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Assessing the long-term impact of a metacognitive approach to creative skill development

Ryan A. Hargrove

Abstract The goal of this research was to determine the long-term impact that selected instructional interventions, based on research in metacognition and learning theory, have on students' creativity. The study builds off research that has been conducted documenting the impact of creative thinking based instructional interventions. The study tracked design students beginning their freshman year to determine if observed improvements have been maintained throughout 4 years of undergraduate study. Preliminary research statistically tested the introduction of structured metacognitive skills on the development of creative thinking ability for a diverse population of undergraduate design students. This research indicated that an approach to education influenced by research in learning theory and metacognition does, in the short-term, result in students who are more creative. By continuing testing throughout students' education an equally important question was answered. To what degree do students maintain or improve this level of enhanced creative thinking ability over an extended period of time? The findings showed that students who participated in one or both interventions finished with significantly higher levels of creative thinking. The knowledge gained also demonstrated how newly structured educational interventions utilizing online blogs and other Internet based technologies were successful in enhancing and maintaining students' creative thinking abilities. The goal was to provide educators with insight and guidance in the application of a metacognitive approach and to introduce available technologies to aid in this process. This study provides educators with a plan of action consisting of a toolbox of creative strategies and a framework for a reflective approach.

Keywords Creativity · Creative thinking · Design education · Metacognition · Technology

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Why is creativity important?

With each generation it is important for designers to be better technically prepared and professionally competent than their predecessors. However, coming into the twenty-first Century it is even more important for them to be creatively prepared to be able to go beyond the ideas of the present and deal with the complex social and environmental issues facing this world. Most design educators have the background and experience that gives them a strong disciplinary competence but have not received any formal training in education, learning theory, or cognition. The goal of this research is to provide educators with insight and guidance in the application of a metacognitive approach as well as introduce available technologies to aid in this process.

The US Department of Labor appointed a commission to determine the skills young people need to succeed in the world of work. The purpose of the Secretary's Commission on Achieving Necessary Skills (SCANS) was to encourage a high-performance economy characterized by high-skill, high-wage employment. Although the commission completed its work in 1992, its findings and recommendations continue to be a valuable source of information for individuals and organizations involved in education and workforce development. The SCANS recommendations provide curricular and pedagogical guidance for preparing students for adult life and pose a substantial challenge to the major institutions charged with responsibility for developing worker competencies. The report distinguishes, in a commonsense way, the elements of being "educated" and then introduces a set of higher order competencies necessary for participation in future economics and politics (Davies et al. 1997).

The final report issued in July 1992, named five competencies and a three-part foundation of skills and personal qualities the Commission believed is necessary for strong future job performance. The foundation of skills consists of thinking skills, specifically creative thinking, as well as the personal qualities associated with self-management or self-regulation, decision-making and seeing things in the mind's eye (US Dept. of Labor 2000).

Design educators and administrators should carefully consider to what extent current educational practices and projects value and promote cognitive process as a main objective. The American Institute of Architecture Students (AIAS) has expressed concern that the current design education approach rewards students with the "best looking" projects and emphasis on appearance takes precedent over the quality of ideas and the process behind the design work. AIAS has confirmed this in their 2002 report on design studio culture. In the report they found that frequently in design schools, students without the ability to produce the "best looking" projects are marginalized and undervalued (AIAS 2002).

The AIAS task force points to a creativity shortfall under the current design education pedagogy. In a call to action it states that design education administrators have the ability to set forth a vision in order to produce an improved educational experience. Through the design of programs and curriculum leaders can implement policies and procedures to promote awareness and understanding of the cognitive processes related to creative thinking. This in turn creates the potential to share and disseminate initiatives to promote creative thinking. They believe that most design schools currently exercise this improved educational approach on a very small scale and efforts could be made to integrate this approach throughout the curriculum (AIAS 2002).

If the goal is to develop design students who are able to express a higher level of creativity there is a need to link design education to the existing research in learning theory, metacognition and creativity; and through this linking develop approaches to

design education that more effectively enhance creativity. This will allow design educators to develop approaches that go beyond those of the past, utilizing Internet based technologies with iteration and reflection as essential parts of the process. It will enable us to go beyond teaching the way we were taught, to understand why some strategies work and some do not, and to find new approaches that will develop creativity in all of our students.

Creativity is not only healthy for student projects, but also when applied to the academic context in the larger sense. In a culture of creative thinking, design schools and educators imagine more effective teaching methods and learning objectives. Also instructional techniques in design remain in development and provide a framework for continued innovation. In her book, Design Juries on Trial (1991), Kathryn Anthony wrote, "It is indeed ironic that throughout the term, design instructors encourage their students to be creative, go out on a limb, take risk—and then when it's all over most of those same instructors rely on the same technique they've been using for years" (p. 129).

Contemporary pressures to meet the needs of professional offices has focused many programs on the technical and management skills most immediately related to practice-based performance, sometimes at the sacrifice of the development of thinking skills. Irrespective of the specific design domain, some educational models in design education are based upon the replication of professional task performance. The measure of learning is generally equated with the evaluation of the design product rather than learning process or skill. The cognitive skill sets of design are not adequately addressed and important learning opportunities are marginalized. As a consequence, there presently exists a lack of cognitive theories that function as underpinnings of design education (Oxman 1999; Kvan 2001; Ehmann 2004).

An examination of design education reveals the lack of instructors' formal training in education/learning theory (Salama 2005, 2008). While many design instructors are accomplished professionals, this competency does not automatically translate into the skills needed to help others reach their creative potential. Design educators should seek out and explore effective models of education and problem-solving that challenge creative practices in the design curriculum. Refusing to acknowledge the shortcomings and limitations of the current educational approach is creating inferior conditions across all design professions and continues to suppress the designer's ability to reach their potential. Design educators should do better than to teach what they were taught; the standard of the profession is perpetually rising and, without change, designers will not be prepared to meet these challenges. Sidney Parnes, Professor Emeritus of Creative Studies and founding director of the Center for Studies of Creativity at State University of New York at Buffalo explains (1981, p. 21):

> We may not be sure what we'll need to know for the future, but we can be reasonably sure that we will need increasing ability to sense and meet the challenges and problems our changing lives present rather than using tranquilizers to deal with them…

The need for exceptional designers has never been stronger. Designers must possess the ability to address and find innovative solutions to the emerging and ever changing challenges of present and future society. Educators cannot rely on a novice understanding of how design students learn the skills and knowledge to be productive and innovative designers. Recognizing possibilities requires that designers have an understanding of design thinking and process. A focus on cognition tends to be stifled by the rigid framework of many university design programs. Students are often told how to think about the design process, without explicit and purposeful instruction that allows for self-regulation of

cognitive processes. When educators stifle the understanding of cognitive processes, they shut out a great many possibilities, and in a world that so desperately needs better solutions, that is something that they cannot afford to do (Lyle 1985).

Cross (1990) describes design as an exploratory, rhetorical, emergent, opportunistic, reflective, and risky endeavor. It is expected that design institutions will develop these attributes in designers. First, they must have a basic understanding of design and how students learn to design. A starting point for this transformation are the cognitive processes that students naturally go through in solving design problems. Educators can teach designers about initial design states and construct an educational experience that affects the way students think about and practice design (Atman 2005). This form of design education is desperately needed to support the idea that strengthening metacognitive skills is essential to improving one's ability to think about and practice creative design.

Identifying design's cognitive processes is attractive pedagogically because it suggests that there are some processes that if taught well would address the core goals of design education (Eastman et al. 2001). The area of metacognition can be the scaffolding for future problem solving, as the goal should be to enable designers to utilize creative design thinking/processes with optimum efficiency.

What is creativity as a metacognitive process?

Metacognition is an essential ingredient of creative thinking (Sternberg and Williams 1996); and to the effectiveness of designers. Creative thinking can be defined as a metacognitive process—of generating novel or useful associations that better solve a problem, produce a plan, or result in a pattern, structure, or product not clearly present before. Designers can improve creativity by focusing on metacognitive thinking in the classroom. Teaching designers to explore their own cognitive processes in a systematic way helps them manage their own creative thought processes and develop their metacognitive knowledge. This knowledge provides designers with the knowledge of when, where, and why to use specific thinking strategies or cognitive approaches. Through an understanding of their thinking designers can trace the success or failure of a decision back through a process of thinking and build knowledge through past experience.

Metacognitive research (Brown 1978; Flavell 1979, 1981) has contributed to the psychology of teaching creative skills (Lawson 2006), as well as the analysis of problem solving, remembering, and thinking. In accordance with Pesut (1990) the author believes that the fundamental skills of creativity are really action-oriented metacognitive guides that operate in concert with metacognition to sustain and enhance creative thinking. As a students' level of metacognitive thinking increases so does their capacity to utilize their creative thinking. By becoming more aware and having a greater understanding of thinking process this clarity and comprehension allow for new and more complex modes of creative thinking and strategy use. What effects would there be if educators taught designers to conceptualize creative thinking as a metacognitive process?

Analyzing creativity from a cognitive framework enables one to gain a perspective of the metacognitive dimensions associated with creative thinking. Pesut (1990), Armbruster (1989) and Jansovec (1994) have conceptualized creativity as a metacognitive process, meaning the ability to think about one's own thought processes, to regulate thinking through planning, monitoring and evaluation is essential to creativity. Creative strategies guide thinking and promote the generation of novel, useful associations. Creativity conceptualized as a metacognitive process can be enhanced because of treatment methods

developed by combining cognitive and metacognitive skills. As a result of the synthesis between educators and psychologists, intervention strategies have been designed to teach people how to "think about thinking."

One way to achieve this synthesis is to disseminate information and develop creative thinking skills of designers through the use of cognitive-behavioral modification techniques (Adams 2001; De Bono 1973, 1992; Gordon 1976). If knowledge is the "mapping of experienced reality," designers need to gain knowledge of creative thinking by "mapping the experience" of an encounter with a creativity training program (Kaplan and Kaplan 1982). Knowledge of cognition may be very important to creativity in that one becomes aware of our biases and preconceived ideas, allowing for an advanced level of creative thinking.

Most creativity training programs are successful (Davies et al. 1972; Mansfield et al. 1978) because these programs encourage the development of "thinking about thinking" or metacognitive abilities. These training programs provide metacognitive experiences to participants and thereby encourage the development of an individual's metacognitive knowledge. Creativity training experiences affect how individuals map and or represent experience by providing them with a generative model to guide future thinking and behavior. One can speculate that creativity training programs install in the participants creative strategies that are supported by metacognitive thinking skills.

A profitable area of research dealing with metacognition is intervention studies that are designed to teach the metacognitive skills that support creativity. It seems likely that some of the principles of metacognitive skills that are derived from intervention studies in learning could be effectively applied to creativity. The potential for such transfer has already been demonstrated by Scardamalia and Bereiter (1983) in the area of writing. These researchers have completed a number of studies in which students receive instruction and help in various cognitive and metacognitive skills that are associated with writing; for example, planning a composition, making evaluative judgments about their writing, and diagnosing text problems. Similar research should be carried out in creative domains such as design.

A study that focuses on the development of creative thinking skills of design students will be a useful addition to the literature because such a study will serve as a model for the dissemination of creativity strategies to design students. Experimental curricula need not be the only way to disseminate creative strategies to students. If creative strategies could be disseminated to design educators through creative training programs, perhaps it would be better utilized for improving the context for effective design education, practice, and research. This would include an optimal and sustained method for dissemination throughout a designers' educational experience.

How does metacognition relate to design?

In a seminal paper design researcher Nigel Cross (1990) summarized the knowledge in the field of design. According to Cross, designers produce novel unexpected solutions, tolerate uncertainty, work with incomplete information, apply imagination and constructive forethought to practical problems and use drawings and other modeling media as a means of problem solving. From this Cross went on to list the abilities that a designer must have. 'They must be able to resolve ill-defined problems, adopt solution focused strategies, employ abductive/productive/appositional thinking and use non-verbal, graphic and spatial modeling media (p. 132).' In addition to these abilities there is clearly some group of

activities that oversee the whole process and provide support for it, metacognitive activities. A more or less conscious effort is needed to keep the whole design activity on course towards its target. Designers seem to be actively looking at and thinking about design even when not actually designing (Lawson 2006). Donald Schon (1983) has written most notably about a range of professionals who seem to depend upon these continuous monitoring and learning processes and calls them 'reflective practitioners'.

Based on research in the area of metacognitive skills, it is worthwhile to draw some conclusions about how metacognitive strategies or skills relate to creative problem solving performance. From a theoretical viewpoint, metacognition is an important aspect of cognition, and can dramatically affect problem-solving performance (Doerner 1974; Schoenfeld 1983; Sternberg 1982). Additionally, empirical research findings indicate individual differences in problem-solving are related to metacognition, and that basic metacognitive awareness and attention through instruction can significantly influence problem-solving (King 1991; Berardi-Coletta et al. 1995). Jausovec (1994) conducted a series of studies designed to investigate the influence metacognition has on problem-solving performance. The results suggested that instructions aimed at manipulating metacognitive processes had a significant impact on the responses to well- and ill-defined problems. Taken together, the results indicate that metacognition is an important factor in problem-solving performance. Metacognition appears to be important for solving open-ended (creative) problems. In addition, it was shown that proficient students seem to know much more about general cognitive strategies—how and when to apply them—than less proficient individuals. Poor problem solvers are also less efficient in monitoring their own cognitive processes during problem-solving than are skilled problem solvers, and they use more rigid solution approaches. In particular, good problem solvers engage in more self-checking procedures and bookkeeping strategies than inferior problem solvers. In essence, good problem solvers are able to carry on an effective and continuous monitoring process.

Because metacognition plays a critical role in successful problem solving, it is important to study metacognitive activity and development to determine how students can be taught to better control their cognitive resources. To that end, Davidson and Sternburg (1998) proposed a variety of approaches for training metacognition in problem solving, including integration of techniques into the curriculum. Mayer (2001) emphasized the importance of teaching through modeling of how and when to use metacognitive skills in realistic academic tasks. Put briefly, instruction should explicitly assist students in acquiring metacognitive knowledge of how to plan their problem solving efforts, how to set goals and sub-goals for their efforts, and how to monitor their progress toward their goals (Jausovec 1994; Berardi-Coletta et al. 1995).

Testing creativity

At virtually all design schools, design is quite rightly considered the heart of the curriculum. Still, the term 'design,' as commonly used by designers and design educators, has taken on limited connotations, focusing more on the aesthetic and theoretical dimensions of design than on the cognitive nature of the process itself (Boyer and Mitgang 1996; Davies and Reid 2000). There is a risk that students will leave school and face the profession without an awareness and understanding of their own cognitive processes and, therefore, lack the metacognitive knowledge to reach their creative design potential. This project attempts to address this need for creative skill development by answering the following research questions:

Will an approach to design education influenced by research in learning theory and metacognition result in students who are more creative? And, will these skills be enhanced through the use of innovative technologies?

To begin to answer these questions this research project focused on the one hundred and twenty members of the first year class of the College of Design at North Carolina State University as they progressed through 4 years of formal design education. The first step in the process was to identify a method to test critical aspects of creativity. This testing would establish a base line and a means of measuring the effectiveness of alternative teaching approaches.

Many researchers have concluded that a search for the essence of creativity is overwhelming unless it is approached with a domain specific focus. Brown (1989) stated that it is unlikely that there will ever be an essence of creativity, and that creativity might be a domain specific construct due to the fact that it is so complex and multidimensional. Taylor (1987) delineated the elements of creativity and concluded that because of the complexity of the creative process in individuals, assessment must focus on one element in a larger comprehensive construct. Hocevar and Bachelor (1989) have acknowledged that no single test of creativity will accurately represent the entire construct. This supports the notion of identifying the most relevant aspect of creativity for the particular domain under investigation. It is critical to select a test or battery of tests to assess a particular component or correlate of creativity that you wish to measure. Most notably by breaking down creativity to a single element of focus a study can maintain greater validity and reliability.

The act of making new associations is an essential part of any design process. Associative thinking is critical in both the divergent and convergent phases of design. That is to say, associative thinking is critical when the designer is expanding the number of possibilities that are in consideration, and when the designer is attempting to reduce options to a final solution. For this reason, the tests used to measure creativity for this study were selected because of their ability to address a critical aspect of creativity, associative thinking, throughout the design process (Fig. 1).

Components of both divergent and convergent thinking are involved in creative work. Divergent thinking, the production of multiple possible solutions, appears to be one important factor in the study of creative ability, since it includes the production of ideas in quantity and originality along with the ability to redefine what is possible. These skills are tested in tests such as Wallach and Kogan's Similarities Test. Undoubtedly, convergent thinking, the type of thinking that narrows down the possibilities and focuses on producing a single solution, also has a role in creative work. These skills are tested in tests such as Mednick's Remote Associates Test. The ability to select and combine numerous alternatives while rejecting others is involved in the later stages of the divergent-convergent

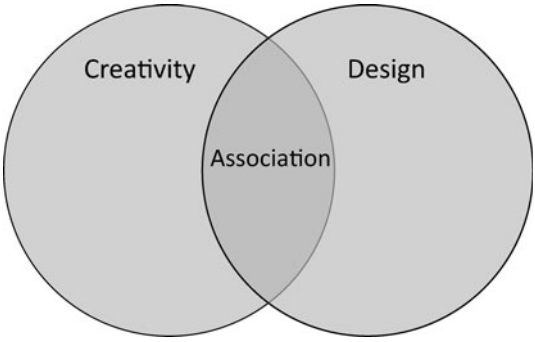

Fig. 1 Defining a critical aspect of creativity

sequence found in creative problem-solving (Fig. 2). Convergent thinking becomes the task of finding the greatest number of interconnections and interrelationships among our vast and diverse internal and external resources and connecting them in both obvious and not so obvious ways.

One of the tests selected, the Similarities Test, was developed by Wallach and Kogan (1965) as part of their research on the creative thinking process. Wallach and Kogan focused on the ability of an individual to utilize a variety of associations. The idea that divergent thought largely focuses on ideational fluency led to the construction of a battery of verbal and visual tests that emphasize the associative aspect of the creative process. For example, when generating creative content for a design project, ideas are expressed in larger quantity and are more unique in the case of a creative individual. This is due to the ability to attend to multiple possible associations.

The Similarities test focuses on two aspects of divergent thinking, fluency, the ability to generate multiple answers to any given scenario, and originality, the ability to identify solutions to a given problem that are unique or not frequently cited by other test individuals. A typical question within the Wallach and Kogan Similarities Test asks students to list all of the ways in which an apple and an orange are alike (Fig. 3). Students have an open time frame and are scored both on fluency, the number of similarities they identified, and originality, the number of their responses that are given by only 5% or less of the test group.

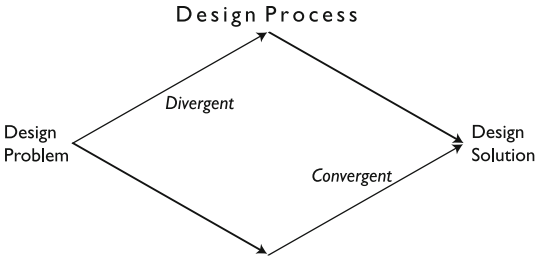

Fig. 2 Divergent/convergent design process

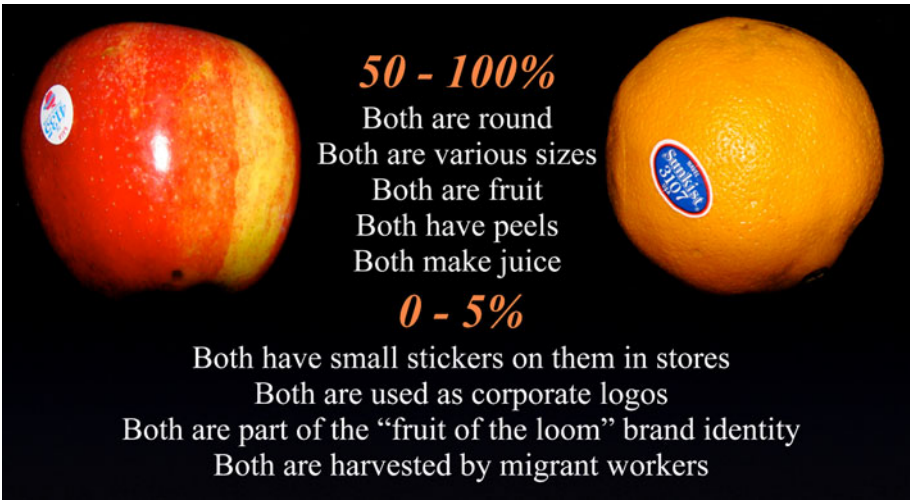

Fig. 3 Example of similarities test question

The second test selected was, the Remote Associates Test, developed by Mednick (1962). He offered an explicitly associationistic theory of creativity based on introspective accounts of creativity. Mednick's straightforward theory has stimulated a growing body of research in which creativity is characterized by the combining of mutually distant associative elements of thought. It proposes that creative individuals solve problems by juxtaposing a number of ideas not previously related to one another. Therefore, creativity involves the novel arrangement of temporarily contiguous, unusual associations to a given stimulus.

The Remote Associates Test (RAT) deals with an individual's ability to identify a common element that links a set of associated elements. This test examines aspects of associative thinking related to convergent thinking and measures an individual's ability to identify a common connection in divergent topics. The test presents students with sets of words and requires them to identify a common word that unites them in a unique way. The items in the RAT consist of three words that can be associated with the solution word in a number of ways e.g., the three words SAME/TENNIS/HEAD are associated with the solution MATCH by synonymy (same = match), by formation of a compound word (matchhead), and by semantic association (tennis match). Thus, reaching a solution requires "creative thought" because the first, most-related, information retrieved in solution attempts is often not correct, and solvers must think of more distantly related information to connect the three words.

In addition to standardized tests there was a required exhibit of the design thought model projects for a general review. Similar to a formal design studio critique projects were reviewed by the course instructor, teaching assistants, and other invited design faculty from other institutions. The invited faculty included eight well-respected professionals from the various design disciplines. The final review session was scheduled across 3 days with each student given the opportunity to present their model to several different reviewers while engaging in a one-on-one discourse. A student's grade was based on a number of categories that are described in detail for the reviewers in a comprehensive scoring rubric (Table 1).

First educational intervention

An incoming class of approximately one hundred and twenty students from the disciplines of architecture, landscape architecture, graphic design, industrial design and art and design

Table 1 Design though model scoring rubric

Craft of the Model (*10* pts)—The quality of the construction. Is the physical artifact novel or unique in its representation of a creative process?
Rigor of the Concept: precision of thinking (10 pts)—The level of exploration and articulation of the concept. Is there a level of refinement and detailed representation of thinking?
Communication: accurate representation of the idea (10 pts)—The congruence between verbal and physical representations. Does the physical model support and strengthen the verbal presentation?
Metacognitive Thinking (10 pts)—The ability to think about your thinking. Does the student have an awareness and understanding of their thinking process?
Metacognition begins with an awareness among thinkers that metacognition exists, differs from cognition, and enhances creative thinking. Beyond this basic awareness metacognition requires *knowledge of cognition* and *regulation of cognition.*
Knowledge of cognition includes what students know about themselves, thinking strategies, and conditions under which strategies are most useful.
Regulation of cognition corresponds to knowledge about the way students plan and implement thinking strategies, monitor and correct errors, and evaluate their thinking.

was divided into two equivalent groups based upon their disciplinary focus, gender, and baseline test scores from the initial set of creativity tests administered by the researchers. The control group went through the conventional design studio/lecture sequence that the College of Design has offered for a number of years. This sequence includes a lecture course on design thinking and one design studio each semester. In the studios approximately fifteen students work with one design instructor for about 9 h per week for the 15 week semester. Students work on a series of basic and disciplinary design problems selected by the instructor and participate in individual and group critiques/presentations. These studios are generally interdisciplinary in character.

The test groups attended the conventional studio/lecture sequence but also participated in one or two educational interventions. These interventions were designed to emphasize associative thinking and introduce students to related metacognitive strategies (Fig. 4). The first intervention occurred in spring semester of the first year and consisted of a 1-h seminar each week for 17 weeks of the semester. Each session concentrated on introducing a different creative thinking strategy. Students were also introduced to metacognitive strategies that helped build a creative knowledge base. The combination of learning creative strategies within a metacognitive framework is essential to developing students' creative thinking abilities. With the creative strategies students gain the procedural knowledge of how to utilize what becomes a creative toolbox of strategies of strategies. However, the metacognitive activities of goal setting, self-monitoring, and reflective practices ultimately build conditional knowledge in order to use the creative strategies most effectively. Strategies explicitly covered during the semester included the following.

Developing metacognition in students

Although most individuals of normal intelligence engage in metacognitive strategies when confronted with a challenging cognitive task, some are more metacognitive than others. Those with greater metacognitive abilities tend to be more successful in their cognitive endeavors (e.g. problem solving/design) (Berardi-Coletta et al. 1995; Jausovec 1994; King

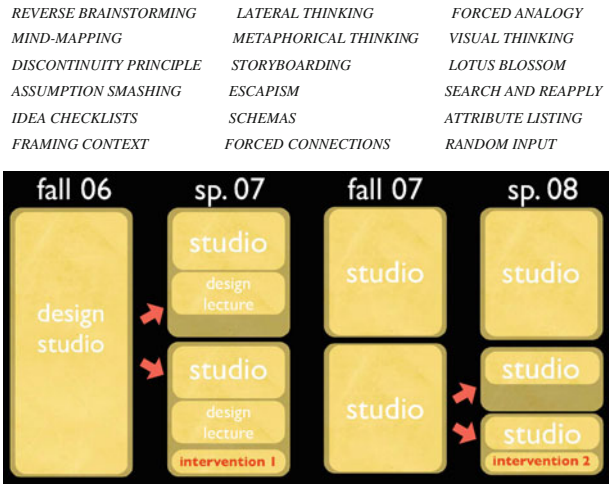

Fig. 4 Timeline of educational interventions

1991). The good news is that individuals can learn how to better regulate their cognitive activities.

Steps toward such advancement are based on an instructional approach that emphasizes the development of thinking skills and processes as a means to enhance problem solving. The objective is to enable all students to become more strategic, self-reliant, flexible, and productive in their problem-solving endeavors. Programs such as these are based on the assumption that there are identifiable cognitive strategies, previously believed to be utilized by only expert problem-solvers that can be taught to most students. Use of these strategies has been associated with successful problem solving (Huitt 1997). Therefore, the challenge is for each individual to become aware and consciously explore his/her own cognitive process to determine where strengths and weaknesses exist. Then strategies can be applied appropriately to ensure each individual reaches his/her cognitive potential, and ultimately maximum design potential.

Metacognitive thinking enables students to benefit from instruction and influences the use and maintenance of cognitive strategies. While there are several approaches to metacognitive instruction, the most effective involve providing students with both the knowledge of cognitive processes and strategies, and experience or practice in using both cognitive and metacognitive strategies while evaluating the outcomes of their efforts. Simply providing knowledge without experience, or vice versa, does not seem to be sufficient for the development of metacognitive control (Huitt 1997). Design educators in all areas of a students' education should embrace this responsibility and structure a learning environment that builds both knowledge and reflective experiences of the cognitive process associated with design.

The study of metacognition has provided educational psychologists with insight about the cognitive processes involved in problem solving and what differentiates successful problem solvers from their less successful peers. It also holds several implications for instructional interventions, such as teaching students how to be more aware of their cognitive processes as well as how to regulate those processes for more effective (creative) problem solving.

Design is a complex behavior. Regardless of how much experience or knowledge a designer has, each new design situation is in some way unique, requiring creative application of problem-solving strategies for posing, solving, and resolving the problem at hand. Expert problem-solvers plan strategies for attacking thinking problems. When they hit conceptual blocks, they stop, analyze, and reflect, and often implore cognitive strategies. Effective thinkers pose alternatives for themselves and choose among them. These skills should become valued and reiterated throughout a designer's education. The first step is making students aware of their own cognitive processes and building a greater understanding.

Surprisingly, metacognitive awareness is not uniformly developed in students. Even college age students are unaware and lack understanding of themselves as thinkers, and struggle with the most basic aspects of how to work through problems that have stumped them (Huitt 1997). In design, novice designers often follow one procedure again and again without flexibility, even in the face of unsatisfying results.

A model of metacognition in the classroom

In an attempt to enhance designers' problem solving ability it must be recognized that metacognitive processes play a central role (Bransford et al. 1986; Berardi-Coletta et al. 1995; Davidson and Sternburg 1998; Jausovec 1994; King 1991; Mayer 2001). The

foundation, the utilization of one's cognitive processes is reliant upon strong metacognitive knowledge and strategies. Therefore, the development of such knowledge and strategies should be a focus of a new design education approach.

Knowledge and strategies in isolation are not sufficient for creative thinking. Students must understand the strengths and limitations of their knowledge and strategies in order to be able to use them efficiently. This capability builds explicit knowledge of one's own cognition (Fig. 5). Metacognition includes two main components referred to as *knowledge of cognition* and *regulation of cognition* (Schraw and Moshman 1995; Baker 1989). Knowledge of cognition consists of explicit knowledge of one's memory, knowledge base, and strategy repertoire, as well as what often is known as conditional knowledge, or knowledge about why, when and where to use strategies. Regulation of cognition consists of knowledge about planning, monitoring, and evaluation (Fig. 5).

If students understand the role of regulation and knowledge of cognition as the main requirements of metacognition they will be able to build metacognitive knowledge through the interaction of these skills. To facilitate this understanding, teachers can discuss the importance of metacognitive knowledge and regulation. Ideally, such a discussion helps students construct an explicit mental model of a metacognitive thinking process (Schraw and Moshman 1995). Another way is for teachers to model their own metacognition for students. When thinking out loud, teachers too often discuss and model their cognition (i.e., how to perform a task) without modeling metacognition (i.e., how they think about and monitor their performance). A third way is to provide time for group discussion and reflection. Peer modeling of both strategies and metacognition not only improves performance, but increases self-efficacy as well (Schraw 1998).

Promote regulation of cognition

The regulation of cognition is the way an individual monitors, controls, and directs aspects of his or her cognitive processes and behavior for themselves by coordinating thinking skills. The regulation of cognition involves the following processes:

- *Planning:* involves goal-setting, developing a strategy, and identifying obstacles; the purposeful selection of strategies for specific tasks and organized steps to execute them.

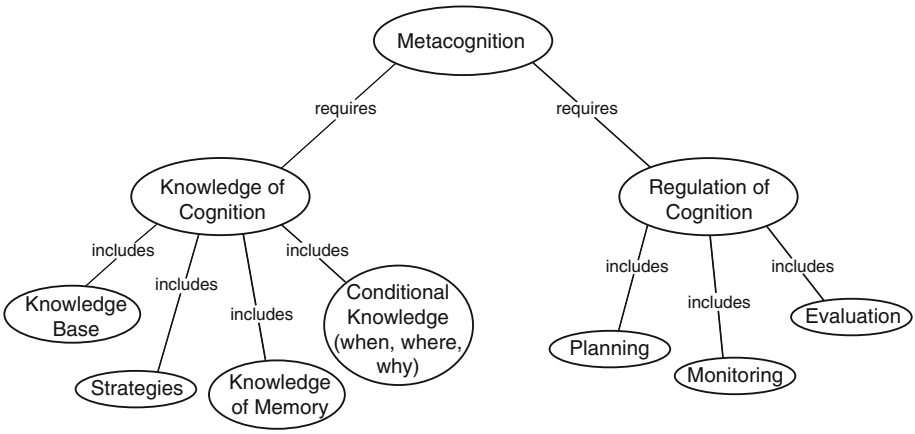

Fig. 5 Knowledge and regulation of cognition (Schraw and Brooks 1999, p. 199)

- *Monitoring:* involves the ability to observe, acknowledge, and measure progress toward one's objectives.
- *Evaluating:* involves assessing outcomes, gauging progress; an ongoing assessments of knowledge or understanding, resources, tasks, and goals.

Evaluation, planning, and regulation help students gain executive control of behavior and should take place before, during, and after stages of tasks.

Designers may benefit from the regulation of cognition because it allows them to create order out of an often chaotic existence, and it helps them organize time, energies, and resources.

When educators help students develop an awareness about their own thinking and learning processes they are helping students think about the effectiveness of the strategies they use in reaching the goals they have set. Students are essentially thinking about their thinking. In general, use of a long-term metacognitive strategy of planning what is to be done, monitoring our progress, and evaluating the results is an effective way of helping students take more control of their own thought and feeling processes (Barell 1985).

You cannot help each student during each creative process; students must take control of the process. After forming initial creative products and awakening the joy of creating in students, one should teach strategies for regulation of cognition. Self-directed creating is how most of us work throughout our lives-and especially in our lives outside of school. Some things students can do to promote their regulation of cognition:

1. List multiple ideas (solutions) to a problem (project)
2. Assess creative strategies and pursue one
3. Defend your choice
4. Develop plans for completing the project, including how and where to find information,
5. and how and when you will finish the project
6. Keep a daily thinking log of progress, roadblocks, and how you surmounted problems
7. Discuss teacher feedback on finished projects
8. Assess a classmate's project and review and discuss peer evaluations (Sternberg and Williams 1996)

Metacognition combines various attended thinking and reflective processes, and the teaching of metacognitive skills is a valuable use of instructional time for design educators. When designers reflect upon their problem-solving strategies, they become better prepared to make conscious decisions about what they can do to enhance their cognitive processes in design. When assessing the role of metacognition in the classroom Neil Anderson (2002) divided these processes into five primary components: (1) preparing and planning, (2) selecting and using strategies, (3) monitoring strategy use, (4) orchestrating various strategies, and (5) evaluating strategy use. While Anderson's assessment was focused on teaching and learning a second language, all of the components apply to problem-solving and the designer. Anderson states that a student's educational experience should include all five areas. Together each of these areas discussed below served as the framework for the first educational intervention.

Preparing and planning

Preparation and planning are important metacognitive skills that can improve student problem-solving. By engaging in preparation and planning in relation to a project goal,

students think about what they need or want to accomplish and how they intend to go about accomplishing it. Teachers can promote this reflection by guiding the students in setting their own project goals. The more clearly articulated the goal, the easier it will be for the students to measure their progress. This relates to the infrequency with which design education engages the student in setting or defining the problem parameters. Many problems arrive stripped of their complexity by the teacher.

Selecting and using strategies

Researchers have suggested that teaching students how to use specific strategies to develop metacognitive skills is a prime consideration in the classroom (Sternberg 1988; Feldhusen 1995; Barak 2010). The metacognitive ability to select and use particular strategies that are appropriate in a given context for a specific purpose means that the design student can think and make conscious decisions about the design process. To be effective, metacognitive instruction should explicitly teach students a variety of creative strategies and also when to use them. The selection of a creative strategy used to work on a problem is critical to how the solution is formed. There are many forms for solving most problems and it is often difficult to know what approach may be the best choice. The first step is realizing that you have a choice. One should consciously think about the various ways of working the problem and follow through with the most feasible against a set of performance criteria. However, as was mentioned before, most students follow the habit of unconsciously selecting a strategy and then unconsciously switching from one strategy to another.

Monitoring strategy use

By monitoring their use of creative strategies, students are better able to keep themselves on track to meet their project goals. Once they have selected and begun to implement specific strategies, they need to ask themselves periodically whether or not they are still using those strategies as intended. For example, students may be taught that an effective creative strategy involves free association. Students can be taught that to monitor their use of this strategy; they should pause occasionally asking themselves questions about what they are doing and whether the strategy they are using is most effective in supporting their project goal and users.

Orchestrating various strategies

Knowing how to orchestrate the use of more than one strategy is an important metacognitive skill. The ability to coordinate, organize, and make associations among the various strategies available are major distinctions between strong and weak problem-solvers. Teachers can assist students by making them aware of the multiple strategies available to them and how to recognize when one strategy isn't working and how to move on to another.

Evaluating strategy use

Problem-solvers are actively involved in metacognition when they attempt to evaluate whether what they are doing is effective. Teachers can help students evaluate their strategy use by asking them to respond thoughtfully to the following questions: (1) What am I

trying to accomplish? (2) What strategies am I using? (3) How well am I using them? (4) What else could I do? Responding to these four questions integrates all of the previous aspects of metacognition. Preparing and planning relates to identifying what is to be accomplished, while selecting and using particular strategies relates to the question of which strategies are being used. The third question corresponds to monitoring strategy use, while the fourth relates to the orchestration of strategies. The whole cycle is evaluated during this stage of metacognition.

An interaction of skills

Each of the five metacognitive skills described interacts with the others. Metacognition is not a linear process that moves from planning to evaluating. More than one metacognitive process may be occurring at a time during a problem-solving task. This highlights once again how the orchestration of various strategies is a vital component of any problem-solving activity. Allowing the student opportunities to think about how they combine various strategies facilitates the improvement of strategy use. Teachers can promote awareness of strategies for thinking by engaging their students in activities that require reflection. Activities that require students to make the sometimes invisible work of thinking visible and explicit help all students to understand that as thinkers, they are in charge. Structured problem-solving strategies can provide novices with mechanisms that promote a more purposeful, flexible, and creative problem-solving. Metacognition is thinking about thinking, knowing "what one knows" and "what one doesn't know." Just as an executive's job is management of an organization, a thinker's job is management of thinking. Some basic metacognitive strategies are:

1. Connecting new information to former knowledge. (Making associations)
2. Selecting creative thinking strategies deliberately.
3. Planning, monitoring, and evaluating thinking processes (Dirkes 1985)

Instruction and activities

In building students' creative thinking abilities the following instruction and activities were used to help develop a metacognitive approach.

Direct instruction

Direct instruction is passive in nature and involves the acquisition of essential knowledge that is used to construct higher-level knowledge. However, the direct teaching of creative thinking does not pour into students' heads a single way of execution. In turn, the modeling procedure provides a takeoff point from which students can gradually construct and develop more personalized but equally effective procedures.

Paired problem-solving

Paired problem-solving encourages students to reflect on their thinking and report to others. It serves as a type of "accountability check," and promotes the active construction of knowledge. The procedure requires students to work in pairs to engage in think-aloud tasks, with one student solving a problem and reporting aloud what he or she is thinking.

This activity helps students practice regulation of cognition, specifically the monitoring of their process. It involves the ability to observe, acknowledge, and measure progress toward one's objectives while in the process of thinking.

Journal keeping

Journal keeping is a form of independent reflection and evaluation that leads to the restructuring of one's knowledge in a manner that promotes an increasingly theoretical understanding of one's creative thinking process. Documentation is important in design. However, it is often that case that students take great care in the documentation of product but do not apply the same approach to the documentation of process. This can be seen in the presentation of design projects; students often have very polished representations of the final product, but lack the documentation to help explain how they reached a solution. Documentation helps designers reflect on and evaluate the results of their process. Without a record of this process the ability to build metacognitive knowledge is greatly reduced. Writing and illustrating a personal log or project diary throughout a problem solving experience or design project over a period of time causes students to synthesize thoughts and actions and translate them into symbolic form (Fig. 6). This record also provides an opportunity to revisit initial perceptions, to compare the changes in those perceptions with additional experience and to recall the success and failures through the experimentation of cognitive strategies. This activity also helps students practice regulation of cognition, focusing primarily on the skill of evaluation. It involves an assessment of outcomes as well as an ongoing assessment of knowledge and understanding, resources, tasks, and goals. By requiring students to document their process and evaluate the results the process of building a creative knowledge base can be modeled.

Case studies: great thinkers

Another way to teach about metacognition is by giving students opportunities to analyze how numerous expert designers engage in various kinds of thinking operations. Here the subject of the lesson is someone else's thinking. Students view, listen to, or read such examples or case studies of thinking in action, and with teacher assistance identify the kinds of cognitive and metacognitive strategies and skills employed and the key attributes of each. It is important to expose students to various creative thinkers, both in and outside the profession of design. Creative individuals such as distinguished artists, musicians, authors and scientists are the focus of study, as students examine other's creative thinking processes. As a part of this practice students are challenged to find new examples of metacognitive thinking in others and various examples of expert thinkers are examined and shared with classmates (Fig. 7). This activity helps build students knowledge of cognition. The introduction to various creative thinking processes helps build students' creative knowledge base. In addition, seeing how others utilize creative strategies helps build conditional knowledge of when, where and why different strategies might be an optimal creative approach.

Design thought model

The Design Thought Model serves as the final project of the semester. The purpose of this exercise is for students to construct what they learned about themselves as a creative

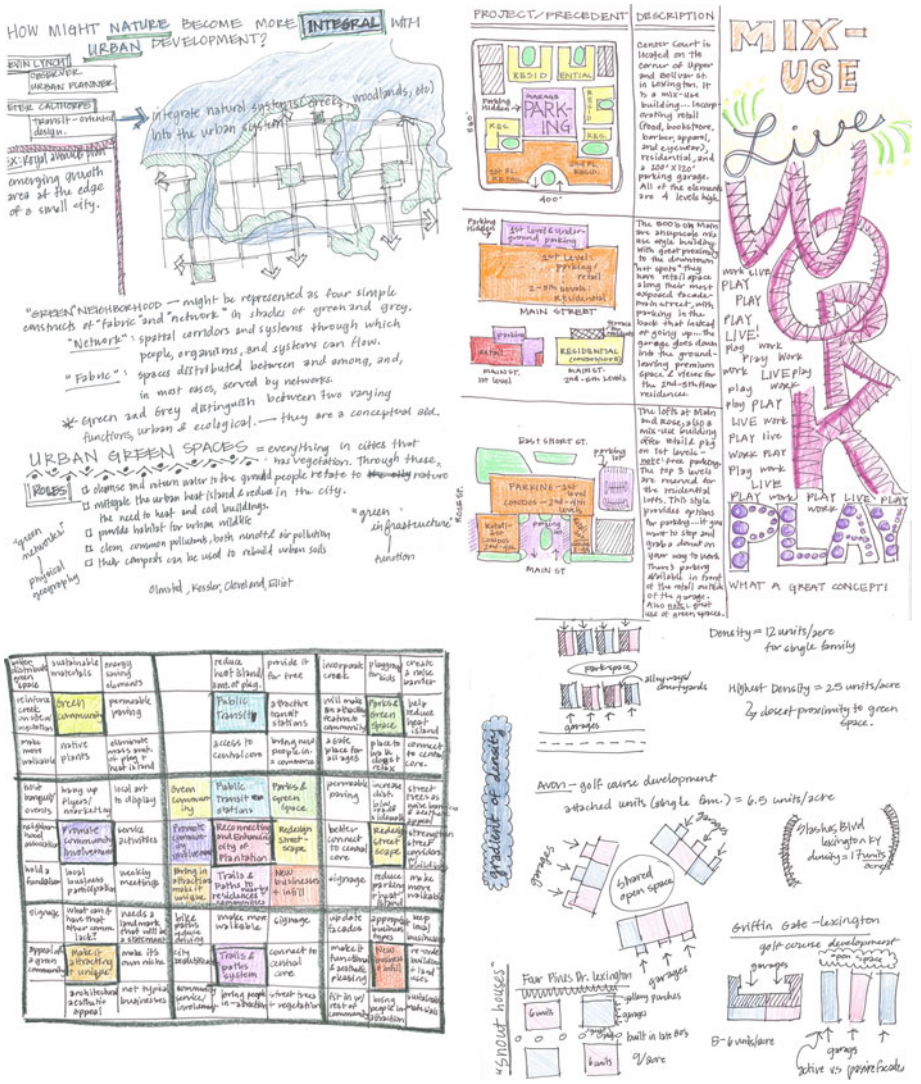

Fig. 6 Example of work in a student process journal—James Calitri, Lauren Fraley, Spring 2009

thinker. In this exercise students must practice the act of "thinking about thinking" in order to articulate their creative processes. Students are asked to carefully reflect on their personal creative process from beginning to end and create one artifact that best represents their creative thinking process (Fig. 8). The artifact could be a model, graphic/video presentation, poem, sculpture, painting, or any physical representation of their creative process. Students use this exercise to strengthen their understanding and expression of their creative process and how it has developed over the semester. By expressing their own creative process students are forced to externalize a process that is typically internal. This expression of process will not only benefit them, but fellow students will be able to compare and contrast different approaches to problem solving, ultimately gaining a broader

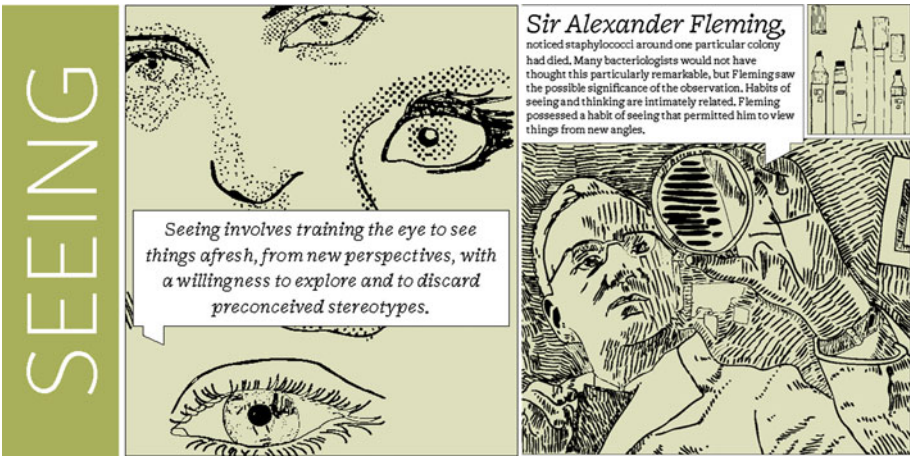

Fig. 7 Creative case studies—Brooke Chornyak, NC state college of design, master of graphic design program

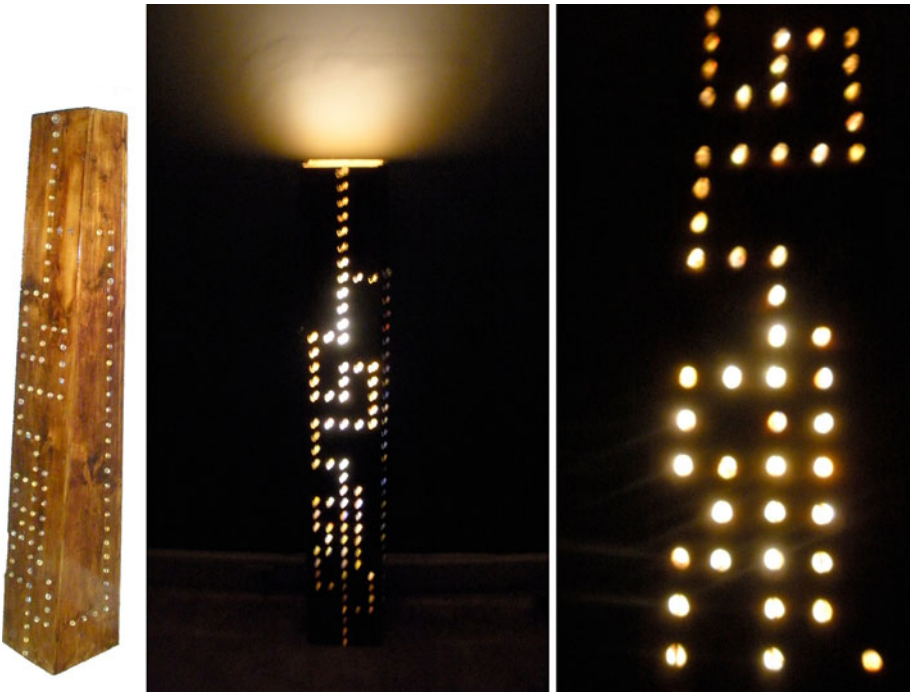

Fig. 8 Design thought model—Joey Carbajal, Spring 2010

perspective through shared insight and reflection. This activity is important because for many students this is the first time externalizing their entire creative process. It is the act of externalizing the process that leads to discovery. Students learn that an accurate representation of their process is essential to continued growth and development.

Second educational intervention

The second intervention occurred in the fourth semester of study and focused on the utilization of internet based technologies as a framework to developing students' creative thinking abilities. Students were responsible to participate on an online blog that served as a metacognitive tool. The Metacog Blog incorporates several emerging technologies in an effort to help students set goals, self-monitor and reflect on their design thinking processes. Through the utilization of these technologies a network of learning was created, building students understanding of their own creative approach to design and how this might be enhanced through metacognitive activities. It was intended that the blog reinforce the value and need for these activities during the process of design. Students were encouraged to set goals for problem solving, record the process that they were utilizing to explore ideas and supplement this with what they learned through this exploration. It also allowed students to observe the behavior and interactions of other students and how others were thinking about and approaching design. The blog encouraged the sharing of ideas and fostered discussion of various topics related to this creative thinking and beyond.

This blog serves primarily as a way for students to externalize their thinking process in an effort to learn from experience and build a creative knowledge base. Offering a medium in which students can easily and effectively share their ideas, insight and experience is invaluable in terms of students' cognitive development. Essentially the blog functions at two levels. Individually students learn about their own approach to design and collectively all users benefit from the network of information and multiple perspectives. As an author each student records observations and insights that pertain to a growing understanding of their creative thinking process–the emphasis should be on the communication of knowledge and ideas. Students are encouraged to supplement writing with diagrams, sketches, and photography as needed. By documenting and evaluating the process of their own creative endeavors students are able to reassess and refine their creative approach throughout the semester. As a respondent each student comments on classmates posts and actively participates in an ongoing thread of dialogue (Fig. 9). Becoming a follower of the blog links you with a larger network of members who will share information and experience. It also allows for individual and group discussion along with email compatibility.

This blog allows for the integration of multiple technologies. One of these is the use of Twitter to notify students of new posts. Students also receive emails when comments are made concerning an entry they posted or commented on.

Students are able to post new content, upload images and participate in ongoing threads of discussion about numerous design issues. This reinforces the value of self-regulation and allows students to observe how others think about and approach design. Many posts include links to additional content. These links allow students to explore the content in greater detail and provide concrete examples to support the topic of discussion. Also, selected posts have links to video content. Often lectures and group exercises from class are recorded and uploaded. Students are also encouraged to unload video that they find or have recorded pertaining to the subject. Several videos document students practicing, experimenting and reporting on various creative strategies.

Each post serves to stimulate discussion. Students comment as a part of a running dialogue. They are able to upload images and video as a part of their commentary. These strands often last for days and may be revisited at any time. An example of a typical exchange is presented below followed by an example of content posted on the blog by students (Fig. 10).

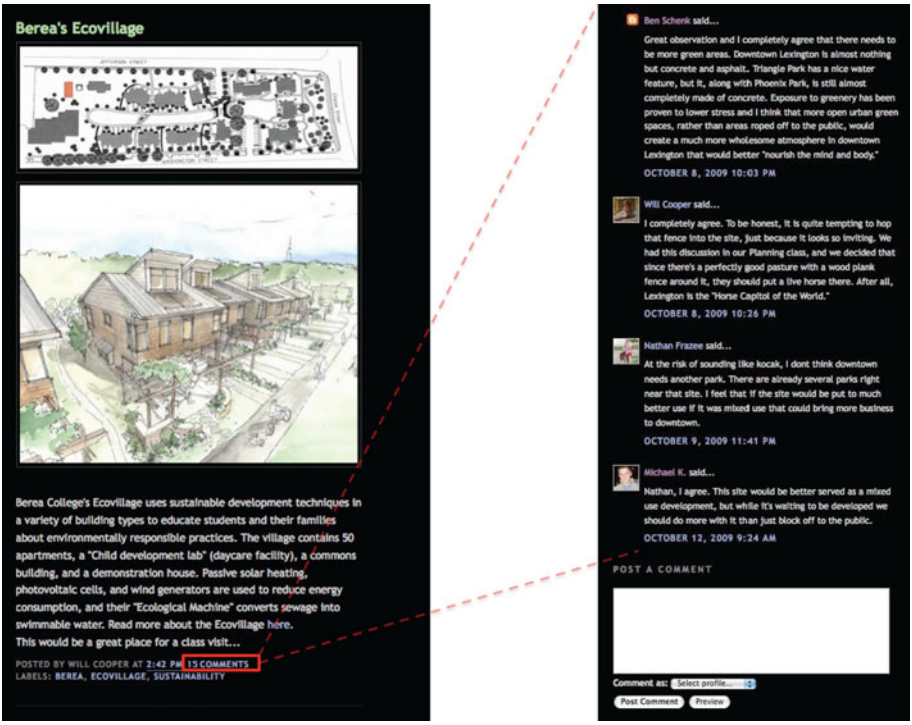

Fig. 9 Classmates participate in an ongoing thread of dialogue

An archive allows students easy access to past discussion topics. This information is organized by date and title. Having a permanent record of all content allows students to revisit past discussions, and with experience often leads to new perspective and insight. All posts are tagged with a set of labels. This allows students to search for content pertaining to specific topics. Often students use this to find threads of dialogue about a particular creative strategy or content objective. Many posts are cross-referenced to multiple labels and provide a network for documentation and reflection.

Since its creation several design professionals have been invited to participate as guest contributors on the blog. Having individuals with a great deal of experience and self-knowledge share insight and perspective only strengthens the experience for students.

The results

Great educators are able to find and use strategies to connect with all students. This is where teaching goes beyond explaining how to design and becomes the art/science of discovering and enriching how students think about and approach design. This goal can be more effectively achieved by utilizing educational research to understand how we think about and build knowledge in the process of designing. It goes beyond teaching the way we were taught and becomes teaching the way that students will most effectively learn.

The goal of this study was to determine the long-term impact that instructional interventions based on research in metacognition and learning theory would have on design

Student A Entry:

The use of multiple creative strategies is also very useful. If you can utilize multiple creative strategies simultaneously I find that the quantity and quality of ideas increases. Switching between two or more creative strategies allows for all of the strategies to build upon each other leading to unexpected areas of thought. Perhaps most important is the fact that this approach ensures that the ideation phase rarely hits a roadblock. When one strategy becomes slow or predictable you can simply switch to another.

Student B Response:

I agree with your comment on working with multiple creative strategies simultaneously. I have always found that working in parallel enhances their effectiveness and often leads to better ideas. Focusing on multiple creative strategies expands the mind and perspective allowing for more creative ideas to appear more often and later in the design process.

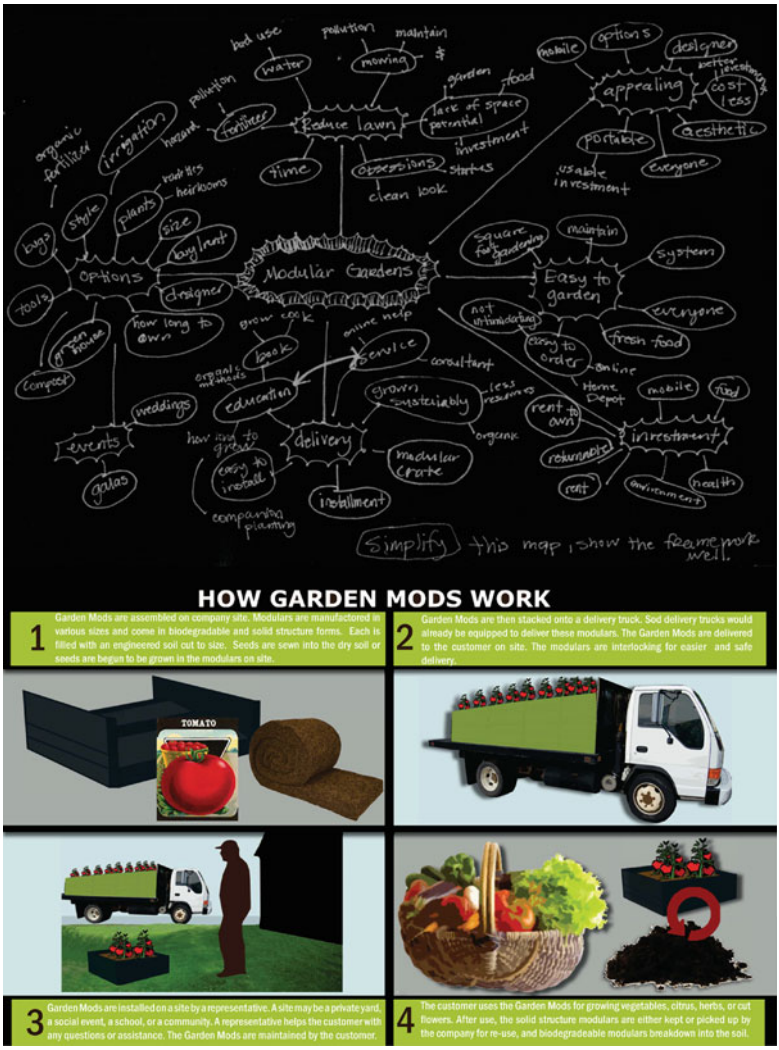

Fig. 10 Example of Student work posted on the blog—Katrina Kelly, Spring 2009

students' creativity. At the conclusion of the research, the results of the various creativity tests and creative performance measures were analyzed and compared across the duration of the study period. Equivalent forms of the creativity tests were administered prior to the first semester intervention and again following students' final semester of study. The final testing helped to determine the long-term impact of both creative thinking interventions. The researchers expected to find results indicating that students' creative abilities, related to association, increased during the 4 years of the study. It was hoped that the group participating in the interventions would show more improvement. Upon examination of the data it was discovered that overall the control group's test scores showed no significant improvement and in some cases declined. However, the majority of test scores of students who participated in one or two interventions improved significantly (Figs. 11, 12, 13). The final testing indicated that students that participated in two interventions were able to maintain a much higher level of creative thinking long-term.

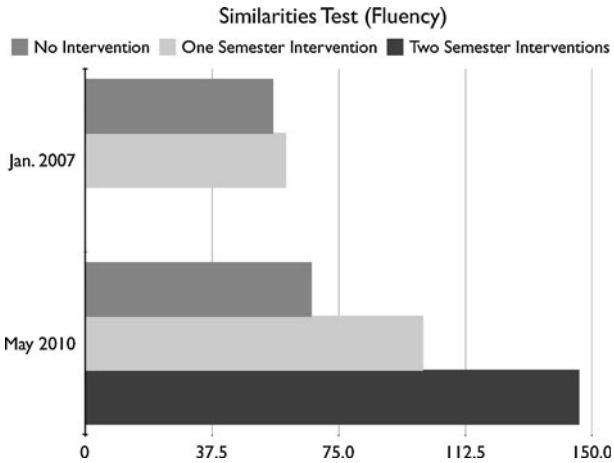

Fig. 11 Similarities test—fluency

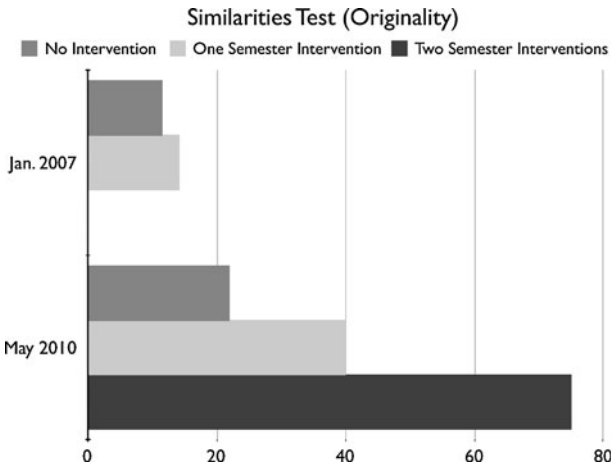

Fig. 12 Similarities test—originality

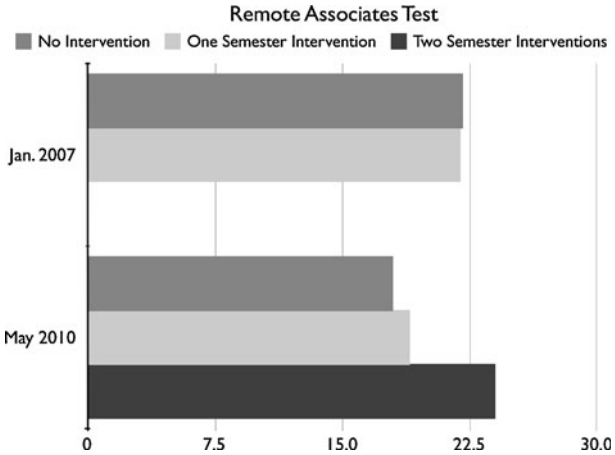

Fig. 13 Remote associates test

Table 2 Means and standard deviations for creative thinking scores across conditions

Condition	Baseline performance RAT		Delayed performance RAT		Baseline performance SIM FL		Delayed performance SIM FL		Baseline performance SIM ORIG		Delayed performance SIM ORIG	
	M	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD
Control ($N = 15$)	21.33	4.89	17.53	3.02	73.80	24.31	67.13	9.10	20.93	9.14	22.13	3.00
Treatment 1 ($N = 17$)	20.18	4.77	19.18	2.94	61.06	31.53	100.29	12.39	13.65	9.42	40.41	12.79
Treatment 2 ($N = 13$)	24.38	5.92	24.08	3.09	57.15	11.69	146.08	18.45	14.85	5.27	75.23	11.30
Overall ($N = 45$)	21.78	5.34	20.04	3.99	64.18	25.23	102.47	34.12	16.42	8.78	44.38	23.52

Three separate repeated-measures ANOVAs were conducted to examine changes in scores on the RAT, Similarities Fluency, and Similarities Originality scores.

For RAT scores the ANOVA (3 groups × 2 testing sessions) revealed a significant main effect, $F(1, 42) = 5.90$, $p = .019$, $\acute{\eta}2 = .123$, indicating that overall RAT scores decreased from the baseline measure to the delayed test across groups (see Table 2). No significant interaction was found across groups that would indicate differential changes across groups from the baseline condition to the delayed test.

For Similarities Fluency the ANOVA (3 groups × 2 testing sessions) revealed a significant main effect, $F(1, 42) = 163.75$, $p < .001$, $\acute{\eta}2 = .796$, indicating that overall Fluency scores improved from the baseline measure to the delayed test across groups (see Table 2).

A significant interaction was found indicating that changes in Fluency varied across conditions, $F(2, 42) = 71.48$, $p < .001$, $\acute{\eta}2 = .773$. Follow up tests indicated that the Treatment 1 ($t(16) = -6.49$, $p < .001$) and Treatment 2 ($t(12) = -24.92$, $p < .001$)

conditions scored significantly higher from baseline to delayed test whereas the Control condition showed no significant change ($t(14) = 1.17$, $p = .260$) (see Fig. 11 for a graphic representation of these results). In sum, students who received metacognitive training for one or two semesters developed more fluency than their peers who received no training. In addition, the effect size reflecting these gains was large in magnitude.

For Similarities Originality the ANOVA (3 groups × 2 testing sessions) revealed a significant main effect, $F(1, 42) = 395.56$, $p < .001$, $\eta 2 = .904$, indicating that overall Originality scores improved from the baseline measure to the delayed test across groups (see Table 2).

A significant interaction was found indicating that changes in Originality varied across conditions, $F(2, 42) = 125.31$, $p < .001$, $\eta 2 = .856$. Follow up tests indicated that the Treatment 1 ($t(16) = -9.64$, $p < .001$) and Treatment 2 ($t(12) = -22.47$, $p < .001$) conditions scored significantly higher from baseline to delayed test whereas the Control condition showed no significant change ($t(14) = -.59$, $p = .565$) (see Fig. 12 for a graphic representation of these results). Similar to findings with fluency, students who received metacognitive training for one or two semesters developed higher originality scores than their peers who received no training. Effect sizes for originality were also large in magnitude.

In addition to the battery of creativity tests students' design thought model projects were scored and compared following the 2007 spring semester. The hope was that students participating in the educational intervention would score higher on the project. Upon examination of the data it was discovered that the treatment group ($M = 37.0$, SD = 1.729) scored significantly higher than the control group ($M = 34.3$, SD = 2.86) as predicted, $p < .001$ (Fig. 14).

A second analysis examined only the metacognitive thinking category. Again, the treatment group ($M = 8.4$, SD = .41) scored significantly higher ($p = .01$; see Fig. 15) than the control group ($M = 7.8$, SD = .52).

Conclusions and reflections

It is the authors' contention, supported by the results of this research, that by consciously encouraging students to explore a wider range of metacognitive approaches, the likelihood of developing creative thinking among all students increases. Additionally, utilizing Internet based technologies provides a framework for development to take place and significantly aids in this process.

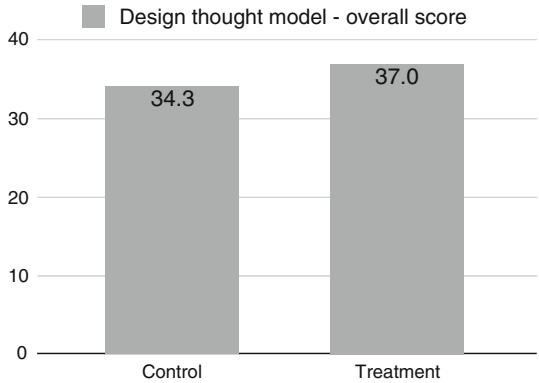

Fig. 14 Design thought model—overall score

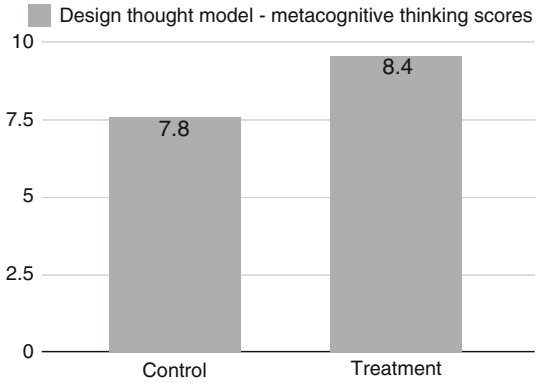

Fig. 15 Design thought model—metacognitive thinking score

Examining the 4-year timeline of the study allows for some important conclusions to be made. First, students in the control group who progressed through the typical design education curriculum finished 4 years of school no more creative as measured than when they started, and in certain cases saw these creative skills diminish. This fact alone is sobering and points to the value of this study and the importance of a new approach to design education. Second, overall students who participated in one or both interventions finished with significantly higher levels of creative thinking. This is an accomplishment that should not be understated, particularly when compared with students who did not participate in any interventions.

Furthermore, it is important to highlight the impact of the second intervention. The reinforcement of the second intervention allowed for an increased positive impact on students' creative thinking. This might indicate that there is a critical level of reinforcement. One semester is good, two semesters is even better, perhaps three semesters or more would allow for continued improvement and long-term retention of high-level creative skills. In other words, at some point the reinforcement may be enough to maintain advanced levels and have a lasting impact as students graduate and enter the professional setting.

A project based assessment of students creative and metacognitive abilities indicated that students who participated in an intervention scored significantly higher overall and specific to metacognitive thinking. This is important because it supports the findings of the creativity tests and shows that these skills are being exercised in student work.

The results of this study point to the need for more structured metacognitive activities across students entire design education. Providing students with one course or even a series of courses focusing on creative thinking is wonderful, but if we hope to maintain these large leaps in creative output there is a need to continue structured metacognitive activities throughout the entire curriculum. Without this structure in place students are not likely to make this behavior a regular part of their design approach. Technology can play a critical role in establishing this structure for students throughout their education. As demonstrated in this study the use of blogs are a powerful and effective tool for the development of creative thinking abilities. In the case of students' creative thinking, prolonged participation on a blog could very easily be incorporated throughout an existing design curriculum. In fact, the addition of a blog can serve to enhance and enrich the experience of all design courses and as a shared experience it may also function as a unifying activity across disciplinary boundaries.

All good design educators encourage students to reflect on and about their design processes. This is not new information. Many experienced and skillful design educators

regularly encourage their students to practice metacognitive skills as a way to develop a creative approach to design. However, by introducing innovative technologies as a part of this process educators are providing students with an advanced tool for planning, monitoring, and evaluating their creative process. Incorporating technologies such as a blog takes advantage of the convenience and power that the Internet provides. Students are able to instantly record, recall, and reflect on information through multiple devices and emerging technologies.

It is important to understand that success in a design profession and a high level of professional competence does not automatically translate to success as a design educator. In design education, even at the highest levels, individuals are very seldom prepared to become teachers. Universities have initiated programs that begin to address this shortcoming however these programs usually examine aspects of teaching related to more general topics and very seldom deal with fostering creativity. As this study has shown, technology can play a critical role in developing students' creative thinking abilities. It is the intent of this study to encourage the process of applying research in creativity and metacognition to design education. Through this work a body of knowledge can be developed that directly relates to the teaching of design. In this way the intuition and experience of design educators can be tested by, and combined with, the results of research in learning theory and metacognition. This combined approach will enable us to develop in our students a higher level of creativity and better prepare them all to be the next generations of designers.

Moving forward

The educational interventions detailed in this paper were first developed through the author's doctoral research at North Carolina State University. This research focused specifically on how to develop students' creative skill set (Hargrove 2008). As a part of this research, creative strategies were introduced to students within a design curriculum. The work at North Carolina State University laid the groundwork for the course that is now offered at the University of Kentucky. The original course that was developed at the University of Kentucky was taught to design students as a part of the Landscape Architecture curriculum. This course was offered on an experimental basis for 2 years. After receiving positive feedback it was decided to submit the course to the new University of Kentucky General Education Curriculum. More development was done on the course with the goal of preserving the underlying principles, while incorporating the feedback received during the first 2 years with design students. This course, *LA 111: Living on the Right Side of the Brain* began as a pilot course in the 2011 spring semester as a part of the new university general education curriculum. Offering the course as a general education course strengthens its educational value. The skills that are being introduced should not be limited to "creative" disciplines. All students need these skills in order to succeed. Also, the infusion of multiple disciplines allows for various perspectives that were not as prevalent in the design course.

The course has a very basic two-part approach. Creative strategies are introduced throughout the semester in an attempt to build students creative toolbox. While the introduction of these strategies provides students with the tools to succeed the foundation of the course is the introduction of a metacognitive approach. Metacognition, the ability to be aware of, attend to, and use information about their own cognitive processes serve students for a lifetime and transcends the ever-changing challenges of the conceptual age.

Metacognitive thinking allows students to build a metacognitive knowledge base and apply their creative thinking skills to an infinite number of applications. This is what separates a truly creative thinking process from a novice approach. By actively engaging students in the practice of both knowledge and regulation of cognition they are able to build conditional, declarative and procedural knowledge that leads to the adaption and combination of existing creative strategies as well as the creation of new strategies. Developing a metacognitive approach is not easy. It is far more difficult for students to make a commitment to think about their own thinking, building an understanding of their own thinking processes. This approach incorporates skills and behavior. Any student can learn the skills needed to be creative, however, it is critical that students' take the next step and adopt a metacognitive approach to problem solving.

Being creative is more than simply coming up with a big idea. It involves a set of behaviors; the way we see, feel, think and do every day. But when we see, feel, think and do things as we've always seen, felt, thought and done them before, our ideas will undoubtedly be the same. Having awareness and understanding of our thought processes in a way that informs, engages and inspires is vital for our continued personal and professional development in today's competitive world.

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