A Technology-Enhanced Metacognitive Strategy

Time-based Media in the Documentation of the Design Process

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This paper describes the implementation of a technology-enhanced metacognitive strategy that seeks to improve the learning outcomes in beginners design studios. The implementation was based on the use of time-based rich-media tools that allowed the students to document and present the different stages of their design process. The results of the design assignment in the experimental group were compared with the results of the same assignment implemented without such a metacognitive strategy and this comparison has provided evidence about the potential benefits of the tested methods.

**Keywords:** Design education; design process; time-based media; metacognitive strategy; self-regulated learning

Introduction

Nowadays, the always increasing level of specialization and complexity of the architectural profession makes it difficult for academic curricula to include all aspects of the practice. The students are expected to cope with these demands through lifelong learning of a wide range of applicable domain knowledge and skills. Architectural educators should not only encourage the development of students’ essential and creative thinking skills, but also, encourage them to engage in learning strategies that help them to take charge of their own future learning (NAAB, 2004; Waldrep, 2006). Metacognition in general and self-regulation in particular are instructional strategies that can allow the design students to create a personal learning schema (understand how one learns) that includes the strategies to accomplish the tasks and the processes by which the learner oversees and monitors his/her use of learning strategies. These strategies will help them to cope with a lifelong learning process.

Beginners design students are in great need to improve their metacognitive skills; skills that provide awareness and reflection about what they have learned and need to learn in order to perform better in design. In a recent experiment undertaken by the researcher in the context of a digital media class, the use of metacognitive learning strategies resulted on improved students’ learning outcomes (Angulo, 2006). Encouraged by these results, a similar experiment was implemented in the context of beginners design studios. In this case the learning was shifted from the traditional “design-output” assessment to the more inclusive “design-process/product” assessment. Links and associations between design process and product, cause and effect, decision and result, were addressed and highlighted as the most important issues within the criteria for evaluation of the design assignment.
This research adds to the body of knowledge regarding the effectiveness of metacognitive and self-regulated strategies in higher education, specifically in design education. It also informs about how time-based digital technologies and media-rich representations support the learning activities in design and encourage the students to become more independent learners.

**Theoretical framework**

Historically, the concept of metacognition was introduced by John Flavel (1976) as “the ability to understand and monitor one’s own thoughts and the assumptions and implications of one’s activities”. Ann Brown (1978) who emphasized the regulation and control aspects of metacognition suggested that planning, monitoring, and revising one’s thinking are important executive processes.

Most theorists believe that the development of metacognitive knowledge begins at young age, and continues through adolescence and adulthood (Schraw & Moshman, 1995; Baker, 1989). Metacognitive skills predict success in academic endeavors and other aspects of life. Students with high metacognitive skills have outperformed those with lower metacognitive skills (Swanson, 1990; Angulo 2006). Most of the studies examining metacognition in education agree on the benefits of applying metacognitive strategies on learning but it requires deliberate, on-going practice. It is also important to teach metacognitive strategies within the context where the strategies are to be applied (Scardamalia et al., 1984; White and Frederickson, 1998). It is then hoped that the metacognitive skills would then be transferred to other areas.

Self-regulated learning (SRL) appears to be the most effective instructional strategy to improving metacognitive skills (Hargis, 2007). The SLR approach develops both the knowledge and control components that comprise metacognition, so students with very different metacognitive abilities can learn to better regulate their cognitive activities. A study comparing SLR in college undergraduates and graduate students (Lindner et al., 1996) showed a strong correlation between metacognition and degree completion, and having a positive influence on academic success (Schunk, 1994; Garavilia et al., 2002). Studies suggest that the student’s learning style has an impact in the effectiveness of metacognitive self-regulated strategies (Code, 2006). Learning style can be described as a set of factors, behaviors, and attitudes that facilitate learning for an individual in a given situation (Reiff, 1992). Felder & Silverman (2003) have synthesized findings from a number of studies to formulate a learning style model for engineering education in specific, but that can be also regarded as relevant to design education in general (Watson, S. 2003). This study shows evidence that the learning style of most engineering students include preference for visual than verbal input; sensing than intuitive perception; inductive than deductive learning; and active rather than reflective processing of ideas.

**The experiment**

The hypothesis of this research states that time-based and media-rich digital tools can support the implementation of metacognitive self-regulation strategies that enhance learning outcomes in beginners architectural design studios. In order to demonstrate this hypothesis, a design assignment was given to an experimental group of students along with a self-regulation set of activities that the students followed. The results of the design assignment of the experimental group were compared with the results of the same assignment implemented with a control group during a previous term and without such a metacognitive strategy. The comparison has provided evidence about the benefits of the tested method.

During the fall semesters of two consecutive academic years, novice students of undergraduate design studios participated in this experiment. Each semester group included 15 students of the
“Environmental Design 1” class. All of them had no previous experience in the application of metacognitive strategies for design. They knew, however, about the use of CAD programs for design (e.g., Autodesk VIZ, Architectural Desktop, and SketchUp), and they also knew how to use basic programs for multimedia presentation (e.g., PowerPoint).

The topic of the assignment consisted in the design of a “Pavilion in a Park”. It was a very basic design task in terms of function and tectonics, and more geared towards the solution of the formal aspects of the project (see figure 1).

Implementation
The experiment was implemented in three stages, (1) first stage, gathering design results from the control group, (2) second stage, gathering design results and feedback from the experimental group, and (3) third stage, blind review of all design results.

During the first stage (2005 fall semester), a control group undertook the design assignment using learning methods without the application of metacognitive strategies. See figure 2 for examples of the design results.

During the second stage, the experimental group (2006 fall semester) undertook the same design assignment as the previous year but with the inclusion of a relevant set of self-regulation activities. These activities were implemented as follows:

- Before the actual undertaking of the design exercise the students were provided with a suggested design methodology that served as scaffolding to the planning of their design activities.
- Throughout the design exercise as reflection in action (Schon, 1987), the students were asked to prepare a project log (recording of activities before and throughout the design process).
- During desk-critic sessions and final presentation of the project, the students were asked to present their project log along with the design results.
- After the submission and presentation of the assignment, as reflection on action or deliberation (Koschmann, 1994; Kvan, 2000), the students were asked to complete a debriefing questionnaire about satisfaction of the perceived learning benefits and usability of the self-regulated activities. See figure 3 for examples of the design results.

During the third stage of this experiment, a panel of experts conducted a blind review of the quality of
the design assignments produced by the control and experimental groups. The results of the blind review helped to determine the level in which the creation of the project logs affected the learning outcomes. The criteria of evaluation that the reviewers followed included mainly the compliance of requirements imposed by the location of the structure (1) link with the urban fabric of the city, (2) nature-friendly attitude, (3) dual character of the space for sheltering static and dynamic activities, and (4) impact of weather conditions. See figure 4 showing the survey web page that includes information about each student’s project.

**Self-regulated digital tools**

The design project logs documented the relevant stages of the design process making use of multimedia presentation programs. The student learning style was taken into account when deciding which multimedia tool to use and what combination of media could result more efficient in order to naturally convey relevant information.

Researchers on multimedia applications suggest that there is a preference for time-based applications among visual-spatial learners (Mayer, 2005). Our design students are visual-spatial learners who could benefit from the preparation and presentation of project logs using a multimedia format consisting of words and images; and moreover they are likely to achieve better learning outcomes when animated graphics are included (Rieber, 1990). Additionally, it was also taken into account that the digital tools to produce and/or prepare the project log should promote a non-intrusive recording of the metacognitive thoughts and design activities. Similarly, the learning curve of the digital tool should not be an additional burden to the design task. The software options included MS PowerPoint, TechSmith Camtasia, Adobe Captivate, and MS Producer. The students chose to use either PowerPoint with voice added and Camtasia, due to flexibility of use, easy availability, and short learning curve.

The project logs were created in certain cases while working in the project (i.e. screen recording of interaction with the CAD programs) in others as an after-design activity (i.e. scanning hand-made sketches, renderings of 3d models). The time-based media included text, pictures, sketches, animations, and live video; in all cases voice was added. The characteristics of the used technology affected the way the logs were created and guidelines in cognitive theory of multimedia learning were followed to allow for the efficient use of media (text and images) regarding the levels of attention of the audience.

The project logs were saved as Flash files if created in Camtasia, or as PPS files if created with PowerPoint. These files were posted in the class website and they were used during the final review of the project. The presentation of the project-logs was not meant to replace any conventional review dynamic. In fact those presentations were part of the discussion that followed after the playback of the files, by suggesting emerging questions regarding decisions in different stages of the process, possible alternatives if other variables would have been taken into account, and more issues that relate directly to the close relationship between process and product. The review of the project logs was in fact one of the deciding moments that contribute the most in the students’ awareness and reflection on the project. So the final assessment of learning included not only the quality of the final product, but also the students’
The debriefing questionnaire completed by the students consisted of 24 questions that provided an indication of their level of satisfaction regarding the instructional methods, the friendliness of the technology, and their perceived learning. The questionnaire was given after the review and presentation of the project was over.

Data analysis and results
The statistical package demonstrated that the students of the experimental group (2006 fall semester) received better assessment from the blind review. See figure 5.

The statistical package used also gave us a clear indication of the higher level of students’ acceptance and satisfaction of the learning experience, instructional methods, and technology used during the experiment. See table 1.

Findings
The design work of the students who implemented a metacognitive strategy did not only promise to be better but was actually better in accordance with the blind review panel of experts. This finding is in conflict with the common belief that the learning task gets in the way of design inferencing task. The findings suggest that our awareness of the learning task empowers performance in an immediate way. This is important because it validates the idea of on-the-job continuing professional development.

The students of the experimental group were taught not only how to approach a design problem (domain knowledge on processes) but also how to develop and implement strategies for planning, monitoring, and the evaluation of the learning task. Their newly acquired awareness of what they know and want to know, as well as their ability to reflect on what they have learned and how it was learned, will most likely provide them with the competency...
to continue learning on their own as self-regulated learners.

The project logs helped the students to articulate a reflective account that explains what they have learned. The sophistication of their explanations indicates the development of knowledge formation. Another externally visible indicator of metacognition in the use of project logs is the students’ reliance on feedback and support of the design representations. Representations provided scaffolding as the students went through the learning process.

**Future work**

This information will be used in the elimination of any possible drawback, in adding flexibility for adapting to the students’ learning styles, in choosing better digital technology tools, and in the general improvement of the methods to be incorporated as a standard component in the syllabi of future classes.

The researcher looks forward to implement these self-regulated strategies not only in beginner design studios, but also, in upper division students, career change students, and graduate students where similar needs are likely to be found. Future research will include:

- A larger sample of students.
- Covariate factors for the analysis, such as prior college academic achievement (GPA) and level of expectancy (motivation) for learning.
- Investigating the benefit of metacognitive/self-regulated strategies during collaborative design tasks.
- Digital tools that record the collaborative interaction

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**References**

