# Enhancing The Learning Proficiency of Students in Higher Education

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## Abstract

Higher education is facing world-wide a number of problems such as: adjusting to larger and more homogeneous student populations, increasing the number of graduating students, and preparing them for lifelong learning. Enhancing students' learning proficiency can make a substantial contribution to solving each of these major concerns.

Taking the growing knowledge base on self-regulated learning as a background, this article presents a project that aimed at the design and evaluation of a powerful learning environment for improving university freshmen's learning proficiency. More specifically the intervention in this environment focused on the trainability of four cognitive (orienting, planning, self-testing, and reflecting), and four complementary affective (respectively self-judging, valuing, coping, and attributing) skills.

The effects of the learning environment were investigated using a pretest–posttest design with control group. The participants were 141 first year students of business economics.

The major positive effects of the intervention on the learning proficiency and the academic performance of the students in the experimental group are summarized and illustrated mainly for two of the eight self-regulation skills, namely orienting (preparing one's learning process by examining the characteristics of a learning task) and self-judging (evaluating one's competencies in view of an accurate appraisal of the efforts needed to approach and accomplish a learning task).

## Introduction

Higher education is facing world-wide a number of major problems. Firstly, universities have to adjust to larger and more heterogeneous populations than in the past. Secondly, in tertiary education in many European countries the output of students completing a degree is largely insufficient. And, last but not least, there is an urgent 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 fostering learning competence in beginning university students (for more detailed information see Masui 2002; Masui and De Corte 1999; Masui and De Corte 2005). In designing the study we took into account the growing knowledge base about self-regulated learning (see e.g., Boekaerts, Pintrich, and Zeidner 2000).

This intervention study embodies major components of the CLIA-model, a framework for the design of powerful learning environments that has resulted from our theoretical and empirical work over the past years relating to the creation of instructional settings that facilitate in students the acquisition of productive knowledge and learning and thinking skills (De Corte, Verschaffel, and Masui 2004). This investigation was not designed as a formal test of the CLIA-model, but was carried out in parallel with its development. As such the study has been instrumental in identifying and specifying the different components of the model as described below. This approach is in line with the perspective of the Design-Based Research Collective

(2003; see also Burkhardt and Schoenfeld 2003) on the potential of intervention research, namely exploring possibilities for novel learning and teaching environments, and developing contextualized theories of learning and teaching.

In the next section we present a brief overview of the CLIA-model as background for the review of the intervention study in the subsequent section.

**CLIA: A framework for designing powerful learning environments**

The framework for designing learning environments that are intended to be powerful is structured according to four interconnected components:
1. ***C****ompetence*: components of competence or expertise in a domain.
2. ***L****earning*: characteristics of effective learning processes.
3. ***I****ntervention*: principles and methods guiding the design of learning environments.
4. ***A****ssessment*: forms of assessment for monitoring and improving learning and teaching.

These four components have been deliberately chosen building on the related views of Glaser (1976), Resnick (1983), and Snow and Swanson (1992) concerning the core elements of a theory of learning from instruction. As argued by Resnick (1983), such a theory must be "both descriptive, explaining why instruction works and why it does not, and prescriptive, what to do the next time for better results" (p. 6). In that perspective the theory must conform to several requirements. First, it must specify the objectives of instruction, thus the competence to be attained. Second, it should provide a theoretical account of the learning processes needed to acquire competence. Third, it should specify guiding principles for instructional interventions to support those learning processes. In addition, it is necessary to assess the outcomes of the interventions (Glaser 1976; Snow and Swanson 1992). As these four components are narrowly interconnected they need of course to be aligned in designing learning environments.

*Competence*

Acquiring competence in a domain requires the acquisition of five categories of components: cognitive ones, on the one hand, and affective-motivational components, on the other hand. (see e.g., De Corte and Verschaffel 2006)

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. Heuristics methods, i.e. search strategies for problem analysis and transformation (e.g, decomposing a problem into subgoals, making a graphic representation of a problem) which do not guarantee, but significantly increase the probability of finding the correct solution of a problem because they induce a systematic approach to the task.
3. Metaknowledge, involving knowledge about one's cognitive functioning (metacognitive knowledge: e.g., believing that one's cognitive potential can be developed and improved through learning and effort), on the one hand, and knowledge about one's motivation and emotions (e.g., becoming aware of one's fear of failure in relation to mathematics tasks and problems), on the other hand.
4. Self-regulatory skills, involving skills relating to regulating one's cognitive processes/activities (metacognitive skills or cognitive self-regulation; e.g., planning and monitoring one's problem-solving processes), on the one hand, and skills for regulating one's affective and motivational processes/activities (metamotivational skills or motivational self-regulation; e.g., keeping up one's attention and motivation to solve a given problem), on the other hand.
5. Positive beliefs about the self in relation to learning and problem solving in a domain, about the social context in which learning activities take place, and about the content domain and learning and problem solving in that domain.

However, research has shown that knowledge and skills that are available in students are often neither accessible nor usable when necessary to solve a given problem (Cognition and Technology Group at Vanderbilt 1997). Acquiring a disposition to skilled learning and thinking should help to overcome this phenomenon of inert knowledge. Therefore, the *integrated* mastery of the different components mentioned above should result in the development of a disposition toward skilled thinking and learning. According to Perkins (1995) such a disposition involves besides ability and motivation, two additional crucial aspects, namely sensitivity for situations in which it is relevant and appropriate to use acquired knowledge and skills, and an inclination to do so.

*Learning*

Although important questions remain for continued inquiry (De Corte 2004), the following characteristics of productive learning are already well documented by a substantial amount of research: it is an active/constructive, cumulative, self-regulated, goal-directed, situated, collaborative, and individually different process of meaning construction and knowledge building (De Corte 2007; see also National Research Council 2005). Therefore, these features of effective learning can and should guide educational practice.

1. Active/constructive: learning is an effortful and mindful process in which students actively construct their knowledge and skills through reorganization of their already acquired mental structures in interaction with the environment.
2. Cumulative: this characteristic stresses the important impact of students' prior formal as well as informal knowledge on subsequent learning.
3. Self-regulated: this feature refers to the metacognitive nature of productive learning; indeed, self-regulation of learning means that students manage and monitor their own processes of knowledge building and skill acquisition. The more students become self-regulated, the more they assume control and agency over their own learning; consequently they become less dependent on external instructional support for performing those regulatory activities.
4. Goal-oriented: effective and meaningful learning is facilitated by an explicit awareness of, and orientation toward a goal. Because of its constructive and self-regulated nature, it is plausible that learning will be most productive when students choose and determine their own objectives. Therefore, it is desirable to stimulate and support goal-setting activities in students.
5. Situated and collaborative: learning is conceived as an interactive activity between the individual and the physical, social and cultural context and artefacts, and especially through participation in cultural activities and contexts. In other words, learning is mostly not a purely "solo" activity, but a distributed one: the learning effort is distributed over the individual student, his partners in the learning environment, and the resources and (technological) tools that are available.
6. Individually different: the processes and outcomes of learning vary among students due to individual differences in a diversity of aptitudes that affect learning, such as prior knowledge, conceptions of learning, learning styles and strategies, interest, motivation, self-efficacy beliefs, and emotions. To induce productive learning in students, instruction should take into account these differences in aptitudes.

*Intervention*

Taking into account the available literature (see De Corte et al. 2004), the following major guiding principles for the design of powerful learning environments can be derived from our present conception of competence (first component of CLIA), on the one hand, and the characteristics of constructive learning (second component of CLIA), on the other. This shows at the same time the interrelatedness of the CLIA-components and the necessity to align them.

1. Learning environments should initiate and support active, constructive acquisition processes in all students, thus also in the more passive learners. However, the view of learning as an active process does not imply that students' construction of their knowledge cannot be guided and mediated through appropriate interventions such as modeling, coaching, and scaffolding (Collins, Brown, and Newman 1989) by teachers, peers, and educational media. Indeed, the claim that productive learning involves good teaching still holds true. In other words, a powerful learning environment is characterized by a good balance between discovery and personal exploration, on the one hand, and systematic instruction and guidance, on the other, always taking into account individual differences in abilities, needs, and motivation among learners.
2. Learning environments should foster the development of self-regulation strategies in students. This implies that external regulation of knowledge and skill acquisition through systematic intervention should be gradually removed, so that students become agents of their own learning. In other words, the balance between external and internal regulation will vary during students' learning history in the sense that progressively the share of self-regulation grows as explicit instructional support fades out.
3. Because of the importance of context and collaboration for effective learning, powerful learning environments should embed students' constructive acquisition activities preferably in real-life situations that have personal meaning for the learners, that offer ample opportunities for distributed learning through social interaction, and that are representative of the tasks and problems to which students will have to apply their knowledge and skills in the future. But stressing the importance of social interaction for productive learning does not exclude the individual acquisition of components of competence (Salomon and Perkins 1998).
4. Because domain-specific knowledge, heuristic methods, metaknowledge, self-regulatory skills and beliefs play a complementary role in competent learning, thinking, and problem solving, learning environments should create opportunities to acquire general learning and thinking skills embedded in the subject-matter fields.
5. Powerful learning environments should create a classroom climate and culture that induces in pupil's explicitation of and reflection on their learning activities and problem-solving

strategies. For instance, Berry and Sahlberg (1996) have argued that in order to modify pupils' ideas about learning in the direction of the characteristisc described above (the second component of the CLIA-model), it is necessary to develop their conceptual metacognitive understanding about learning through reflective practices and dialogues with peers in small groups.

6. Learning environments should allow for the flexible adaptation of the instructional support, especially the balance between self-regulation and external regulation, in order to take into account the individual differences in aptitudes among learners. In addition, the important impact of affective characteristics, especially emotions, on students' learning activities and outcomes points to the necessity of alternating instructional interventions with emotional support, depending on whether the individual student is in the learning or in the coping mode (Boekaerts 1993).

*Assessment*

Forms and methods of assessment should be aligned with the preceding components of the CLIA framework, and integrated with instruction. This implies that classroom assessments should satisfy the following conditions (see also Shepard 2001).

1. Assessment instruments should address and monitor students' progress toward the acquisition of the full range of aspects of the competence component of the CLIA-model, i.e. the different kinds of knowledge, skills, and beliefs.
2. Assessment instrument should provide diagnostic feedback about students' deep understanding of content and their mastery and productive use of learning and thinking skills, which is helpful for students and teachers in view of further learning and instruction. In that perspective assessment tools should not only address learning outcomes but trace also students' learning processes and strategies.
3. The conception of learning outlined above (the second component of the CLIA-model) also implies that alternative assessment forms should contain assignments that are meaningful for the learners, and that offer opportunities for self-regulated and collaborative - besides individual - approaches to tasks and problems.
4. Assessment practices should help students develop skills in individual and group self-assessment.

**A learning environment for enhancing the learning proficiency in university freshmen**

Using the CLIA-model as a framework and, thus, starting from a constructivist perspective on learning, several aspects of competence, namely metacognitive, affective, and motivational skills and related metaknowledge, were integrated into the real instructional context of an experimental group (E) of 47 first year students in business economics. The intervention focused on the acquisition in students of eight regulatory skills that were taught in a series of ten sessions of 90 minutes each, supplemented by numerous homework assignments aimed at practising and transferring knowledge and skills. The intervention took mainly place in two subject-matter domains of the curriculum, namely macro-economics and management accounting. As explained below, this learning environment embodied numerous components of the CLIA framework.

The study involved also two control groups of 47 students each: in the first control group (C1) a treatment was applied that focused on cognitive activities such as 'analyzing' and 'rehearsing'; the second control group (C2) was a non-treatment group. All students in the three groups were selected from the total group of freshmen (N = 352) taking into account several entrance characteristics (prior academic knowledge, intelligence, cognitive study skills, attribution behavior, self-judgments about executive regulation activities, and gender). E and C1 were independent, but equivalent groups in terms of average level of intelligence, and prior knowledge; E and C2 were matched groups.

*Competence*

The available literature shows convincingly that metacognitive knowledge and a large variety of cognitive as well as motivational self-regulation skills have an effect on learning processes and outcomes (Masui 2002). Because research also reveals intimate relationships between those skills, we opted for a multidimensional approach, i.e. a substantial number of regulatory activities were addressed integratively in the learning environment. 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 different aspects of metacognitive 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 backwards 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 characteristics of the learning component of the CLIA-framework mentioned above were taken as the starting point for developing a learning environment to elicit and stimulate these learning qualities. Besides, learner-related parameters (esp. prior knowledge), instruction-related aspects (goals, domain content, support), and particular features of the research context (e.g., free entrance to the study program on the basis of a certificate of secondary education) were considered. Taking into account all these variables, the design of the experimental intervention was based on the following integrated set of seven interconnected and partly overlapping instructional principles.

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 more and more disciplines became involved using thereby a variety of teaching methods such as modeling, coaching, scaffolding, articulating or verbalizing and reflecting. To sequence the learning tasks their complexity and diversity was progressively increased over time. The aim was to induce constructive frictions by creating challenging learning tasks and by continuously capitalizing on the use of already acquired learning and thinking skills (Vermunt 1996). The following is an example of this built-in progression: To teach students to spend enough time on 'orienting' they sometimes had to prepare a class by orienting themselves in a few assignments without trying to finish them.
4. Use a variety of forms of organisation and social interaction (variation in organisation 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 answering 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 (see above), transfer exercises were assigned in different other disciplines of the curriculum, especially history and sociology.

The intervention sessions in the E took place in groups of 15 students. 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.

In C1 the focus of the treatment was on cognitive activities. This implied practicing such activities as 'relating', 'analyzing', 'structuring', 'concretizing', 'applying' and 'rehearsing' during the intervention sessions (for macro-economics and management accounting), as well as in homework assignments. C2 was only exposed to the usual instructional support and study guidance consisting of lectures, practicals, consulting hours, and individual feedback on assignments and examinations.

*Assessment*

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.

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 characteristcs, 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.

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.

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.

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.

**Conclusions, discussion, and implications for educational policy and practice**

The implementation of our CLIA-inspired learning environment resulted thus in significant positive effects in an experimental group of university freshmen in comparison to two equivalent control groups. 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).

Although the results of the intervention are favorable, we have nevertheless to admit that the observed effect sizes of the learning gains are mostly rather small. But, in this respect one should take into account that several features of the intervention may have had an oppressive impact on the learning outcomes. First of all, the scope and the duration of the intervention were rather limited, and focused on only a restricted part of the students' curriculum; in other components of the curriculum they were still immersed in a more traditional approach to teaching and learning. Moreover, during their preceding school career in primary and secondary school the students had been taught for years mostly according to a more traditional approach. This approach had not only a lesser focus – if any – on higher-order skills and interactive learning, but it may even have resulted in habits and beliefs about learning that are at right angles with the CLIA-framework, and have – so to say - to be "deconstructed" before the novel learning environment can be really productively implemented. Besides, as argued by Gage (1996), the behavioral sciences - just as medical science - should take small effects seriously, especially when they are supported by relevant theory and consistent with other research findings. And, our findings are consistent with results reported by others such as Brown and Campione (1996), the Cognition and Technology Group at Vanderbilt (1997), and Summerlee (2008).

Taking into account that there is now a fair amount of research evidence supporting the overall approach to learning and teaching underlying the learning environment presented above, and showing the power and the trainability of self-regulation skills (see also Bransford et al. 2006; National Research Council 2005), it is important to reflect on the implications of these work for educational policy and practice.

The most obvious implication is of course that this new overall approach to learning and instruction and the teaching of self-regulation activities and skills should be widely adopted, integrated, and appropriately implemented in everyday educational practices. But this represents a major challenge. Indeed, research on educational reform and innovation has for long documented that the school system is very resistant to change, and this holds certainly for higher education. A first condition for the large-scale dissemination of novel learning environments is undoubtedly that educational policy-makers and school leaders should stimulate and promote the intended innovation. Furthermore, curricula, educational materials such as textbooks, and assessment instruments need to be revised and designed in accordance with the new perspective on learning and teaching as embedded in a framework like the CLIA-model. But whereas all this is necessary it is certainly not sufficient. Indeed, there is nowadays ample research evidence showing that introducing reform-based textbooks and materials does not easily and certainly not automatically result in a high-fidelity implementation of the underlying innovative ideas. It is obvious that teachers play an active role in the implementation of curricular materials and textbooks: they interpret – often unconsciously – the new ideas through their existing prior knowledge, beliefs and experiences (Depaepe, De Corte, and Verschaffel 2007; Remillard 2005; Spillane, Reiser, and Reimer 2002). Therefore, the most important and indispensable condition for success lies in the training of teachers. Besides the fundamental reform of initial teacher education based on the innovative ideas and practices, an *intensive* system for sustained staff development of teachers who are in-service is required. As argued by the Cognition and Technology Group at Vanderbilt (1997) the changes that we are asking the teachers to make are "much too complex to be communicated succinctly in a workshop and then enacted in isolation once the teachers returned to their school" (p. 116). Indeed, we should realize that implementing powerful learning environments as the one designed in our project, requires drastic changes in the role of the teacher. Instead of being the main, if not the only source of information - as is often still the case in average educational practice - the teacher becomes a "privileged" member of the knowledge building community, who creates an intellectually stimulating climate, models learning and problem-solving activities, asks provoking questions, provides support to learners through coaching and guidance, and fosters students' agency over and responsibility for their own learning. Putting this new perspective on learning and teaching into practice will take a long time, substantial investments, and much effort in partnership between researchers and practitioners. Indeed, it is not just a matter of acquiring a set of new instructional techniques, but it calls for a fundamental and profound change in teachers' beliefs about learning an instruction, and in the current school and classroom cultures. In addition, policy makers and university leadership should reward teaching competence, and induce and promote actions and regulations aimed at reducing the currently detrimental conflict between research and teaching at universities.

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