-concept in the first place undergoes normative-developmental changes, parallel to cognitive development. Specific socialization experiences can also have an impact, for example on accuracy of self-knowledge, but an important condition is that the new information must fit with the student's present self-concept. Referring to the mixed opinions about the learning style information, this might not have been the case for some students. Interventions to improve the accuracy of self-evaluations have shown to be very difficult: many individuals go to great lengths to seek feedback that confirms their self-concept and typically reject information that threatens the stability of their self-representations (Harter, 1999, p. 322). This is similar to the dynamics of classic cognitive dissonance theory (Festinger, 1957). These dynamics might also explain the resistance we felt amongst the students against the results of the LSI. Some students were very skeptical: "How can such a 'stupid' short questionnaire tell something about my personal way of learning... ". They probably experienced a tension between the straightforward, simple, decontextualized learning style labels (as contended by Reynolds, 1997; Stellwagen, 2001) and their conceptions of their own learning as being more "serious", complex and context-specific, which resulted in

rejection of the learning style information. The LSI might have lacked “respondent validity” (Silverman, 1993) in this study.

Second, in the literature on metacognition and self-regulated learning the pervasive relationship between metacognitive awareness and metacognitive regulation is a basic assumption (Brown, 1987; Hacker, 1998; Schraw, 1998). The knowledge that all the students who participated in the program showed higher ability to self-regulate than the students who did not, together with the current result that fostering metacognitive awareness in terms of learning styles or in more general terms does not make a significant difference, stresses this importance of *metacognitive* awareness in general, rather than the importance of *learning style* awareness in particular.

Last, embedding the theoretical process model within the broader framework of self-regulated learning clearly showed that effective learning involves more than only metacognitive knowledge of the person factor and accuracy of self-knowledge. It is a very complex process, with many intertwined sub-processes (Schunk, 2001; Zimmerman, 1989, 1995, 2000). To be an effective learner, a student also needs metacognitive knowledge about strategies and tasks, and the skills to plan, set up, control and monitor his or her learning process. All these aspects have been addressed in both versions of the self-regulated learning program. Within this broader framework, learning style awareness becomes merely a cog in the wheel of the learning process: its limited surplus value in this study is therefore not surprising.

The strength of this study lies in the fact that we explicitly situated the idea of learning style awareness within this broader framework of self-regulated learning. Up to now, the idea was commonly put forward within the learning style literature in a rather isolated fashion. This is reflected in the existing empirical studies, which often do not allow for the isolation of the effect of learning style awareness from the effects the broader intervention might have had on general metacognitive knowledge, learning strategies, self-concept etc. Our results show that when learning style awareness is considered next to these other sub-processes of learning, we must be less optimistic about its unique impact. Further, the decision to include qualitative elements in our investigation also constitutes a strength of this study. Without the information from the

interviews, we would never have been able to understand how the students experienced our attempts to foster learning style awareness.

Before formulating final conclusions regarding the “learning style awareness” hypothesis and its value for educational applications at university, some limitations of this study must however be considered.

First, our sample of students was very small, and we worked within the specific context of academic counseling in first year medical education. Our results therefore have limited generalizability.

Second, the medical students involved in this study had a very one-sided learning style profile: the vast majority of these students preferred the abstract conceptualization or active experimentation learning style. The other two learning styles were strongly underrepresented. This lack of diversity within the groups probably made the learning style differences not very tangible for the students. There was little opportunity to actually experience the differences between the learning styles of their fellow-students. In a more diverse group, the students might have experienced the learning style information as more relevant. In retrospect, we may have chosen the wrong learning style model for this specific group.

A final limitation might be the operationalization of the core variables in our theoretical process model. Especially the measures of metacognitive knowledge about the person factor in learning and of self-efficacy in accuracy of self-knowledge might pose problems of reliability and validity, for they were developed solely for the purpose of this study.

In conclusion, it would be a step too far to fully reject the “learning style awareness” hypothesis and its possible value for educational applications, solely on the basis of this limited study. However, the results point out that the impact of learning style awareness on the quality of learning must be reconsidered and certainly not be overestimated.

But finally, if not through matching, and not through stimulating awareness, what value do learning styles hold for improving learning at university?

What seems to be sure is that fostering effective learning at university requires complex interventions, with plural foci (see meta-analysis Hattie et al., 1996). Within

the context of such an intervention, learning styles can play a role in stimulating metacognitive awareness of personal strengths and weaknesses in learning. It however appears from this study that some well-chosen questions can just as well boost these processes of self-reflection. A formal assessment does not seem necessary. As Reynolds (1997) and Dixon (1985) also suggested, learning style measures can as well be bypassed. Knowing from this study that strictly adhering to results of a particular learning style instrument which are not considered very relevant by the students, might even cause resentment, the introduction of learning style information should always be carefully considered. It appears that if this information does not fit into the everyday experiences of the students, the risk exists that it will be rejected. Our results confirm that learning style instruments hold as much potential for harm as they do for good (Dixon, 1985).

The value of learning styles for university education could also be considered from a different position. They brought individual differences to the notice of educators who are concerned about the learning process of their students. Without the dimensions along which students can differ in mind, it would be more difficult for these educators to formulate the right questions to foster reflection on learning and to provide the rich environments in which all learners can thrive. The merit of the learning styles research is that it explicitly conceptualized these fundamental dimensions of individual differences.



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## Appendix

### Appraisal of the Program – Interview Guideline

The following questions and sub-questions were literally posed:

- Which effect did the self-regulated learning program have on you? Note three things that you have learned on separate response cards.

What would have been more difficult to learn without the program? Mark it with a red sticker. Where did you not need the program for? Mark it with a green sticker.

- Which aspects of the program did you particularly appreciate? What was good? Note three aspects on separate response cards.

What should remain unchanged when the program is repeated? Mark it with a red heart sticker.

- Which aspects of the program were not good? Note three aspects on separate response cards.

What should be changed when the program is repeated? Mark it with a lightning sticker.

For each question, the interview was structured as follows:

- The main question was written on a flip-over sheet and posed literally to the group.
- The students individually wrote down their answers on the response cards.
- The answers were collected and hung on the blackboard. The students explained their answer.
- The answers were ordered thematically in front of the class by the students and discussed in group.

The sub-questions were posed, by which the students could consider the answers of the whole group.

## **General Discussion and Conclusions**

In this dissertation, our primary aim was to tackle two problems that often reoccur in the critical literature on learning styles and that hamper the development of educational applications of this – very popular – concept.

The first problem, the conceptual confusion in the learning style research field, was the focus of chapter 1 of this dissertation. Chapters 2 to 5 reported on four studies that build on an experiment that was set up in the context of university education, more specifically in first-year medical education, and that was focused on the second problem, the problem of educational applications of learning styles. We investigated the potential of the “learning style awareness” hypothesis as an alternative for the traditional matching-approach, within the context of an academic counseling program aimed at fostering self-regulated learning.

In this final chapter, we bring together the results of these five chapters. We present a general discussion, together with an account of the limitations and implications of this research project.

### **Overview of the Results**

In chapter 1, an alternative overview of the cognitive style and the learning style literature was developed, using citation analysis. This enabled us to distinguish the dominant theoretical orientations in the field, to point at their specific interrelationships, and to clarify the broader context of the various definitions, models and instruments. It also showed the differences and overlap between the concepts learning style and cognitive style. With regard to our further investigations, the results grounded the central position of Kolb’s learning style model. It is this model that has been selected for our further investigations.

In chapter 2, the learning styles of the first-year medical students who were involved in our experiment were examined. A comparison was made with the learning styles of first-year pedagogical sciences students. The results showed that, as was expected,

first-year students in medicine and pedagogical sciences have significantly different learning styles. Abstract conceptualization was the dominant learning style in the group of medical students. More than half of these students showed this preference. Another third of the students preferred active experimentation. In the pedagogical sciences group, the four different learning styles were more equally distributed.

Chapter 3 focused on the general effectiveness of both versions of an academic counseling program. The students who attended the full program (the learning style as well as the standard version) were compared with the students who dropped out and the students who did not participate.

First, the results showed that, contrary to our predictions, the self-regulated learning program had no effect on the students' final exam results. The participating students did not obtain significantly better final grades than the non-participating and the drop-out students. But second, the self-regulated learning program did have an effect on the students' method of learning. The hypothesis that students who participated in the program would be more likely to report a method of learning incorporating self-regulated learning was confirmed. Lastly, the program also had an effect on an aspect of the participating students' perceived self-efficacy. Their self-efficacy in self-regulated learning increased over the course of the year. The program however did not have an effect on self-efficacy with regard to academic performance. As to general learning efficacy, there was an effect of participation, but it were the non-participating students who reported the highest self-ratings.

By incorporating the individual differences factors sex, primary learning style, and academic experience (freshman or not) in the design, some interesting interaction effects were revealed, which suggests that the self-regulated learning program was able to abridge differences that were related to personal characteristics of the students. Participants from groups that tended to fall behind in some respects (male students, students with an active experimentation primary learning style, non-freshmen students) apparently took advantage of their participation.

As to the main effects of the individual differences factors, it appeared that sex was an important variable. First of all, female students were diligent participants in

this study: they were overrepresented in the post-test session and in the program as a whole. Next, female students had a more strategic approach to studying based on achieving motivation and strategic, systematic self-regulation of learning. Also gender differences in self-efficacy could be observed.

In chapter 4, we examined whether and how the dynamics that are set out in the social cognitive model of self-regulated learning manifest themselves in the study processes of the first-year medical students. Learning styles were situated within this broader model of self-regulated learning.

First, several relationships were found between the person and behavior variables as measured at the start of the academic year: between prior knowledge and domain knowledge, between cognitive processing skills and cognitive style, between learning style and cognitive style, between learning style and method of learning, and between cognitive style and method of learning.

Next, with regard to the prediction of perceived self-efficacy at the end of the academic year, we hypothesized that prior and domain knowledge, and method of learning as measured at the start of the academic year, would be the strongest predictors. A central observation, however, was that this was different for the different types of perceived self-efficacy. The above hypothesis could therefore not be rejected, but needs further refinement. We observed that prior and domain knowledge only predicted self-efficacy in achieving a good final result (14-15) in one specific course (biochemistry). Sex significantly added to the prediction of this variable. Method of learning only had an impact on self-efficacy in self-regulated learning. High levels of general learning efficacy and self-efficacy in achieving a score between 700 and 799 as total exam score were not reliably predicted by the antecedent person and behavior variables.

With regard to the prediction of method of learning at the end of the academic year, the hypothesis that perceived self-efficacy and method of learning at the start of the academic year would play a crucial role, could be accepted. Again the results showed, however, that self-efficacy must be seen as a differentiated concept. The different types of self-efficacy had different effects on method of learning. For

example, self-efficacy in self-regulated learning had a positive effect on strategic approach to studying based on achieving motivation and strategic, systematic regulation of learning: students who felt confident about their capacity to self-regulate also reported a corresponding method of learning. Another interesting finding was that self-efficacy in achieving 700-799 as total exam score led to a lower concern about systematic and strategic regulation, but to a stronger engagement in deep learning based on effective self-regulation in study activities.

Sex also had a considerable effect on method of learning, with female students reporting a more strategic approach to studying based on achieving motivation and strategic, systematic regulation of learning at the end of the academic year.

For the prediction of academic performance, the hypothesis that both perceived self-efficacy and method of learning would make a significant contribution, did only partly hold. Self-efficacy in achieving 700-799 as total exam score and self-efficacy in self-regulated learning indeed directly affected total exam score. This effect was however not mediated by method of learning. It was domain knowledge, as measured by the knowledge of and insight in the sciences part of the entrance examination, which significantly added to the prediction of academic performance.

Finally, chapter 5 tackled the central question about the potential of the “learning style awareness” hypothesis within the context of academic counseling at university.

In the first part of the chapter, we developed a theoretical explanation for the expected surplus value of learning style awareness within the broader framework of self-regulated learning. Based on cognitive psychology, research on metacognition, theories about self-regulated learning, and theories about the self, we managed to write a plausible narrative.

The results however showed that none of the hypotheses derived from this hypothetical process model could be accepted. The students whose learning style awareness was explicitly stimulated, did not have more and more refined metacognitive knowledge about the person factor in learning; they did not incorporate “learning styles” in their language to talk and think about learning; they were not more motivated and they did not report less fear of failure; they did not report higher

judgments of accuracy in self-knowledge. There also was not sufficient evidence in support of the primary hypothesis that students in the learning style condition would to a higher extent report a method of learning incorporating effective metacognitive monitoring and self-regulated learning. Overall, the “learning style awareness” hypothesis and its expected value for educational applications at university were not empirically supported by the results of the study.

Throughout the results, we rather found indications that the students in the experimental condition had mixed feelings regarding the learning style information. Apparently, the students did not consider Kolb’s learning styles as particularly relevant to understand their own learning. Although the learning style information was explicitly contextualized and the students were stimulated to relate their learning styles to their concrete learning experiences, integration did not occur.

### General Discussion

In the discussion sections of our five chapters, many (alternative) explanations and implications have been digressed upon in detail. Here, we will repeat the most important topics, focus on recurrent themes, and draw links between the separate chapters.

Considering this dissertation as a whole, Chapter 1 clearly took up a separate place. However, it is a crucial place, for developing an alternative overview of the cognitive style and learning style literature was the necessary first step to be able to consider the problem of educational applications. The overview enabled us to make a more informed choice about which learning style definition, model and instrument to use in developing further educational applications. We hope this “road-map” will also be helpful for future researchers and practitioners who want to use learning styles to address individual differences in learning.

Chapter 2 clarified that the Flemish admission examination selects a specific group of students, in which the abstract conceptualization primary learning style is



overrepresented. Its implications for the question whether the admission examination selects the “right” students, and for medical education itself, are the points of discussion within chapter 2.

This chapter was however also necessary to better understand the context of the studies reported in the subsequent chapters. It helped to ground that these medical students indeed showed specific characteristics because of the selective admission. Often, this selectivity was the core element of alternative explanations for unexpected results: the students’ high level of prior knowledge helped to explain why a self-regulated method of learning did not affect academic performance, the lack of diversity in learning styles in the counseling groups helped to explain why the students did not consider the learning style information particularly relevant, and so on.

In the social cognitive model of self-regulated learning, the environment, the context, plays an important role. By including chapter 2, we have shed light on the specific context of the core experiment of this dissertation.

Chapters 3 and 4 were strongly interrelated. Chapter 3 examined the effect of our self-regulated learning program on method of learning, perceived self-efficacy, and academic performance, while chapter 4 was about the dynamic interactions between these and other core variables of self-regulated learning. The social cognitive model of self-regulated learning was the framework of both chapters.

When we relate the results of these complementary studies, we see that participating in the counseling program had a positive effect on self-efficacy in self-regulated learning, a variable that adds to the prediction of academic performance. Although chapter 3 did not show a significant direct effect on academic performance of participation in the counseling program, the participants had slightly higher total exam scores, and this might be mediated by their increased self-efficacy in self-regulated learning.

Furthermore, some important themes reoccurred in both chapters.

First, there was the observation that, contrary to our expectations, a self-regulated method of learning did not translate into better total exam scores. Two explanations were formulated. The first explanation referred to the students’ high level

of domain-specific prior knowledge. The second explanation built on the knowledge that a deep, strategic, self-regulated method of learning does not necessarily lead to better learning outcomes if the learning environment, and more specifically the assessment procedure, does not emphasize and reward this method of learning. Although at Ghent University, assessment in first-year medicine is partly based on permanent evaluation of work in problem-based tutorials and practical training sessions, the final (multiple choice) examinations still emphasize and reward pure reproduction of knowledge.

Second, the results of both chapters corroborated the knowledge that perceived-self-efficacy must be conceptualized as a differentiated set of beliefs that are task- and situation-specific and that are linked to distinct realms of functioning. This is illustrated by the findings that a program focused on self-regulated learning only had an effect on self-efficacy in self-regulated learning, and that the different types of self-efficacy were predicted by different antecedent variables and had differential effects on the dependent variables method of learning and academic performance.

Third, gender differences occurred in both chapters. Both studies confirmed that female students tend to have a more strategic approach to studying based on achieving motivation and strategic, systematic regulation of learning, and that male students tend to report higher levels of perceived self-efficacy.

Last, considering the role the learning style concept played in these studies, we see that learning styles could not account for large differences in perceived self-efficacy, method of learning or academic performance. They did moderate the effect of the counseling program, and they were related to other individual differences variables like sex, age and cognitive style.

Overall, the strength of both studies lies in the fact that the full complexity of self-regulated learning was considered within an ecologically valid environment, taking into account individual differences, including learning styles, and a differentiated set of self-efficacy beliefs.

Chapter 5 finally showed that the high expectations regarding the value of the “learning style awareness” hypothesis for educational applications at university could not be redeemed.

The explanations for these “unexpected” results all boiled down to the conclusion that when learning style awareness is considered within the full complexity of self-regulated learning, as investigated in chapters 3 and 4, it becomes merely a cog in the wheel of the learning process. Its unique impact should not be overestimated.

Also interview data were used to find alternative explanations. Without these qualitative data, we would never have been able to understand how the students experienced our attempts to foster learning style awareness: when we realized that the students did not experience the awareness of their personal learning style as a powerful tool to ameliorate their study method as it is generally thought to be, it became very clear why learning style awareness did not have the effect we expected.

### Limitations

The results of the present dissertation must be considered in the light of a few limitations.

To begin with, although citation analysis enabled us to get a workable overview of the learning style literature, our investigations in chapter 1 can still be criticized. First of all, the logic and assumptions of this quantitative analysis technique can be questioned. However, we have always been fully aware of its inherent limitations, and we have made sure that we did not use citation analysis as “a shortcut to be used as a replacement for thinking”. Also remarks can be made about the database search procedure, the database itself, and the analysis procedure. We used basic bibliometric data and analysis techniques. Further refinement is needed, for example by including impact scores and using more sophisticated multidimensional scaling techniques.

Chapters 2 to 5 reported studies that build on the same experiment. The following five points of concern more or less apply to all these studies.

First, there was the reliability and validity of Kolb's learning style inventory. Like many learning style measures, the LSI is criticized on this point. The ipsative scoring technique is the main cause of these problems. We therefore used an alternative statistical procedure to appropriately analyze the LSI scores.

Second, a recurrent theme in the limitations sections of these studies was the limited generalizability of our findings. Our sample was small to very small, and consisted of a select group of first-year medical students. Whether this really has to be considered as a problem is however open to debate: all studies referred to the conceptual framework in which self-regulated learning is explicitly defined as determined by the triarchic interaction between person, environment, and behavior. The latter implies that self-regulated learning is to a certain extent always dependent on contextual variables. This process, and all attempts foster and understand it, must therefore always be understood within its unique context. This inherently limits broad generalizations.

Third, the fact that our sample was small to very small resulted in limited options with regard to the data analysis techniques that could be used. We consistently computed effect sizes to be able to uncover potentially interesting and valuable effects that were not significant, but that might have yielded more significant results if only there had been more subjects in the study. However, replication studies involving larger student groups are needed. Fourth, since we worked within an ecologically valid context, in which students could not always be randomly assigned to the groups of interest, this affected the experimental design. For example, the participants in the post-test session were not entirely representative for the participants in the pre-test session, and the experimental group was not perfectly equivalent to the control group. However, these differences were always explicitly investigated, and where possible, statistically controlled for.

Finally, also the limitations of using self-report measures must be acknowledged. For example, in the light of the result that a reported self-regulated method of learning did not translate in better academic outcomes, the possibility that these self-reports do not reveal what students actually do, could have limited the interpretive power. Also the grain size of these measures might have been too large to

be able to state which aspects of self-regulated learning were important. Thinking-aloud protocols or traces have been suggested as alternatives, but also these approaches affect the actual learning process. Moreover, since it takes a lot of time to collect and analyze these protocols, they also pose practical problems.

### Implications

The results of this dissertation have theoretical and practical implications, as well as implications for further research.

First, our results contribute to progress in theory construction. For example, the results showed that the dynamics that are set out in the social cognitive model of self-regulated learning do manifest themselves in data from first-year medical students. We have been able to disclose this complex interactive process within an ecologically valid context. Especially the behavioral self-regulation feedback loop between method of learning and perceived self-efficacy could be clearly distinguished. The key role of perceived self-efficacy was confirmed. A particular strength of this study was that by using a differentiated set of self-efficacy beliefs, a more refined picture of their antecedent and consequent variables within the process of self-regulated learning could be revealed. Also individual differences, including learning styles, and differences in prior/domain knowledge, which have often been overlooked in previous research, have shown to be relevant elements in the prediction of self-efficacy, method of learning and academic performance.

Furthermore, the results of this study corroborate the knowledge that self-regulated learning can be taught by providing adequate instructional support. More specifically, they support the contention that elective counseling programs outside the normal teaching context can be effective if they are set up as relational interventions based on an integrative conceptual framework and the instructional principles of social learning, direct instruction, realistic context and content, and metacognitive awareness. In addition, this study stresses that the effects of these programs can only be fully

understood if the interactions with individual characteristics and the learning environment are also taken into account.

The results however did not support the hypothesis that learning style awareness would have surplus value within this complex interactive process. The “learning style awareness” hypothesis and its hypothetical process model were not empirically supported. The learning style variables did - to some respect - play a moderating role in the explanation of the dependent variables. Chapter 2 showed that the concept was able to explain differences between students as related to the learning environment. Therefore, in further theory construction, learning styles do have their role to play as individual difference variable within the full complexity of the learning process. However, the idea that learning style can be the sole explaining variable, which is implicit in many learning style research, is far too optimistic. When learning style research wants to remain relevant, it has to align itself with the recent developments in the literature on self-regulated learning, which integrates aspects of metacognition, motivation, self-efficacy and so on, and in which individual differences have often been overlooked.

In all chapters, practical implications have been formulated: for example, with regard to medical education, or with regard to the development and amelioration of academic counseling.

However, our main practical concern was the educational application of learning styles within a university setting. We expected that the “learning style awareness” hypothesis would be a promising starting point to elaborate a fruitful educational application of the concept in higher education. Our results, however, pointed out that the impact of learning style awareness on the quality of learning must be reconsidered and should certainly not be overestimated.

The question then rises, if not through matching, and not through stimulating awareness, what value learning styles do hold for improving learning at university level?

What seems to be sure is that fostering effective learning at university requires complex interventions, with plural foci. Within the context of such interventions,

learning styles can play a role in stimulating metacognitive awareness of personal strengths and weaknesses in learning. From this dissertation appears however that some well-chosen questions can just as well boost these processes of self-reflection. A formal assessment of learning styles does not seem necessary to invoke this type of reflection.

The value of learning styles for university education could also be considered from a different position. They can bring individual differences to the notice of educators who are concerned about the individual learning process of their students. Without the dimensions along which students can differ in mind, it would be more difficult for these educators to formulate the right questions to foster reflection on learning and to provide the rich environments in which all learners can thrive. The merit of the learning style research is that it explicitly conceptualized these fundamental dimensions of individual differences.

On the basis of this dissertation, suggestions can be made for further research into the two research fields central to this study.

With regard to the research into self-regulated learning, we look forward to more qualitative research into the fine-grained complexities of the learning process. We learned that understanding students' personal beliefs, motives and strivings is crucial to interpret their behavior. For example, in chapter 5, we would not have been able to interpret the results of the questionnaires without the qualitative information from the interviews.

More research is also needed into the different forms of self-efficacy, their genesis, and their differentiated effects on relevant variables. The usually too general statements about the concept need further refinement. Also the concept of self-regulated learning itself needs further refinement. Our results suggest that more research is needed to explore the development from conscious, systematic self-regulation to more automated and efficient self-regulation.

With regard to the research into learning styles, more research is needed to examine the conditions under which learning style awareness in students might have a positive effect on their learning process. Since our study had some apparent

limitations, we consider it a step too far to fully reject the “learning style awareness” hypothesis and its possible value for educational applications. It might be projected that with a different learning style model, in a different context, learning style awareness can have a surplus effect. Additionally, a new research question might be whether learning style awareness in educators has surplus value for the quality of their teaching.