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RYAN HARGROVE
University of Kentucky

Fostering creativity in the design studio: A framework towards effective pedagogical practices

ABSTRACT

Design is a discipline of innovation: its essence is the creation of something new and unique. An assumption has been that the inclination and ability of a person to respond in novel and useful ways is largely inherited. Present research refutes this view, and it is now believed by many that, however creativity is defined, it is a form of behaviour that can be taught. Acknowledging this point leads to the questioning of how creativity is situated in the design curriculum. If, as present research suggests, most creativity training programmes are successful in that they encourage the development of metacognitive abilities, then the study of creativity as a self-regulatory metacognitive process is timely and important to design education.

KEYWORDS

design education
creativity
creative thinking
metacognition
self-regulation
design studio

THE PROBLEM

Design educators are faced with a unique challenge in respect to the need for increasing the level of the creative performance of their students. Teachers have a responsibility that goes beyond contributing to the development of creative designers. However, design courses stand out as those in which students not only have the time and freedom to be creative, but are required to have and are rewarded for such behaviour. The goal is to develop creative strategies in all design courses, with these strategies transferring across the entire breadth and depth of a designer's education. To date, however, there is little indication that deliberate creative thinking/strategies are being taught in design courses (Houtz 1994; Oxman 1999; Cropley and Cropley 2010; Kowaltowski et al. 2010). A review of current practice throughout higher education in the United States conducted by Fasko (2000–2001) pointed out that the available information indicates that deliberate training in creativity is rare. The problem is also not confined to the United States. Lewis (2005) summarized the literature by stating that we still have some way to go before creativity becomes a more central feature of the teaching of design in the United States and elsewhere. If creative behaviour is to be the central theme in the designer's education, new pedagogical approaches are needed.

At virtually all design schools, design is quite rightly considered the heart of the curriculum. However, 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). 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 product of the design rather than on what might be considered a learning process or skill. As a consequence, the cognitive skill sets of design are not adequately addressed and important learning opportunities are marginalized (Oxman 1999; Kvan 2001; Ehmann 2004). There is a risk that students will leave school and face the profession without an awareness and understanding of their own cognitive processes, and will therefore lack the metacognitive knowledge to reach their creative design potential.

THE QUESTION

The model of representation-redescription proposed by Karmiloff-Smith (1995) clearly articulates the importance of cognitive strategies in design education. This model refers to learning as the succession of representations that become progressively more manipulable and flexible due to the emergence of conscious access to knowledge structures. With this consciousness comes the belief that understanding and awareness of cognitive principles and processes will enhance ability to create novel solutions. In her research Karmiloff-Smith hypothesizes that learning in design is to be able to utilize various cognitive strategies of design thinking. That is, cognitive strategies of design thinking can become the content of design education (Oxman 1999).

Following Karmiloff-Smith, Oxman (1997) introduced a model of re-representation that provides one basis for a formal theory of creativity. This conception of design as a sequential process of description and re-description provides a powerful basis for the understanding of creative behaviour in design. It also provides important insights on the externalization of domain-specific schema and knowledge structures as phenomena of creativity. Creativity can be explained in such an approach by demonstrating how designs can be accessed and transformed in novel ways.

Cross (2006) describes design as exploratory, rhetorical, emergent, opportunistic, reflective and risky endeavour. 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 is 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 supports the idea that strengthening metacognitive skills is essential to improving one's ability to think about and practice creative design.

Metacognition is an essential ingredient of creative thinking (Sternberg and Williams 1996), and of the effectiveness of designers. 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.

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 remains to enable designers to utilize creative design thinking/processes with optimum efficiency. Knowing this, design educators should ask themselves how effective current design education is at developing students with strong creative thinking abilities, and how this potential connection between creativity and metacognition can translate into an educational model that will encourage a disposition for creative thinking?

THE RESPONSE

An important aspect of the growing interest in metacognition in recent years has been an increasing emphasis on the role of self-management. Authors such as Sternberg (1988), Runco (1990), Feldhusen (1995) and VanTassel-Baska and MacFarlane (2009) have stressed the importance of self-evaluative skills and metacognition to creative thinking. Nickerson, in his chapter on enhancing creativity in the *Handbook of Creativity* edited by Sternberg (1999), suggests a range of recommendations for enhancing creativity that are consistent with what is known about creativity and what has been learned from the efforts of teaching creativity in the classroom. Among the measures Nickerson describes is developing self-management (metacognitive) skills. Self-management involves becoming an active manager of one's cognitive resources. It is, in part, a matter of paying attention to one's own thought processes and taking responsibility for thinking. It involves learning one's strengths and weaknesses as a creative problem solver, and finding ways to utilize the strengths and mitigate or work around the weaknesses. It means making an effort to discover conditions that facilitate one's own creative work (Nickerson 1999).

In a seminal paper, design researcher Nigel Cross (1990) summarized creative 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 modelling media as a means of problem solving.

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'. In addition to these abilities, there are clearly metacognitive activities that oversee the whole process and provide support. 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 Schön (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'. He sees design as a reflective activity in which the designer has a reflective conversation with the situation. This behaviour can be classified as self-regulatory metacognitive thought.

Schön breaks reflection into two kinds of action: reflection-*in*-action and reflection-*on*-action. Reflection-*in*-action refers to the immediately recursive thought a person puts towards the action at hand – 'during which we can still make a difference to the situation at hand – our thinking serves to reshape what we are doing while we are doing it' (Schön 1987). This behaviour relates to self-regulatory planning and monitoring. Schön defines reflection-*on*-action as 'thinking back on what we have done in order to discover how our knowing-in-action may have contributed to an unexpected outcome' (1987), or post-activity reflection on the activity. This can be described as self-regulatory evaluation.

Schön's work bolsters the argument that by leading design students in conversation on their projects, educators nurture their concurrent reflection on their creative problem-solving skills (reflection-*in*-action), and that by asking them to rethink what happened and why (reflection-*on*-action), educators allow them to understand their own cognitive processes. In doing so, educators prepare them for success in a variety of future design situations.

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. 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, these results indicate that metacognition is an important factor in creative 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.

In another study, Hargrove (2008) determined the impact that selected instructional interventions, based on research on metacognition and learning theory, had on students' creativity. The study tracked design students beginning their freshman year to determine the impact throughout their undergraduate study. This research indicated that an approach to education influenced by research on learning theory and metacognition does result in students who are more creative.

DIAGRAMMING CHANGE – METACOGNITION AND COGNITIVE STRATEGY INSTRUCTION

The following is an educational framework that the author created to enhance students' creative thinking abilities (Hargrove 2008). This framework introduces and develops a self-regulated metacognitive approach to design thinking. It has been practiced in various undergraduate design courses over the last five years. This approach involves the two aspects of metacognition distinguished by Flavell (1979): knowledge of cognition and regulation of cognition. These aspects are developed collectively in an effort to obtain the goal of enhanced creative thinking abilities.

Steps towards the advancement of cognition are based on an instructional approach that emphasizes the development of creative thinking strategies and processes as a means to enhance creativity (Figure 1). By making these strategies and principles more explicit, by grounding them in relevant research and practice, and by illustrating them with specific examples, the goal is to make them more accessible and applicable in various design situations.

Steps towards the advancement of metacognition require the development of both knowledge of cognition and regulation of cognition. An

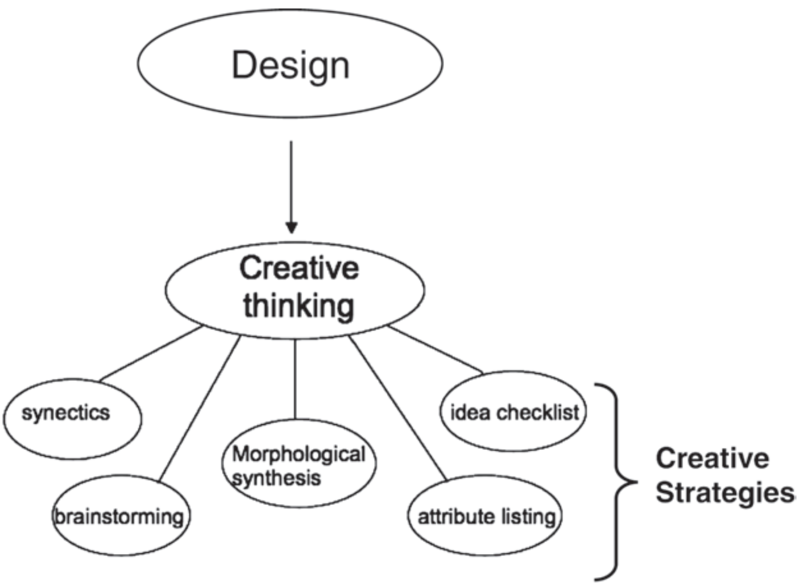

Figure 1: Development of creative thinking strategies.

Reverse Brainstorming	Lateral Thinking	Forced Analogy
Mind-mapping	Metaphorical Thinking	Visual Thinking
Discontinuity Principle	Storyboarding	Lotus Blossom
Assumption Smashing	Escapism	Search And Reapply
Idea Checklists	Schemas	Attribute Listing
Framing Context	Forced Connections	Random Input

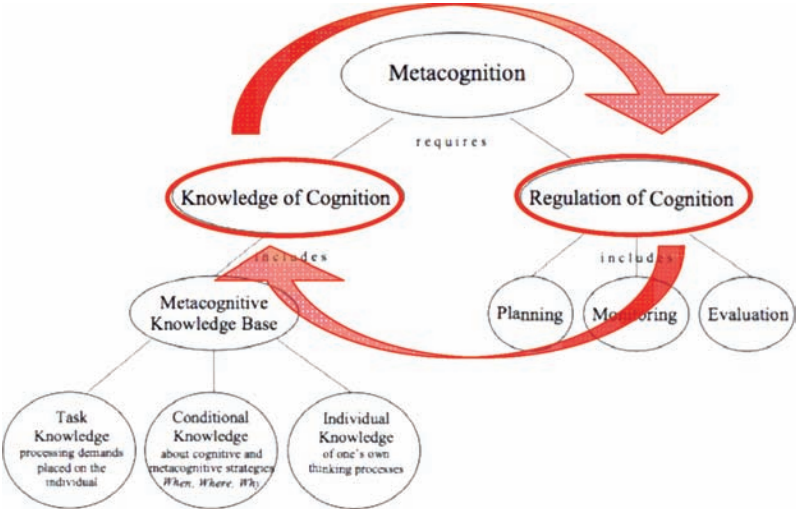

Figure 2: Cycle of metacognition.

examination of the educational framework reveals a cycle of building knowledge of cognition that in turn contributes to an advanced regulation of cognition (Figure 2). A primary goal of this educational approach is to help support this cycle and foster its growth through instruction.

KNOWLEDGE OF COGNITION

Knowledge of cognition includes a metacognitive knowledge base. This knowledge is founded on the understanding of various types of creative thinking strategies. An individuals' knowledge of these creative strategies consists of three different types of understanding (Figure 3). First, task

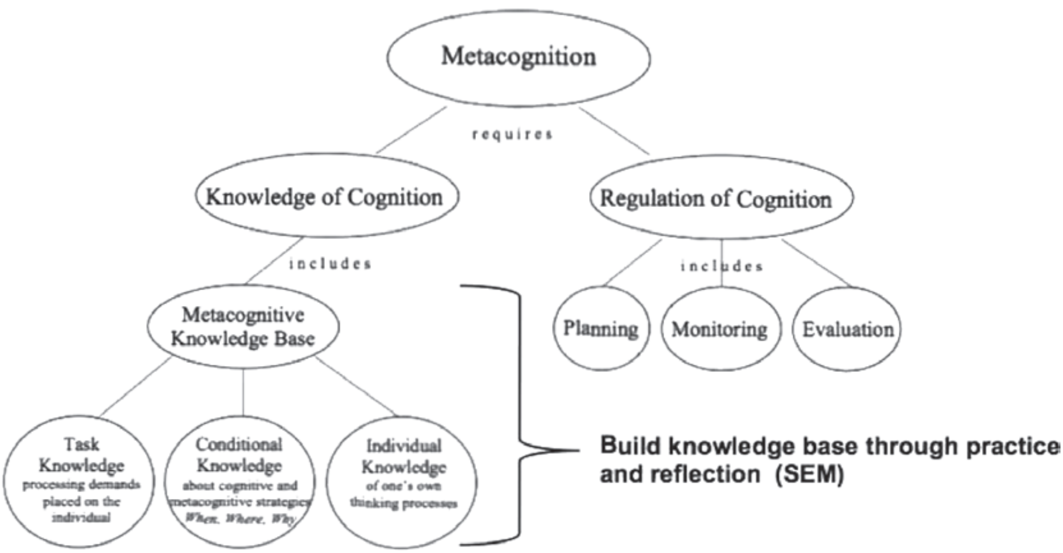

Figure 3: Building metacognitive knowledge base.

Strategy	How to use	When to use	Why to use

Figure 4: Strategy evaluation matrix (SEM) (Schraw and Brooks 1999).

knowledge (procedural knowledge) represents an understanding of the processing demands placed on the individual, or how to utilize various creative strategies. Second, conditional knowledge represents the understanding of when, where and why to use particular cognitive strategies. Third, individual knowledge (declarative knowledge) represents the knowledge of one's own thinking processes, or an understanding of the creative strategies that an individual possesses.

As a part of this educational approach, students are asked to complete a strategy evaluation matrix (SEM) (Schraw and Brooks 1999) (Figure 4). The SEM is introduced during the first week of the semester and students focus on a new strategy each week. Students are given time to reflect individually and in small groups about strategy use, talking about how, when and why to use specific creative strategies and also interviewing other students about their strategy use. Students are expected to revise their SEMs as a learning portfolio. The SEM serves three very important functions:

1. Promotes strategy use
2. Promotes explicit metacognitive awareness
3. Encourages students to actively construct knowledge

REGULATION OF COGNITION

The second part of metacognition is the regulation of cognition. This includes the planning, monitoring and evaluation of various creative strategies (Figure 5). Regulation through the use of these processes contributes to the proper use of creative strategies, and, more importantly, the development of the knowledge of cognition, which serves to improve future creative problem solving.

The key operations of metacognition are used as a structure or guide for helping students to think about their own thinking as their thinking becomes more self-regulated (Table 1).

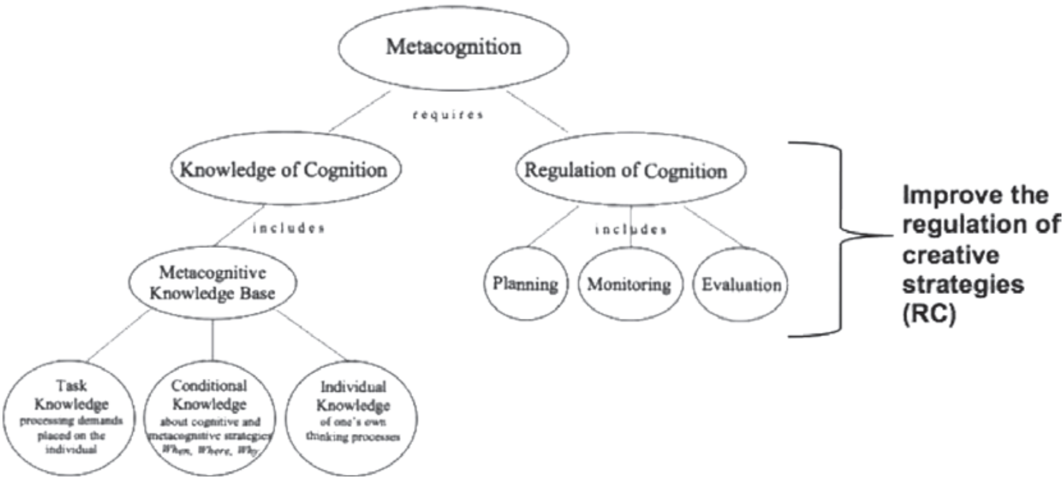

Figure 5: Regulation of creative strategies.

I. PLANNING Stating a goal Selecting operations to perform Sequencing operations Identifying potential obstacles/errors Identifying ways to recover from obstacles/errors Predicting results desired and/or anticipated II. MONITORING Keeping the goal in mind Keeping one's place in a sequence Knowing when a subgoal has been achieved Deciding when to go on to the next operation Selecting next appropriate operation Spotting errors or obstacles Knowing how to recover from errors, overcome obstacles III. EVALUATION Evaluating goal achievement Judging accuracy and adequately of the results Evaluating appropriateness of procedures used Assessing handling of obstacles/errors Judging efficiency of the plan and its execution

Table 1: Key Operations of Metacognition.

Planning

1. What is the nature of the task?
2. What is my goal?
3. What kind of information and strategies do I need?
4. How much time and resources will I need?

Monitoring

1. Do I have a clear understanding of what I am doing?
2. Does the task make sense?
3. Am I reaching my goals?
4. Do I need to make changes?

Evaluation

1. Have I reached my goal?
2. What strategies worked?
3. What strategies didn't work?
4. Would I do things differently next time?

Figure 6: Regulatory Checklist (RC) (Schraw and Brooks 1999).

The use of a Regulatory Checklist (RC) provides an overarching heuristic that facilitates the regulation of cognition (Schraw and Brooks 1999) (Figure 6). It enables novice thinkers to implement a systematic regulatory sequence that helps them control their performance.

REACHING A CONCEPTUAL LEVEL

The goal is for students' creative thinking to become more rapid, smooth and self-regulated, thus contributing to ongoing knowledge construction. Because design education seeks to develop skilful creative thinking practices, such teaching involves more than developing technical expertise in a number of cognitive operations. It also involves helping students become independent thinkers, proficient at self-regulated thinking.

Beyond this level of proficient self-regulated thought is the development of a conceptual level. This conceptual level includes theories and mental models of one's cognition, as well as the task at hand. Mental models are necessary not only to monitor performance, but more importantly to monitor how well one is self-regulating. There are three basic levels at which one can achieve a mental model, the most basic being a tacit model, advancing to an informal model and eventually developing a formal model.

Tacit model – implicit understanding. This helps explain why some students can solve complex design problems but are unable to explain how they reached a solution.

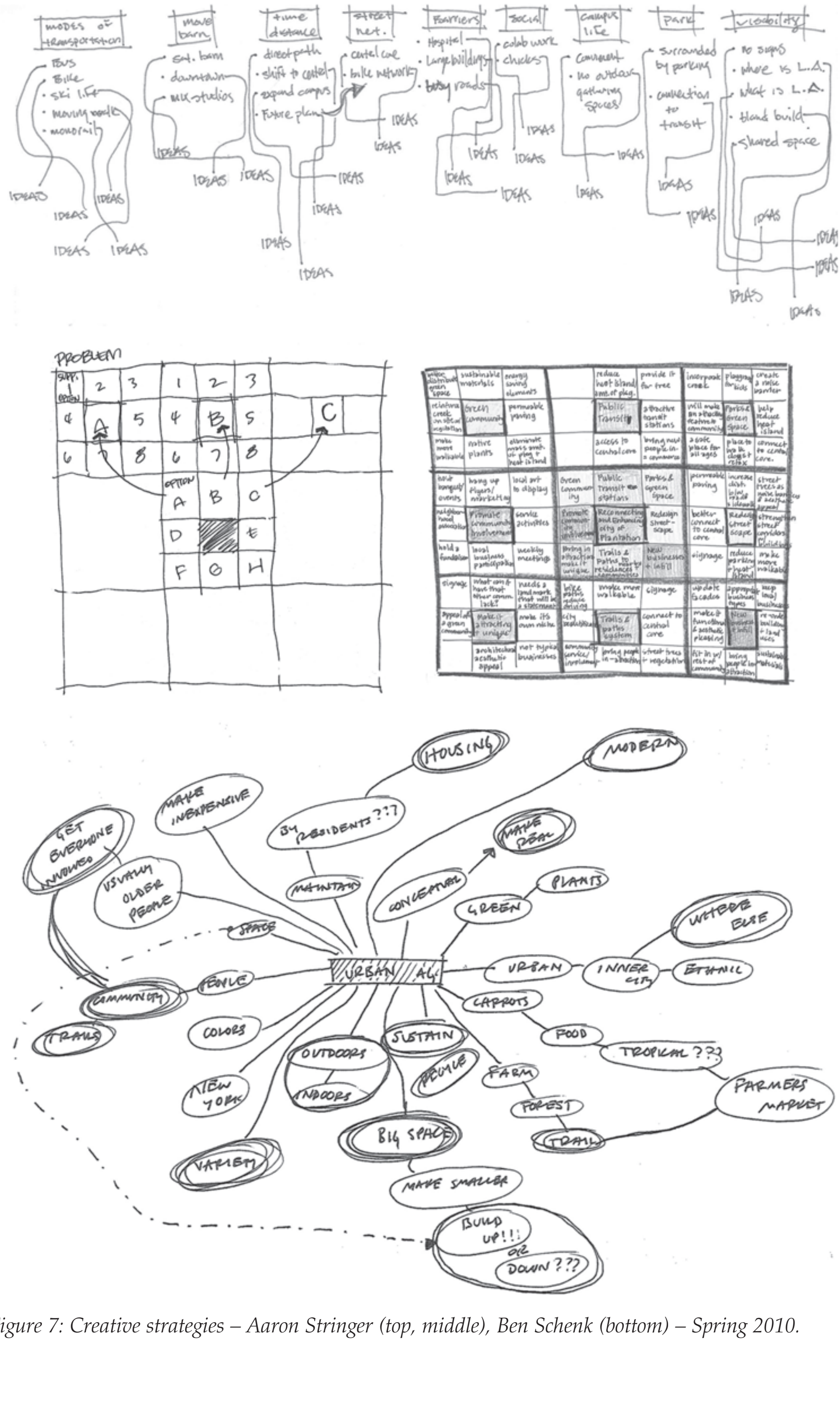

Figure 7: Creative strategies – Aaron Stringer (top, middle), Ben Schenk (bottom) – Spring 2010.

Informal model – partially accessible to conscious introspection, scrutiny and revision. This is more advanced than the tacit model and offers the benefit of introspection. This introspection allows for scrutiny and revision of one's model. Over time, this revision leads to a more advanced (formal) model.

Formal model – explicit, explanatory, representation of complex phenomena such as creative thinking. This is the ultimate goal of this self-regulated metacognitive approach to design.

EDUCATIONAL PRACTICES

Good instructional strategies alone do not guarantee successful real-life creative production. At best, they facilitate thinking processes, making it easier to access creativity. The best sources in the development of creative training are theories and models of creative thinking processes. Constructing a set of programme goals would then consist of sorting through the components of these processes and deciding on a manageable set for inclusion in the programme (Feldhusen and Eng Goh 1995). Using this approach, educators would not try to teach 'creativity', but rather isolate creative thinking strategies and introduce metacognitive thinking in support of these skills. The following are practices to help students reflect on or think about their own thinking.

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 modelling procedure provides a take-off point from which students can gradually construct and develop more personalized but equally effective procedures (Figure 7).

PAIRED PROBLEM SOLVING

Paired problem solving encourages students to reflect on their thinking and report to others (Figure 8). It serves as a type of 'accountability check',

Figure 8: Student reflecting-in-action.

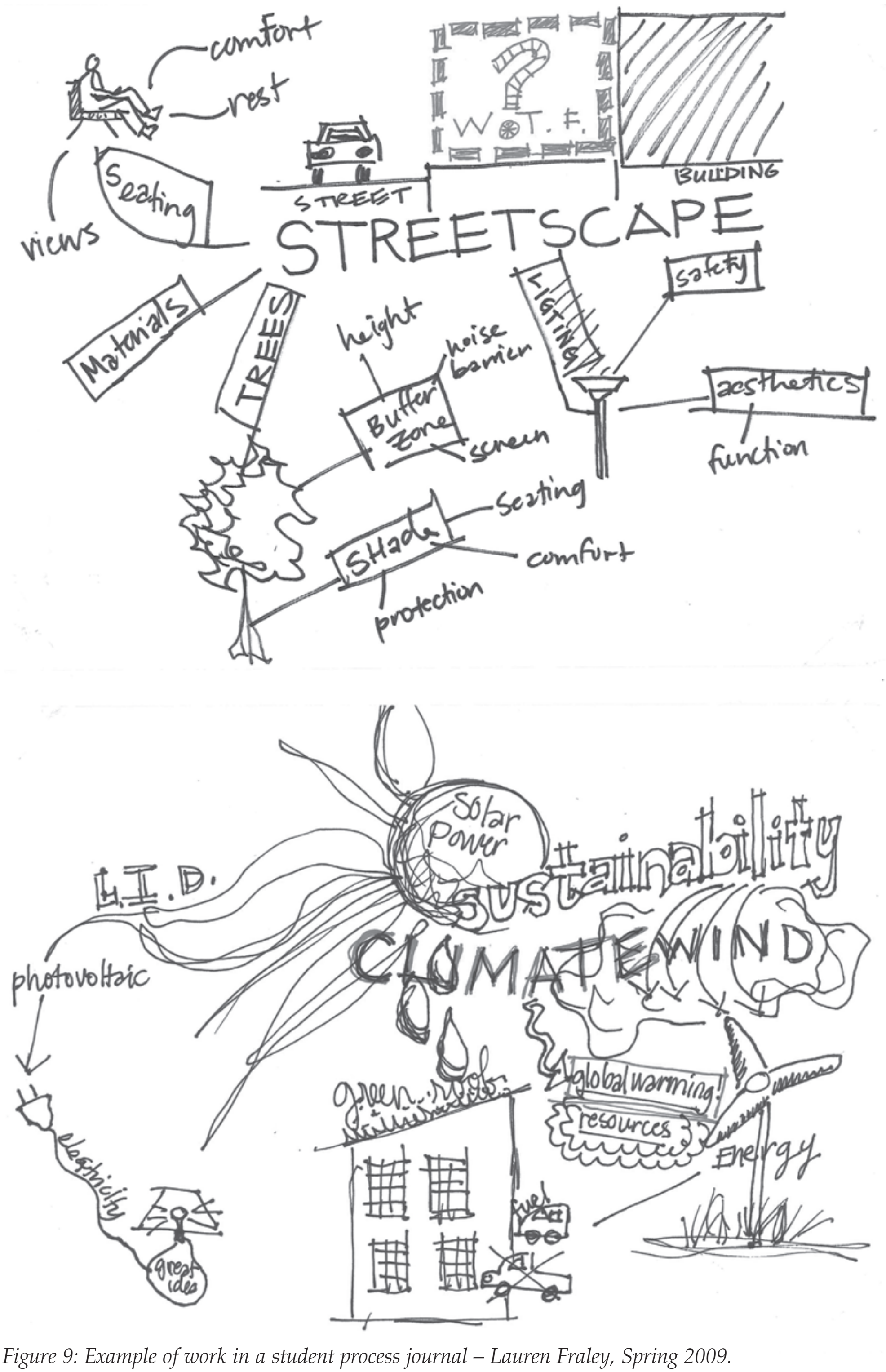

Figure 9: Example of work in a student process journal – Lauren Fraley, Spring 2009.

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.

JOURNAL KEEPING

Journal keeping is a form of independent reflection – reflection that leads to the restructuring of one's knowledge in a manner that promotes an increasingly theoretical understanding of one's metacognitive knowledge. Documentation is important in design. However, it is often the 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 their process, and 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 (Figure 9). This record also provides an opportunity to revisit initial perceptions, to compare the changes in those perceptions with additional experience, and to recall the successes and failures through experimentation with cognitive strategies.

CASE STUDIES – GREAT THINKERS

Another way to teach about metacognition is by giving students opportunities to analyse 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 others' creative thinking processes. As a part of this practice, students are challenged to find new examples of metacognitve thinking in others, and various examples of expert thinkers are examined, modelled and shared with classmates (Figure 10).

These cognitive case studies are of prime importance in enhancing the creative process. Akin (1986) states that conceptual abstractions, coming from references, create bridges between mental and physical activities, and are the basis for deeper exploration of theoretical concepts. The same holds true for cognitive case studies. Given a specific cognitive reference, a student may learn to identify relevant concepts and build a theoretical basis for his or her design process, which can then generate new design solutions. In the cognitive case studies approach, the acquisition and the construction of a body of cognitive and metacognitive strategies from precedents is considered a means to demonstrate and facilitate meaningful knowledge creation.

Rivka Oxman (2003) introduced a similar pedagogical framework for design learning and teaching termed Think-Maps. This framework proposes that by constructing a conceptual map that reflects one's thinking in a

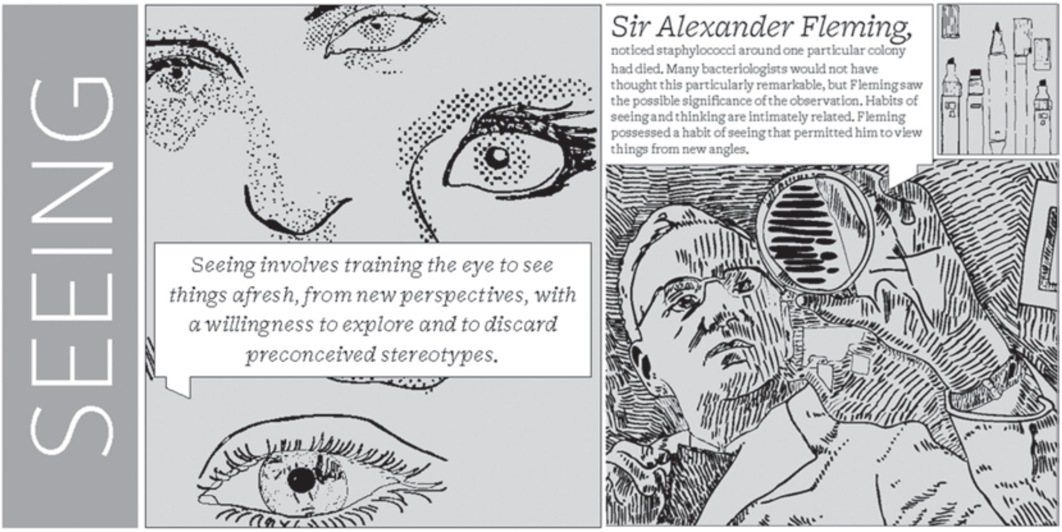

Figure 10: Cognitive case studies – Brooke Chornyak, NC State College of Design, Master of Graphic Design Programme.

domain, we make explicit the knowledge learned. In this approach, domain knowledge in relation to design thinking becomes explicit as the significant component to be taught and transferred in education. Oxman's framework is more advanced in that the constructions of conceptual structures are exploited through computational modelling.

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 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 artefact that best represents their creative thinking process (Figure 11). The artefact 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 perspective through shared insight and reflection.

A FRAMEWORK TOWARDS EFFECTIVE PEDAGOGICAL PRACTICES

This educational approach is based on implementing in the classroom a carefully sequenced curriculum of selected cognitive and metacognitive operations. Swartz (2001) first introduced this approach that supports the previously mentioned cycle of metacognition (Figure 2). What stands out is that these

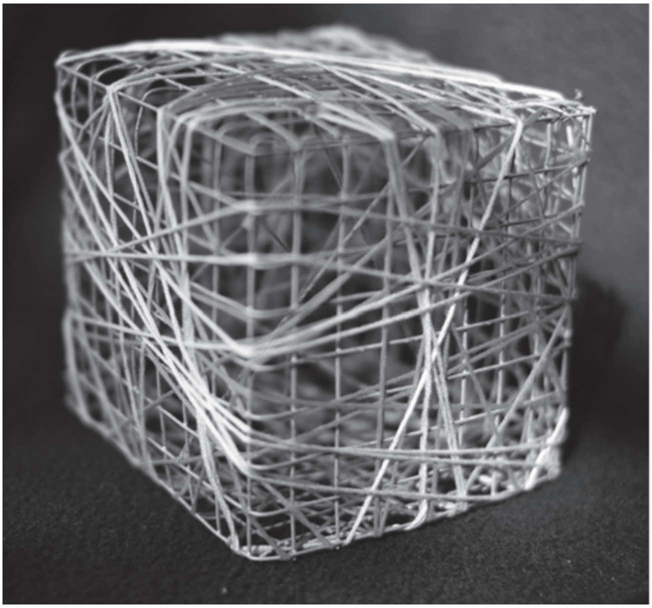

Figure 11: Design Thought Model – Julie Allen (left), Eun Young An (right) – Spring 2011.

practices include a set of basic components that are believed to make a great difference in the success of the instructional approach. Using this framework of pedagogical practices, each of these basic components is examined in relation to the content of design education.

-Help students develop and learn explicit cognitive strategies that inform and organize the way that they do specific types of creative thinking.

Knowledge of cognition – creative strategies are introduced and an effort is made to discuss the three different knowledge components (declarative, procedural, conditional) in relation to one another. This includes individual reflection that leads towards the development of each student's knowledge base. Students are expected to build and modify their SEM portfolios as the semester progresses.

-Build into their instruction significant opportunities for students to plan, monitor and evaluate their thinking.

Regulation of cognition – various design studio projects that students are participating in across the semester serve as an opportunity to practice the regulation of cognition. Students are asked to reflect on their (regulatory practices) planning, monitoring and evaluation of chosen creative strategies. This takes place through class or small group discussion, or journal entries in a project diary. A RC helps in the stimulation of these practices. In addition, short design tasks are assigned in class periods to utilize creative strategies and practice the regulation of these strategies.

-Prompt specific engagement by students in the types of skilful creative thinking being taught in the content that they are learning.

Active Construction of Knowledge – activities such as paired problem solving and case studies allow for the active construction of knowledge. In paired problem solving, students are expected to reflect on their thinking and report to others. This is often based on an in-class problem-solving activity or a reflection of a student's design studio project. Most important to this educational technique is that students are forced to have an awareness of their thinking processes, both the knowledge of cognitive strategies and the regulation of their use. In addition, this exercise builds accountability, as students are required to explain their process to a classmate or small group. This is advantageous for everyone involved. Students reporting are actively reflecting and building a greater understanding, and students listening are exposed to multiple different approaches that may or may not be similar to their own.

Case studies allow students to seek out and study other creative individuals who may or may not have a similar process to their own. This not only includes a group of creative strategies, but different approaches towards regulating these strategies. Exposure to successful creative individuals from various professions certainly helps build knowledge and perspective.

-Follow up specific lessons with opportunities for students to get more practice in guiding themselves to apply the same sort of creative thinking in new situations.

This practice can take place in the classroom with short design problems, but should also be extended into students' studio practice. It is important that the learned creative strategies and regulatory practices are continued and applied to their design projects. This should occur in conjunction with a project diary recording the use and success of these practices. A cycle of building metacognitive knowledge is established through the use of the creative strategies learned (SEM) and the regulation of these strategies (RC) in the context of a design problem. Reflection of this process, including in design process journals, proves extremely valuable for knowledge construction and future problem solving.

-Lessons are conducted in an open learning environment where advanced creative thinking is modelled and where students are given opportunities to reflect on their thinking.

As a part of this educational framework, students are exposed to a new approach to design thinking and problem solving. This is a self-regulated metacognitive approach. Each student is exposed to these practices in his or her design thinking. In addition, students learn the value of this approach and why it is essential to successful design. Reflection is a major component of introducing students to their own thoughts and fostering the realization that their current approach may be enhanced.

ASSESSMENT

In this educational approach, assessment is utilized as a tool to create the optimal educational experience for students. It serves to first make students aware of the level of metacognitive thinking that they are practicing, and then of what is needed to reach a higher level.

Assessment is important for both students and teachers. For students, assessment provides feedback and a guide towards improving thinking. Determining what level the students are achieving and how they might approach a higher level certainly includes making these levels of achievement explicit through a rubric. In addition, the teacher needs to have criteria in order to determine which students are reaching higher levels or advancing in their thinking, and which students are struggling. This allows for more focus on those students who struggle, and also serves as a way to identify those students who are excelling in an effort to provide peer support to other students.

Assessment is an important part of students reaching a conceptual level and building a mental model. Mental models monitor performance and help determine self-regulatory practices through self-assessment. Students should be aware of the different levels that exist and what is needed to advance to a higher level. This process starts by making a clearly defined criterion for assessment and providing students with a rubric as a guide towards identifying strengths and weaknesses. Advancement is based on monitoring current performance and understanding what aspects of thinking are desired.

Students are at different levels of thinking and therefore possess different levels of mental models. An initial step for any student is the awareness that these levels of assessment exist. Making one's mental model explicit and accessible to conscious introspection is a significant challenge for many students. However, it is this introspection that allows for scrutiny and revision of one's model over time, and ultimately this revision leads to a more advanced (formal) model.

From this point, students begin to assess their own performance through self-regulation, and eventually develop a plan for enhancement of their thinking. Over time, students develop an explicit, explanatory representation of creative thinking. This is the ultimate goal of this self-regulated metacognitive approach to design.

TWO BASIC QUESTIONS

Thinking like an assessor boils down to two basic questions. Where should one look to find characteristics of metacognitive thinking, and what should one look for in determining and distinguishing degrees of metacognitive thinking? The first question asks us to consider the necessary evidence in general – the kinds of performance and behaviour indicative of metacognitive thinking. The second question asks us to focus on the most salient and revealing levels or degrees of metacognitive thinking – using criteria and rubrics to sort thinking by quality along a continuum (Figure 12).

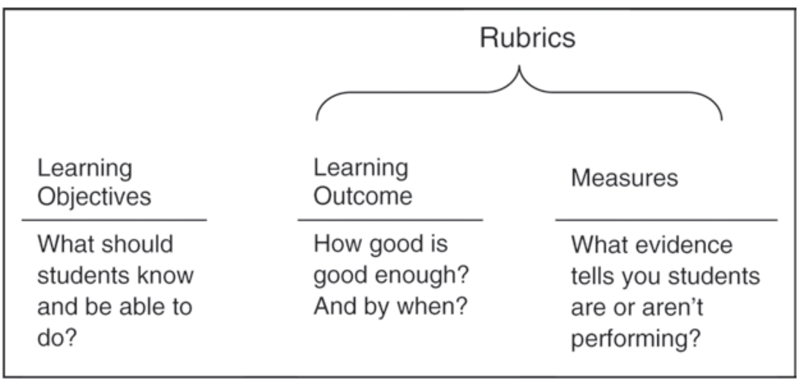

Figure 12: Rubrics: Learning outcomes and measures.

Thinking Like an Assessor	Thinking Like an Activity Designer
What would be sufficient and revealing evidence of understanding?	What would be interesting and engaging activities on this topic?
What performance tasks anchor the unit and focus the instructional work?	What resources and materials are available on this topic?
How will I be able to distinguish between those who really understand and those who don't (though they may seem to)?	What will students be doing in and out of class? What assignments will be given?
Against what criteria will I distinguish work?	How will I give students a grade?
What misunderstandings are likely? How will I check for those?	Did the activities work? Why or why not?

Table 2: Thinking like an assessor (Wiggins and McTighe 2005).

The first set of questions in Table 2 (Wiggins and McTighe 2005) ensures that the eventual activities and instructional strategies simultaneously derive from and point towards the appropriate final assessments. The second set of questions, though logical from the perspective of activity design, makes it far less likely that the instruction will culminate in metacognitve thinking, or that one will have the evidence one needs to judge whether such metacognitive thinking has occurred. In effect, when one only thinks like an activity designer, one ends up lacking a learning outcome and a measure to determine this outcome. Even though some students may develop important metacognitive skills through the various activities comprising this approach, this does not consider, at the design stage, how to build the activities around the need for evidence of metacognitive thinking.

CRITERIA AND INDICATORS

Having clarified the kinds of evidence needed to assess for metacognitve thinking, the focus shifts to the second phase of thinking like an assessor, asking against what criteria one will judge such evidence. What are the kinds of things to look for? These questions challenge educators to clarify the criteria for judging performance. One asks, given the right kinds of evidence, what the difference is between successful and unsuccessful metacognitive thinking.

Presumably, for example, a high-level metacognitive thinker displays 'sophisticated' and 'in-depth' explanation – two criteria seemingly central to the first facet, explanation (Table 3). And what distinguishes metacognitive thinking from the absence or lesser degrees of metacognitive thinking? A rubric makes

Facet 1 Explanation	Facet 2 Interpretation	Facet 3 Application	Facet 4 Perspective	Facet 5 Empathy	Facet 6 Self-Knowledge
Sophisticated In-depth Developed Intuitive Naïve	Profound Revealing Perceptive Interpreted Literal	Masterful Skilled Able Apprentice Novice	Insightful Thorough Considered Aware Uncritical	Mature Sensitive Aware Developing Egocentric	Wise Circumspect Thoughtful Unreflective Innocent

Table 3: Facets and levels of metacognitive thinking (Wiggins and McTighe 2005).

clear all of the relevant criteria, and helps differentiate levels of understanding. Table 3 (Wiggins and McTighe 2005) provides a partial list of applicable criteria.

NAÏVE VERSUS SOPHISTICATED METACOGNITIVE THINKING

> Sophistication: Of a person: free from naiveté, experienced, worldly-wise, subtle, discriminating, refined, cultured, aware of, versed in the complexities of a subject or pursuit. Of equipment, techniques, theories, etc.; employing advanced or refined methods or concepts; highly developed or complicated.
>
> (*Oxford English Dictionary*)

This definition of sophistication is good, but to develop a sound and comprehensive assessment of metacognitive thinking, one needs more than this picture of what metacognitive thinkers do. One needs some way to more precisely, validly and reliably distinguish between degrees of metacognitive thinking. Assessment is about judging relative strengths and weaknesses with increasing precision. Which actions, responses or performances are most characteristic of metacognitive thinking? Table 4 (Hargrove 2008) is a modified version of a rubric created by Wiggins and McTighe (2005), and provides a comprehensive list of applicable criteria along with a detailed explanation of each.

Explanation	Interpretation	Application	Perspective	Empathy	Self-Knowledge
Sophisticated: an unusually thorough, explanatory and inventive account (mental model); fully supported, verified and justified; deep and broad: goes well beyond a basic understanding and awareness of one's thought process.	*Profound*: a powerful and illuminating interpretation and analysis of the importance/meaning/significance of cognitive strategies; gives a rich and insightful account of cognition through reflection; provides a rich history or context from which to build future knowledge; sees deeply and incisively any ironies in different interpretations of thinking.	*Masterful*: fluent, flexible and efficient use of cognitive strategies and skills; also able to use knowledge and skill and adjust understandings to address novel, diverse and difficult problem-solving contexts.	*Insightful*: a penetrating and novel viewpoint of one's own thinking processes; effectively critiques and encompasses other plausible perspectives in a disciplined introspection of one's own thinking processes; infers the past or present assumptions in one's thinking upon which a cognitive strategy is based.	*Mature*: disposed and able to see and feel another's problem-solving situation, affect or thinking process; unusually open to and willing to seek out the odd, alien or different approaches to thinking.	*Wise*: deeply aware of the boundaries of one's own and others' thinking; able to recognize his or her own prejudices and approach to thinking, and how they colour perception and understanding; able to recognize strengths and weaknesses in one's thinking process and willing to act on what is revealed (self-regulate).

(Continued)

Explanation	Interpretation	Application	Perspective	Empathy	Self-Knowledge
In-depth: an atypical and revealing account, going beyond what is obvious, or what is explicitly taught; makes subtle connections; well supported by experience and evidence; novel thinking displayed.	*Revealing*: a nuanced interpretation and analysis of the importance/meaning/significance of cognitive strategies; gives an insightful account of cognition; provides a telling history or context of knowledge; sees subtle differences, levels and ironies in diverse interpretations of thinking.	*Skilled*: competent in using knowledge and skill and adapting understandings in a variety of appropriate and demanding problem-solving contexts	*Thorough*: a revealing and coordinated viewpoint of one's own thinking processes; makes own thinking processes more plausible by considering the plausibility of other approaches/perspectives; makes apt criticisms and qualifications of one's own cognitive strategy use.	*Sensitive*: disposed to see and feel another's problem-solving situation, or thinking process; open to unfamiliar and different approaches to thinking.	*Circumspect*: aware of one's ignorance; intellectually honest, and will work to overcome conceptual blocks; aware of one's prejudices, knows the strengths and limits of one's thinking process and the self-regulatory operations to improve.
Developed: an account that reflects some in-depth and personalized reflection; the student is making a thinking process that is his or her own; going beyond the given – there is supported theory here, but insufficient or unsupported evidence and experience.	*Perceptive*: a helpful interpretation or analysis of the importance/meaning/significance of cognitive strategies; gives a clear and instructive account of cognition; provides a useful history or context of knowledge; sees different levels of interpretation of thinking.	*Able*: able to perform well with knowledge and skill in a few key contexts, with a limited set of cognitive strategies; flexibility or adaptability to address diverse contexts is minimal.	*Considered*: a reasonably critical and comprehensive look at others' thinking processes in the context of one's own; makes clear that there is plausibility to other approaches to cognition and problem solving.	*Aware*: knows and feels that others see and approach thinking differently; somewhat able to empathize with others' explanations of thinking processes; has difficulty making sense of odd or alien approaches to thinking.	*Thoughtful*: generally aware of what is and what is not a part of one's thinking capacity; aware of how prejudices and projection can occur without awareness and self-regulation of one's thinking processes.

(Continued)

Intuitive: an incomplete account but with apt and insightful reflection; extends and depends on some of what was learned through experience; some 'reading between the lines'; account has limited support/experience data and sweeping generalizations. There is theory but with limited testing and evidence.	*Interpreted*: a plausible interpretation or analysis of the importance/meaning/significance of cognitive strategies; makes sense of an account of cognition; provides a history and context of knowledge.	*Apprentice*: relies on limited repertoire of cognitive strategies and skills; able to perform well in familiar or simple problem-solving contexts, with perhaps some need for coaching; limited use of personal judgment and responsiveness to specifics of feedback or a problem-solving situation.	*Aware*: knows the different approaches to thinking and somewhat able to place own cognitive processes in perspective, but weakness in considering worth of each differing approach or critiquing each approach, especially one's own; uncritical about tacit assumptions.	*Developing*: has some capacity and self-discipline to see thinking through another's eyes, but is still primarily limited to one's own reactions and attitudes; puzzled or put off by different feelings or attitudes towards thinking processes.	*Unreflective*: generally unaware of one's specific lack of self-reflection; generally unaware of how one's own knowledge of cognition determines one's thinking process/cognitive strategy use.
Naïve: a superficial account, more implicit than analytical or explanatory; a fragmentary or sketchy account of experience using cognitive strategies; less a theory than an unexamined hunch or borrowed ideas.	*Literal*: a simplistic or superficial reading of cognitive strategies; borrowed translation; a decoding with little or no interpretation; no sense of wider importance or significance; a restatement of what is habitual or stereotyped.	*Novice*: can perform only with coaching or relies on highly scripted, singular 'plug-in' (stereotypical) cognitive strategies, procedures or approaches.	*Uncritical*: unaware of differing approaches to thinking; prone to overlook other approaches; has difficultly imagining other ways of seeing things; prone to egocentric argument and either/or thinking.	*Egocentric*: has little or no empathy beyond intellectual awareness of others; sees cognitive tasks in the context of one's own thoughts and beliefs; ignores or is threatened or puzzled by opposing outlooks or approaches to thinking.	*Innocent*: completely unaware of the bounds of one's thinking and of the role of reflection and self-regulation in the development of knowledge of cognition.

Table 4: Rubric for metacognitive thinking (Hargrove 2008).

STEPS TOWARDS SUCCESSFUL IMPLEMENTATION

This educational approach begins with an introduction of purpose, content and goals. The metacognitive framework and cycle of metacognition serve as guidelines for student advancement throughout the semester. However, before the focus of the instruction is placed on the creation of metacognitive knowledge, it is critical to clearly identify the meaning of metacognition and how it applies to design, making students aware of their value and building relevance on a personal level.

First, a goal is to obtain a sense of where students currently stand in terms of cognitive (creative) strategies. This determines what strategies students currently use explicitly in design thinking. After establishing a baseline for the class, instruction begins by introducing a single creative strategy and discussing it in detail. This includes all three types of knowledge of cognition (procedural, declarative and conditional). The addition of creative strategies continues in the subsequent weeks of class by learning a new strategy each week. This is incorporated into a SEM portfolio and aided by the use of the RC. Students start in a cycle of building knowledge of cognition that contributes to an advanced level of regulation of cognition, and continue this cycle throughout the semester, building metacognitive knowledge.

Second, in addition to learning a new creative strategy each week, students learn about metacognitive thinking and the relationship between cognition and metacognition. When new strategies are introduced, it is critical to discuss all three knowledge components (conditional, procedural, declarative) as they apply to metacognitive thinking. Metacognition is broken down into knowledge of cognition and regulation of cognition. Tools such as the SEM and the RC serve to aid in this process. Teaching techniques such as direct instruction serve to provide basic knowledge of metacognitive thinking. Paired problem solving, case studies and journals (project diary) serve as experience, practice and reflection on both knowledge and regulation of cognition. Finally, in-class design problem-solving exercises provide students with multiple opportunities to practice and reflect on their strategy use, as well as regulate the use of these strategies.

Third, reflection with students on their mental models takes place in the last portion of the semester. Utilizing the assessment rubric, students become aware of their current abilities in relation to multiple facets of metacognitive thinking. Mental models are necessary not only to monitor performance, but more importantly to monitor how well students are self-regulating. It is critical to help students form these models by making them aware of their function and value in design thinking. In addition, it is important to formulate a plan to help students move from implicit to informal to formal models, or at least make them aware that these different stages exist and why one should strive towards a formal model. The goal is that each student is able to monitor his or her own performance of cognitive and metacognitive processes in relation to clearly understood assessment standards.

When presented with situations that cannot be solved by learned responses (ill-defined problems), metacognitive behaviour is brought into play. Metacognitive skills are needed when habitual responses are not successful (e.g. basic retrieval of information). Guidance in recognizing, and practice in applying, metacognitive thinking will help students successfully solve problems with novel and innovative solutions. In this rapidly changing world, the challenge of design educators is to help students develop skills that will not become obsolete. Creative thinking (metacognition) is essential for the twenty-first century as it will enable designers to successfully cope with new situations.

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CONTRIBUTOR DETAILS

Ryan Hargrove received his doctoral degree in Design from North Carolina State University in 2007. At NC State University he conducted research in design education, examining how to enhance the creative thinking of design students. Ryan is currently continuing several research projects on creative thinking, and his most recent findings have led to the creation of a course that is currently being implemented as a general education requirement at the University of Kentucky. Ryan currently teaches fourth-year design students, as well as the creative thinking course entitled Living on the Right Side of the Brain. His future research involves the development of innovative teaching methods. This area of research encompasses design pedagogy, creative thinking, metacognition and technology.

Contact: University of Kentucky, College of Agriculture, S305 Agriculture Science Building, Lexington, KY 40546-0091, USA.
E-mail: ryan.hargrove@uky.edu