An Innovative Perspective on Learning and Teaching in Higher Education in the 21st Century

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Abstract. The current perspective on our society as a *learning* society implies that education must focus more than has been traditionally the case on fostering in students *adaptive competence,* i. e. the ability to apply meaningfully learned knowledge and skills flexibly in a variety of contexts.

Based on the available research this article first discusses the question: What should students learn to acquire adaptive competence in a domain? It is argued that developing adaptive competence requires the acquisition of several cognitive, affective, and motivational components, namely a well-elaborated domain-specific knowledge base, heuristic methods, metaknowledge of one's cognitive functioning, motivation and emotions, self-regulation skills for regulating one's cognitive, motivational and emotional processes, and positive beliefs about oneself as a learner and about learning in different domains.

Next the questions is addressed: What are characteristics of productive learning processes for acquiring adaptive competence? In this respect the view of learning is presented as an Constructive, Self-regulated, Situated, and Collaborative (CSSC) process of knowledge and skill building.

From a teaching perspective this leads to the question: How can such CSSC learning processes be stimulated through instructional intervention? An illustrative powerful learning environment for improving learning proficiency in beginning university students is presented.

Some final comments conclude the article.

Key words: adaptive competence; self-regulation skills; CSSC (Constructive, Self-regulated, Situated and Collaborative) learning; beliefs about learning; powerful learning environment; beginning university students.

Introduction

Changes in society during the late part of the 20th century have induced a growing need for the acquisition by *all citizens* of *high literacy skills*, such as thinking critically, solving complex problems, regulating one's own learning, information and communication skills. However, it has repeatedly been observed that education has not

been able to keep up with these developments. For instance, in a report of the European Round Table of Industrialists (ERT) entitled *Education for Europeans. Towards the Learning Society, a* cry of alarm was raised to alert society to the so-called educational gap, i. e., the fact that—due to its slowness in responding to changes in society—there is «an ever-widening gap between the education that people need for today's complex world and the education they receive» [ERT, 1995. P. 6].

Since then this problem has even increased because recently the pace of societal developments has accelerated dramatically due, among others, to the exponential knowledge explosion, to globalization in many domains of society, and to the large-scale introduction of the new information technologies. The same report put forwards the following characteristics of a learning society:

- learning is accepted as a continuous activity throughout life;
- learners assume responsibility for their own progress;
- assessment is designed to confirm progress rather than to sanction failure;
- personal competence and shared values and team spirit are recognized equally with the pursuit of knowledge;
- learning is a partnership between students, teachers, parents, employers, and the community working together.

This vision of a learning society implies that education at all levels must focus more than has been traditionally the case on developing and fostering in students *adaptive competence*, i. e. the ability to apply meaningfully learned knowledge and skills flexibly and creatively in a variety of contexts, as opposed to *routine expertise*, i. e. the ability to complete typical school tasks quickly and accurately but without understanding [De Corte, 2010].

In this article I will review and discuss the following themes:

- What should students learn to acquire adaptive competence in a domain?
- What are characteristics of productive and meaningful learning processes in view of acquiring adaptive competence?
- How can productive/meaningful learning processes be stimulated and kept going in students through instructional intervention: An illustrative powerful learning environment.
- Final comments.

What should students learn? Acquiring adaptive competence as the ultimate goal of learning and teaching in a content domain

Developing adaptive competence in a domain requires the acquisition and mastery of several cognitive, affective, and motivational components [De Corte, 2010]:

1. A well-organized and flexibly accessible domain-specific knowledge base, involving the facts, symbols, concepts, and rules that constitute the contents of a subject-matter field.
2. Heuristic methods, i. e. search strategies for problem analysis and transformation which do not guarantee but significantly increase the probability of finding the correct solution through a systematic approach to the task. Examples are: decomposing a problem into sub-goals; making a graphic representation of a problem.
3. Metaknowledge:
   - Knowledge about one's cognitive functioning (metacognitive knowledge), e. g. knowing the strengths and weaknesses of one's cognitive capacities,
   - knowing that one's cognitive potential can be developed through learning and effort;
   - Knowledge about one's motivation and emotions that can be actively used to improve learning, e. g. becoming aware of one's fear of failure in mathematics.
4. Self-regulation skills:
   - Skills for regulating one's cognitive processes/activities (cognitive self regulation), e. g. planning and monitoring one's problem-solving activities, reflecting on a solution process;
   - Skills for regulating one's motivational and emotional processes (motivational self-regulation), e. g. maintaining attention and motivation to solve a given problem.
5. Positive beliefs
   - about oneself as a learner in general and in particular subject-matter fields (self-efficacy beliefs);
   - about the classroom or the context in which learning takes place;
   - about the content of a subject-matter field.

I will here only briefly discuss the importance of self-regulation and beliefs.

Importance of self-regulation

Successful learners and problem solvers can *simultaneously* perform two functions: executing a task, and at the same time organizing and evaluating (= self-regulating) the task related activities using orientation, planning, monitoring, evaluation and reflection.

Examples of cognitive self-regulating activities are following.

- *During text reading:* a student regularly interrupts reading to ask him/herself whether his/her interpretation of the text is coherent and consistent.
- *During text writing:* a student re-reads from time to time his/her text to check the logic of the argumentation.
- *During problem solving:* a student realizes that he/she gets stuck. As a consequence the student says:
  – Let me read the problem again;

– Did I overlook something in the problem statement?
– Until where did my solution process go well; where did I get in trouble?
– Can I restructure the problem or consider it differently?

Schoenfeld [1985] videotaped high-school and college students working in pairs on unfamiliar problems during 20-minute sessions, and contrasted the solution processes with those of experts.

Example of the problems used in this study:

"Consider the set of all triangles whose perimeter is a fixed number P. Of these, which has the largest area? Justify your answer as best as you can."

The solution processes were parsed into episodes representing different activities: reading the problem, analyzing, exploring, planning, implementing, and verifying.

Time-line graphs were used to represent the course of the solution processes visually.

The graphs illustrative of the novice solution processes showed how students read the problem, choose for a certain approach and keep going with it, sometimes even when there is evidence that they are on the wrong track. This contrast very strongly with the varied solution process of an expert, who after reading a problem analyses it before planning the solution process, followed by verifying the plan, then getting back to analyses, etc.

Brown and Campione [1994] have shown that more successful learners are better self-regulators than less successful learners. It has also been demonstrated that self-regulation skills enhance the ability to transfer one's knowledge and skills.

Importance of beliefs

In an article entitled "When good teaching leads to bad results: The disasters of 'well-taught' mathematics courses, Schoenfeld [1988] showed that in high school classes where mathematics was taught in a way that would generally be considered good teaching, students nevertheless acquired debilitating beliefs such as:

- solving a mathematical problem should not take more than a few minutes
- being able to solve a math problem is a mere question of luck

It is obvious that such negative beliefs do not promote a mindful and persistent approach to new problem. This shows how important it is to foster positive beliefs in students about subject-matter domains.

Some comments

Prioritising adaptive competence does not mean that routine expertise becomes unimportant. It is obvious that mastering certain skills routinely (e.g., basic operations in arithmetic, spelling, technical skills) is crucial to efficient functioning in all kinds of situations. If certain as-

pects of solving a complex problem can be performed more or less mechanically, it creates room to focus on the higher-order cognitive activities needed to reach a solution.

But adaptive competence is so important because it goes beyond that: it involves the willingness and ability to change core competencies and continually expand the breadth and depth of one's expertise. Furthermore, it is fundamental, indeed necessary, to acquire the ability to transfer one's knowledge and skills to new learning tasks and contexts. Hence, it follows that pursuing adaptive competence is central to lifelong learning, and represents an important component of so-called 21st Century Skills.

Implications

Considering adaptive competence as a key goal has important implications for the kind of learning processes to best acquire it. The traditional dominant form of school learning has been teacher-directed or *guided learning*: a trainer or teacher takes all the relevant decisions and the learner can and should follow him or her. Because an important component of adaptive competence consists of skills in self-regulating one's own learning and thinking, it is obvious that such guided learning is not, and certainly not the only appropriate way of learning to achieve it. Indeed, to support the acquisition of adaptive competence by students, novel classroom practices and cultures are needed that create the conditions for a substantial shift from guided learning towards more *active and self-guided student learning,* resulting in a balanced and integrated use of both ways of learning. Such a balance allows for structure and guidance by the teacher where and when needed, and creates space for substantial self-regulated and self-determined learning by students

What are characteristics of active learning processes needed to facilitate and support students' acquisition of adaptive competence?

To realize the required shift, taking thereby into account the importance of contextual and social factors impacting learning, school learning needs to embody more than was traditionally the case the characteristics summarized in the following definition: *it is an active/ constructive, cumulative, self-regulated, goal-directed, situated, collaborative, and individually different process of meaning construction and knowledge building.*

In this article I will focus on four key characteristics: *C*onstructive, *S*elf-regulated, *S*ituated, and *C*ollaborative, building thereby on students' *prior knowledge* and taking into account *individual differences.* This CSSC view integrates the *individual and social aspects of learning* [Salomon, Perkins, 1998].

Constructive

Learners are not passive recipients of information. Indeed, learning is always constructive, even in environments that embody a dominantly guided learning approach. This is well illustrated by the occurrence of misconceptions, for instance, in physics (about Newton's

laws even in college students who have already followed physics courses).

What is essential in the constructivist perspective on learning is *the mindful and effortful involvement of students* in the processes of knowledge and skills acquisition in interaction with the environment. This is illustrated for example by the cumbersome but accurate calculation procedure invented by a Brazilian street vendor as observed in a study by Nunes, Schliemann, & Carraher [1993]:

> Someone buys from a 12-year-old street vendor in Recife, Brazil, 10 coconuts at 35 cruzeiros per piece. The boy figures out quickly and accurately the price in the following way: "3 nuts is 105; 3 more makes 210;... I have to add 4. That makes... 315... It is 350 cruzeiros."

Self-regulated

If students have to become life-long learners responsible for their own progress, they must be able *to manage and monitor their processes of knowledge building and skill acquisition*: i. e. they should become self-regulated learners. This is also well illustrated by the calculation procedure invented by the Brazilian street vendor in the realistic context of his street business

Skilled self-regulation facilitates appropriate decision-making during learning as well as the monitoring of an ongoing learning process by providing one's own feedback and performance evaluations, and by keeping oneself concentrated and motivated

Research has identified the following major characteristics of self-regulated learners: they manage study time well; set higher specific and proximal goals; monitor more frequently and accurately; set a higher standard for satisfaction; are more self-efficacious; and persist despite obstacles. It has also been shown in a variety of content domains that students' degree of self-regulation correlates strongly with academic achievement. Very important from an educational perspective is that recent meta-analyses of training studies show convincingly that self-regulatory processes can be enhanced in students through appropriate guidance [Dignath, Buettner, Langfeld, 2008].

Situated or Contextual

Constructive and self-regulated learning processes should preferably occur in context, i. e. in relation to the social, contextual, and cultural environment and factors in which these processes are embedded and that influence them, and through participation in cultural activities and contexts. This is again well illustrated by the calculation procedures invented by the Brazilian street vendor in the realistic context of his business

Collaborative

The collaborative nature of learning is implied in the situated perspective that stresses the social character of learning: effective learning is

not a purely 'solo' activity, but essentially a 'distributed' one, i. e. the learning efforts are distributed over the individual student, his partners in the learning environment, and the resources and tools (including technological ones) that are available.

The literature provides substantial evidence supporting the positive effects of collaborative learning on academic achievement (see e. g., [Slavin, 2011]). A shift toward more social interaction in classrooms would therefore represent a worthwhile move away from the traditional overemphasis on individual learning.

Parrying challenges to constructivist approaches to learning from instruction

The constructivist perspective has recently been criticized, arguing that it focus on pure discovery learning with minimal guidance, and ignores the structure of the human cognitive architecture in the sense that it imposes heavy loads on working memory [Kirschner, Sweller, Clark, 2006].

Starting from these arguments the critics plea in favor of direct instruction (see e. g. [Tobias, Duffy, 2009]).

However, these criticisms can be refuted on the basis of the currently available research literature. Whereas it is certainly correct that pure, unassisted discovery learning is not productive or effective, the critics mistakenly equate constructive learning with pure discovery learning. Indeed, constructive learning can be guided and mediated through appropriate interventions such as scaffolding, feedback, worked examples, technological tools, and peer tutoring.

Based on a review of the relevant literature since 1960, Mayer [2004] has come to the conclusion that such guided discovery yields better results than direct instruction. He states:

> "Overall, the constructivist view of learning may be best supported by methods of instruction that involve cognitive activity rather than behavioral activity, instructional guidance rather than pure discovery, curricular focus rather than unstructured exploration."

A recent extensive meta-analysis of the available research [Alfieri, Brooks, Aldrich, Tenenbaum, 2011] confirms Mayer's conclusions, stating that direct teaching is better than unassisted discovery, but that guided-, enhanced- or assisted discovery learning is superior to direct or explicit teaching. But an important remark has to be added. Indeed, the amount of guidance/structure will vary depending on students' prior knowledge as well as their achieved mastery level. In other words, the ratio between teacher guidance and student self-guidance will vary throughout students' learning trajectory.

An example of an approach to teaching and learning that represents a form of implementation of a constructivist, guided-discovery method and that is today successfully used in higher education is so-called problem-based learning (see e. g., [Hmelo-Silver, 2004]).

How can CSSC learning processes be stimulated and kept going in students through instructional intervention? An illustrative powerful learning environment focused on fostering self-regulation in university freshmen

In the first part of the third millennium higher education in Europe is facing several major problems such as: the need to adjust to larger and much more heterogeneous populations; the largely insufficient output, certainly in Flemish Belgian tertiary education; the need for graduates who are prepared for lifelong learning. In response to these challenges we carried out a research project aiming at the design, implementation, and evaluation of a powerful learning environment for improving learning proficiency in beginning university students (for a more detailed report see [De Corte, Masui, 2009]). Thereby we took into account previous research and we made use of the growing knowledge base about self-regulated learning.

In this article I will discuss the following aspects of the study: the theoretical and empirical background, the quasi-experimental design, the assessment instruments, and the results.

Theoretical and empirical background

We used the CLIA-model as a framework for designing a powerful learning environment [De Corte, Verschaffel, Masui, 2004]. The model consists of four components.

- *Competence:* components of adaptive competence in a content domain.
- *Learning:* characteristics of effective learning processes.
- *Intervention:* principles and methods guiding the design of learning environments.
- *Assessment:* forms of assessment for monitoring and improving learning and teaching.

Competence

The literature shows that metacognitive knowledge and a large variety of cognitive as well as affective-motivational self-regulation skills have an effect on students' learning processes and outcomes. Research also reveals an intimate relationships between those skills Therefore, we opted for a multidimensional approach, i.e. a substantial number of regulatory activities were addressed in an integrated way in the learning environment (LE)

Taking the research findings as well as the context of the present study into account, we first selected *four cognitive self-regulation skills*, namely 'orienting', 'planning', 'self-checking' and 'reflecting'. They represent aspects of regulation behavior which are undoubtedly significant for freshmen at the university.

'Orienting' means preparing one's learning process by examining the characteristics of a learning task, such as the learning goal, relevant prior knowledge and skills, the time available to accomplish the task. *'Planning'* is taking a series of decisions on how to approach the learning process taking into account the information gathered through the orientation. *'Self-checking'* means testing whether intermediate outcomes match the requirements of the intended learning goals, for example by making a trial exam. *'Reflecting'* involves looking back-

wards to the learning process in view of drawing conclusions about factors that influenced the process and its outcomes, such as strategies and approaches that worked well and others that did not.

Subsequently we chose four matching affective and motivational skills. Since 'orienting' also implies to determine the difficulty of the task and to estimate the time it will take to finish it, we firstly choose *'self-judging'*. This affective and motivational skill refers to the willingness to evaluate one's own strengths and weaknesses in relation to the learning task, such as the level of one's prior knowledge. Next we assumed that 'planning' offers a good opportunity to learn to make choices or to *'value'*. When making a plan a student decides about a learning goal and the way to attain it; this involves assigning some value to this goal and to the efforts to attain it. Thirdly, we included *'coping with emotions'* (e. g., frustration because of a failure) as the affective counterpart of 'self-checking'. When taking a test or an exam the outcome can be satisfying or disappointing. In both situations the student has to cope with these emotions, for instance, avoiding to be overwhelmed by proud in the first case, or by shame or fear in the second case. Finally 'reflecting' seemed to provide good opportunities for learning to *'attribute'* in a constructive way; for example, attributing a failure to factors that are perceived to be controllable by the student—such as lack of effort—rather than to uncontrollable aspects—such as the difficulty of a test. By analyzing the strategies and the study efforts that produced different learning outcomes, a student can learn that good study results (in most cases) are not a matter of luck, but the result of a set of variables that are to a certain degree controllable by the student. There is evidence regarding the effect of all these activities and skills on study results in higher education, but an integrated approach using these types of skills is mostly lacking in previous training studies.

Learning and intervention

The starting point for the development of the instructional intervention was that it should stimulate the following characteristics of effective learning: active, *constructive*, cumulative, goal-oriented*, self-regulated, situated/contextualized,* interactive/*collaborative,* individually different, and transfer promoting.

Taking this into account an integrated set of seven instructional principles guided the development of the *intervention:*

1. Embed the acquisition of knowledge and skills in the real study context, i. e. the selected activities have to be taught in the context in which students must apply them (*situated learning*). This principle was mainly realized during the sessions in collaboration with the instruction team of the courses macro-economics and management accounting. This kind of situatedness was also intended to promote transfer.
2. Take into account the learning orientation of the students and their need to experience the usefulness of the learning and study tasks

(*personal usefulness*). Due to the highly selective nature of the first year at Flemish universities, students are only prepared to invest great efforts when they are convinced that this will be rewarding. Therefore, it was explicitly explained to the students how each part of the intervention could be linked to their learning orientation and their personal goals (especially being successful in their first year). Providing this kind of information is also a condition for facilitating transfer and effort investment.

3. Sequence teaching methods and learning tasks and relate them to a time perspective (*sequencing and time perspective*). This principle fits well with the cumulative, goal-oriented and self-regulated character of productive learning. The intervention was spread over a period of six months in which a variety of teaching methods was used, such as modeling, coaching, scaffolding, articulating or verbalizing and reflecting. To sequence the learning tasks their complexity and diversity was progressively increased over time.
4. Use a variety of forms of organization and social interaction (*variation in organization and social settings*). By alternating modeling, individual assignments, working in pairs, small-group work, whole-class discussion, and different kinds of homework a stimulating social environment was created in line with the constructive and collaborative nature of learning.
5. Take into account prior knowledge and large differences between students (*adjusting to prior knowledge and differentiating*). This principle serves especially the cumulative and the active character of effective learning. By using a variety of teaching methods (third principle) and social settings (fourth principle) it was possible to meet students' informal prior knowledge and individual differences and to stimulate them to be active. For instance, by working in pairs a student with less prior knowledge could be coached by a more advanced peer.
6. Stimulate articulation of and reflection on learning and thinking processes (*verbalizing and reflecting*). Articulating or verbalizing problem-solving strategies and processes is necessary as a starting point for reflection; indeed, verbalizing is a pre-eminently appropriate method to become aware of metacognitive, affective and motivational aspects of learning. Techniques used for verbalizing were thinking aloud, writing while thinking, and oral or written retrospection. Reflecting was one of the four metacognitive regulatory skills on which the intervention focused because it is essential to achieve conscious regulation of learning, thinking and problem solving. For example, oral retrospection was used during the macro-economics classes. Students had to answer multiple-choice questions. In discussing their solutions they were invited to reconstruct their line of thought. These oral reports provided opportunities to compare differences between students in their argumentation and, to articulate heuristics that are useful in answer-

ing this type of questions. In addition, students could draw conclusions with regard to gaps in their knowledge base and with respect to learning activities that can help to remedy.

7. Create opportunities to practice and to transfer learned activities to new content domains (*practice and transfer*). Whereas the intervention focused on the courses macro-economics and management accounting, transfer exercises were assigned in different other disciplines of the curriculum, especially history and sociology.

Quasi-experimental design

The treatment of the experimental group (E) involving 47 students consisted 10 sessions of 90 minutes (2 general, 3 macro-economics, 5 management accounting) + homework assignments aimed at practicing and transferring knowledge and skills. The treatment took place in groups of about 15 students and focused on the eight regulative skills. A session started with an overview of the goals to be attained, the activities that were planned, and the kind of contribution that was expected from the students. Next, the students made two or more exercises in macro-economics or management accounting individually or in pairs. After each assignment they were invited to draw some conclusions, both with regard to the specific content and with regard to the problem-solving process. At the end of the session students received all necessary information about the homework they had to make individually or in collaboration with a fellow student. All experimental sessions were audiotaped.

The treatment of the first control group (C1) involving 47 students consisted also of 10 sessions + homework, but the focus was on cognitive skills, such as analyzing, structuring, relating, rehearsing. The second control group (C2) involving also 47 students received no special treatment, but participated in the regular practicals for macro-economics and management accounting.

Assessment instruments

A variety of *summative assessment* instruments were used spread over three posttest sessions to assess the effects of the intervention on self-regulation behavior. In the first posttest session assignments for management accounting and multiple-choice questions for macro-economics were administered; besides solving the questions, students were also asked to write while thinking, a variant of the thinking aloud technique. During the second posttest session an attribution questionnaire was used, and metaknowledge of the regulatory skills on which the intervention focused was assessed with a direct knowledge test. For instance, with regard to 'orienting' students were asked: "*What do you have to know at the start of a trimester in order to be able to organize and plan your study for a particular course? Also mention how you can obtain that information";* and with regard to self-judging: *"Which personal characteristics of a student can be advantageous or disadvantageous when studying or making exams? Explain their effect"*.

In the last posttest students had to fill in again questionnaires on self-efficacy, on self-regulation skills, and on attribution style that were already administered as pretests. At this stage transfer of regulation activities to a course in statistics that was not involved in the intervention was also measured. Therefore, a questionnaire containing eleven questions about study activities in the statistics course was administered. For example, with respect to orienting students were asked: «*How much time do you think you will have to invest in the theoretical and practical parts of the statistics course, including the lessons?*; and with regard to self-judging: *"Do you think that the statistics course will be easy or difficult for you? Explain your answer"*. The overall exam result at the end of the academic year was used as indicator of academic performance.

Multiple opportunities for *formative assessment* resulting in diagnostic feedback and coaching were also integrated during the interventions in the learning environment. This was realized especially through discussion about and reflection on articulated problem approaches and verbalized difficulties experienced by the students, as well as through feedback on individual assignments.

Results

The results of the intervention were quite positive as is shown by the following major overall outcomes of the learning environment.

Knowledge about regulatory skills

The experimental students demonstrated significantly more metaknowledge than the control students about each regulatory skill included in the direct knowledge test. The effect sizes for the difference with C1 varied for the eight regulatory skills between.41 and.93, and with C2 between.26 and.56. For instance, with regard to knowledge about 'orienting', this means that the experimental students referred significantly more to items such as the importance of evaluating the study load of a course, taking into account the way it is organized including the teaching method during classes, considering the usefulness of all types of study material and resources as well as the reliability of all kinds of informants and sources of information. With regard to knowledge about 'self-judging', the experimental students showed more awareness of the impact on learning and taking exams of important affective and motivational student characteristics, such as calmness (avoiding to panic or becoming nervous), concentration, determination (withstanding temptations), assiduity (as opposed to laziness), interest, persistence, self-confidence or fear of failure, and initiative. Another interesting finding is that the experimental students had more extended knowledge about how to cope with negative emotions and stress during learning. Striking was the fact that they described more than the control students coping methods that affect the stressor itself, for example they propose to learn specific strategies to answer multiple-choice questions as a manner to cope with uncertainty and fear of failure towards this kind of questions.

Relationship between knowledge of regulatory activities and academic performance

Also a positive relationship was observed between metaknowledge of self-regulatory activities and academic performance. The entering characteristics of the students such as prior knowledge and intelligence, explained 43% of the variance in performance. When entering the metaknowledge variables in the regression equation the amount of criterion variance explained increased to 54%. In other words, differences in performance between students can be partly explained by differences in their entering characteristics, but also partly (up to 11%) by differences in their metaknowledge. This implies that on average students who showed more metaknowledge got better study results.

Transfer of the trained regulatory skills

An important question was whether, as a result of the intervention, students had become more competent in learning, in the sense that they transferred the trained regulatory skills to a course that was not involved in the intervention, more specifically statistics. Analysis of students' answers to the open-ended questionnaire with eleven questions (see above), showed that the E-students were indeed more self-regulating for the statistics course than their peers in the control groups. For the difference with C1 the effect sizes for the distinct skills varied between.27 and.69, and with C2 between.28 and.58. This means, for example, that the experimental students proved to be better informed about the statistics course, and, therefore, showed evidence of more orienting behavior. More specifically, we observed differences on the following aspects. In the experimental group more students made an acceptable and well-grounded estimate of the study hours they will need for the statistics course, and more students were capable of recalling orienting information supplied by the statistics teachers at the start of the course. The experimental students were also better informed about several characteristics of the examination, such as the content, the type of questions and the availability of a trial exam. With regard to transfer of self-judging behavior the experimental students gave a more extensive description of their position with respect to the statistics course and mentioned more personal arguments (such as having to cope with insufficient prior knowledge, or on the contrary, having a good deal of aptitude for mathematics) for their self-judgments (experiencing a lot of difficulties studying statistics or being able to pass smoothly, respectively). The experimental students were also able to formulate more study recommendations (such as the importance to prepare classes in detail and to be active and concentrated during the practicals) with regard to the statistics course, which shows that they were more skilled in reflecting. Moreover, this transfer behavior explained a substantial part of the variance in the exam scores for statistics: entering variables explained 41% of the criterion variance; this increased to 67% when the transfer scores for all the regulatory activities were included in the regression equation. In other words, differences in exam scores for statistics can be partly explained by differences in their entering characteristics, but

also partly (up to 26%) by differences in their self-regulating behavior in the first weeks of the course. This implies that on average students who showed more self-regulation behavior got better study results.

Study results

Finally, the students of the experimental group obtained better study results as measured by exam scores, pass rates, and study careers. In the first year the experimental students outperformed the control students as well in terms of the overall result (effect size.36 for the difference with C1 and.38 for C2), as for the two intervention courses: macro-economics (effect size.41 for C1, and.26 for C2), and management accounting (effect size.57 for C1 and.26 for C2).

From the 47 students in each of the three groups significantly more experimental students succeeded in the first year, and obtained their master's degree. In E, C1 and C2 respectively 38, 28 and 34 students were successful in the first year, and respectively 37, 26 and 30 got their degree.

Final comments

The example of a design experiment supports the view that the CSSC conception of learning as a constructive, situated/contextualized, collaborative, and progressively more self-regulated process can guide the design of novel, but also practically applicable powerful learning environments, i. e. settings that facilitate in students the acquisition of adaptive competence, in this case esp. self-regulation skills. Indeed, after the intervention the students in the experimental group had more metaknowledge about regulation skills, they produced more self-regulation activities in the courses involved in the intervention, and were more in control of their academic performance. They also achieved better academic performance as measured by examination scores, pass rates, and study careers.

Furthermore, the E-students showed significant transfer of the acquired self-regulation skills to a non-intervention course, namely statistics. This finding as much as anything shows that these students' learning proficiency has been enhanced, and it fits well with the rather new and educationally relevant perspective on transfer introduced by Bransford and Schwartz [1999]. Traditionally transfer has been narrowly conceived as the independent and immediate application of knowledge and skills acquired in one situation to another. As an alternative to this *direct-application* view of transfer, Bransford and Schwartz have proposed a much broader perspective that emphasizes *preparation for future learning* as the major aspect of transfer, and puts the focus in assessing transfer on students' abilities to learn in novel, resource-rich contexts. This approach to transfer is obviously more in line with the now prevailing notion of learning as an active and constructive process, that also underlies our learning environment described above (for a more detailed discussion see [De Corte 2003]).

However, the effective and sustained implementation of novel learning environments puts *high demands on the teachers and requires drastic changes in their role and teaching practices*.

Instead of being the main source of information, the teacher becomes a «privileged» member of a knowledge building community who creates an intellectually stimulating classroom climate; models learning, thinking, and problem-solving activities; asks provoking questions; provides support to learners through coaching and guidance; and fosters students' self-regulation of their own learning. In other words, the teacher practices *guided- or enhanced-discovery learning*.

Sustained large-scale innovation of higher education in line with the new approach to learning and teaching is a major challenge for educational leadership and policy makers, aiming at transferring research-based knowledge about learning and teaching to educational professionals and warranting its high-fidelity application in classrooms. An indispensable condition for success in this regard lies in the design and implementation of a well-grounded and well-elaborated system for initial and continued teacher professional learning and development based on the innovative ideas and practices.

To make significant changes in their practices teachers need time and multiple opportunities in a variety of activities (e. g., modeling, coaching) to learn new info and grasp its implications for classroom practice. Furthermore, teachers need to develop self-regulation skills that will enable them to monitor and reflect on the effectiveness of changes they make to their practice. In other words, they have to become *reflective practitioners* (see e. g. [Timperley, 2008]).

References

Alfieri L., Brooks P. J., Aldrich N. J., Tenenbaum H. R. (2011) Does Discovery-Based Instruction Enhance Learning? *Journal of Educational Psychology,* vol. 103, pp. 1–18.

Bransford J. D., Schwartz D. L. (1999) Rethinking Transfer: A Simple Proposal with Multiple Implications. *Review of Research in Education*, vol. 24, pp. 61–100.

Brown A. L., Campione J. C. (1994) Guided Discovery in a Community of Learners. *Classroom Lessons: Integrating Cognitive Theory and Classroom Practice*. Cambridge, MA: The MIT, pp. 229–270.

De Corte E. (2003) Transfer as the Productive Use of Acquired Knowledge, Skills, and Motivations. *Current Directions in Psychological Science,* vol. 12, no 4, pp. 142–146.

De Corte E. (2010) Historical Developments in the Understanding of Learning. *The Nature of Learning. Using Research to Inspire Practice* (eds H. Dumont, D. Istance, F. Benavides), Paris: OECD, pp. 35–67.

De Corte E., Masui C. (2009) Design and Evaluation of a Learning Environment for Self-Regulation Strategies: An Intervention Study in Higher Education. Proceedings of the *14*th *Annual Conference of the European Learning Styles Information Network (ELSIN XIV)* "*Learning in Higher Education—How Style Matters*", Brno, Czech Republic: Tribun EU, pp. 172–183.

De Corte E., Verschaffel L., Masui C. (2004) The CLIA-Model: A Framework for Designing Powerful Learning Environments for Thinking and Problem Solving. *European Journal of Psychology of Education,* vol. 19, pp. 365–384.

Dignath C., Buettner G, Langfeldt H. (2008) How Can Primary School Students Learn Self-Regulated Learning Strategies Most Effectively? A Meta-Analysis on Self-Regulation Training Programmes. *Educational Research Review,* no 3, pp. 101–129.

European Round Table of Industrialists (ERT) (1995) *Education for Europeans. Towards a Learning Society.* Brussels, Belgium: ERT.

Hmelo-Silver C.E. (2004) Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review,* vol. 16, pp. 235–266.

Kirschner P. A., Sweller J., Clark R. E. (2006) Why Minimal Guidance during Instruction Does not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching. *Educational Psychologist,* vol. 41, pp. 75–86.

Mayer R. E. (2004) Should There Be a Three-Strikes Rule against Pure Discovery Learning? *American Psychologist,* vol. 59, pp. 14–19.

Nunes T., Schliemann A. D., Carraher D. W. (1993) *Street Mathematics and School Mathematics.* Cambridge, UK: Cambridge University.

Salomon G., Perkins D. N. (1998) Individual and Social Aspects of Learning. *Review of Research in Education,* vol. 23, pp. 1–24.

Schoenfeld A. H. (1985) *Mathematical Problem Solving.* New York, NY: Academic Press.

Schoenfeld A. H. (1988) When Good Teaching Leads to Bad Results: The Disasters of "Well Taught" Mathematics Courses. *Educational Psychologist,* vol. 23, pp. 145–166.

Slavin R. E. (2011) Instruction Based on Cooperative Learning. *Handbook of Research on Learning and Instruction* (eds R. E. Mayer, P. A. Alexander), New York: Routledge, pp. 344–360.

Timperley H. (2008) *Teacher Professional Learning and Development*. Geneva: International Bureau of Education.

Tobias S., Duffy T. M. (2009) *Constructivist instruction: Success or failure?* New York: Routledge.