



# Embedding Metacognitive Skills in Spatial Design Education

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## **Abstract**

Metacognitive skills are considered to be essential for graduates from higher education institutions. In teaching spatial design, a fundamental aspect of student learning is the ability to 'frame' problems, generate solutions and explore possibilities of different solutions. This article proposes an innovative approach to design education through the implementation of strategies into the design process. The externalisation of implicit and tacit learning through metacognition connects theoretical concepts to interior design process and practice, as well as allowing students to engage and critically analyse issues surrounding theory and practice, thus equipping them with the skills as future design professionals.

**Keywords: higher education, design, metacognition, thinking, reflection, critical thinking, design thinking, design process**



## **Introduction and Background**

Despite the fact that metacognitive skills are critical in formulating our understanding of who we are and what we do in everyday life, these skills are considered to develop as a gradual and uncertain process that is dependent upon the quality of education and training individuals receive and cannot be assumed to be a cultural given in commonplace and everyday activity. It could be presumed that the development of critical, reflective and collaborative metacognitive thinking skills is an expected result of experiences, responses, simple representations and intuitive logic toward increasingly logical and adaptive representations of reality. However, this view is fundamentally erroneous, culturally bounded, and idealistic; the complexity of metacognitive skill development and the educational challenges associated with cultivating these skills is always complex and hard-earned. Having a good understanding of the development of such skills and what influences them is essential for further cultural evolution, and ultimately, the survival, adaptation and flourishing as developed and complex human beings.

New information is increasing at an exponential rate every year (Jukes and McCain, 2002), so higher-order, metacognitive skills are essential in order to assist individuals in becoming more adaptable and better able to cope in the context of a rapidly evolving information society. The importance of teaching undergraduate students to consciously process thinking patterns and actively approach problem solving and experimentation with a mindful, reflective, collaborative sensibility facilitating adaptive action, is discussed in this paper.

In higher education, besides domain-specific knowledge, it is crucial for students to develop reflective and critical thinking, as these skills are considered important for an educated individual to "be able to make well-informed judgements, be able to explain their reasoning and be able to solve unknown problems" (Thomas, 2011, p.26). Graduates able to make well-informed judgements have an increased capacity to interpret the connections between what they learn at university, and what they will practice in their chosen field. It is fundamental that in a rapidly changing world, future graduates will be equipped to deal with the unknown and solve problems that may not exist currently.

Paul (1993) describes critical thinking as cognition or the intellectual work of the mind that involves reasoning and self-discipline using particular skills, whilst reflective thinking is considered to be metacognition or a level of consciousness that exists through executive cognitive control and self-communication about experiences (Flavell, 1979, Mezirow, 1981). Both these types of thinking are regularly used conceptually in a variety of ways to understand and explain the dynamics of problem-solving and reasoning in a variety of practices. Analytical thinking is another way of examining a situation or context, pursuing "an analytical investigation of a problem setting by decomposing all its components or its determining factors" (Plattner, Meinel and Leifer, 2012, p.231). Thinking critically, reflectively and analytically are essential components that characterise professional growth and development (Brasford, 2002). This ability to evaluate, compare, contrast, critique, explain why, and examine are considered core graduate capabilities.



To be successful in the highly technological and globally competitive world today, an individual is required to develop and use a different set of skills than were needed in the past (Shute and Becker, 2010). Along with critical and analytical thinking, design thinking is another skill that has increasingly gained attention over the past decade. It is a problem solving method which supports the consideration of socially ambiguous aspects of a design problem and is in contrast to orthodox engineering design paradigms. The core element of design thinking is the need to empathise with others, their situations and experiences, and is vital to designers, who need to be sensitive to ‘the user’ (those who use the products or interact and use spaces and places). Empathy supports the design process as design considerations move ‘from rational and practical issues to personal experiences and private contexts’ (Mattelmäki and Battarbee, 2002). Through ‘empathic design’ (Koskinen et al. 2003), designers attempt to get closer to the lives and experiences of (putative, potential or future) users, in order to increase the likelihood that the product or service designed meets the user’s needs.

### **Design process**

As a general definition, the design process can be described as a series of events, stages and phases in design. It has been summarised as three interrelated phases that are iterative: analysis, synthesis and evaluation (Jones, 1963). While some designers and theorists articulate distinct phases in their process where creativity is necessary (Jones, 1963; Archer, 1980), other designers see the process as a way to guide creativity (Brawne, 2004; Cross, 2004b; Sasaki, 1950). Rather than presume when and where creativity is a part of design expertise, the authors of this paper recognise that each individual designer applies creativity in their own manner, and that creativity is required in all phases of the design process. Regardless of the varying schools of thought in design process, it is important to note that the design process is not a guaranteed “recipe” (Harfield, 1999), which will always produce creative results but a creative process which results in a novel and appropriate design solution.

### **Thinking and design process**

This paper focuses on thinking methods which utilise the internal mental processes that result in creativity and discusses research that reflects this. Ward and Kolomyts (2010) combined these processes under the term ‘creative cognition’, which “is concerned with explicating how common cognitive processes, available to virtually all humans, operate in stored knowledge to yield ideas that are novel and appropriate for the task at hand” (Ward and Kolomyts, 2010, p.93). Among these processes suggested in creative cognition are divergent thinking, convergent thinking, and knowledge. Divergent thinking can be best defined as the ability to produce a variety of solutions to a given situation; the generative process of creativity where the mind is able to conceive several ideas that spawn from a single source. This ability is linked to any generative phase of the design process where the designer proposes a possible design solution. Divergent thinking is central to numerous current psychological and creativity studies. For further detailed explanation, refer to (McAuliffe, 2013).



Convergent thinking is defined as the union of associative elements into new combinations, which either meet specified requirements or are in some way useful (Mednick, 1962). Convergent thinking is needed to sift through and evaluate any confusion created by divergent thinking and is important in the synthesis phase of the design processes of Jones (1963) and Sasaki (1950), but fits into the creative phase of Archer (1980). Although an important component of creativity, too much and too little pre-existing knowledge may be detrimental to effective novelty. If the individual lacks sufficient knowledge in a given realm, they will not be able to demonstrate creativity, as is typically the situation in novice designers. Conversely, if a person is too familiar with the precedents of any given realm, they could become entrenched and rely upon old solutions rather than generating new ones (Mumford and Gustafson, 1988; Martinson, 1995).

### **Metacognition and learning process**

In the context of design, Lawson (2006) describes metacognition as the process which guides our internal processes, or “productive thinking”(Lawson, 2006, p. 140). If creativity is a set of internal cognitive processes, it stands to reason that through increased awareness we can implement thinking processes more often, which in theory should be able to boost our own creativity (Hargroves, 2012). Metacognitive skills aid in consciousness of an individual's own mental processes; thinking about how we think enables a more efficient process of creativity (Hargroves, 2012).

Metacognitive knowledge is inclusive of learning process; learning strategies, and knowing when and how to use those strategies. An example of this might be a design student considering what might be the most appropriate tool to use when demonstrating their concepts to their tutors and fellow students; is digital design the best medium, or is pen and sketchbook better? Metacognitive strategy is centred on the learners' ability to monitor their own learning, set goals, plan, and evaluate the outcomes of these strategies, while providing insights on one's learning process. This in turn, helps facilitate the ability for the learner to regulate cognition and enables a more positive learning experience potentially increasing motivation (Lai, 2011).

Grasping the design process can be challenging for students, as it relies on more than a single skill. Learners require and benefit from learning a variety of skills, not least of which are metacognitive skills to optimise learning (Azevedo and Cromley, 2004; Winne and Hadwin, 1998). It is important to embed these metacognitive skills as part of the learning process within learning how to design instead of asking students to learn these in isolation, for example in a subject specifically dealing with learning about thinking. In current interior design education, learning these skills is considered tacit, rather than made explicit, particularly in design studio or visualisation units. Assuming that students will tacitly learn these skills, or adding them into other units is known as the “bolt-on” approach (Bennett, Dunne, and Carre, 2000). The “built-in” approach (as we suggest in this paper) proposed by Wingate (2006) is where learning is developed through the subject taught. One of the many limitations of the “bolt-on” approach is that often students do not make the connection between these skills and how to apply them to their subject (Durkin and Main, 2002). According to Kolb (1984) effective learning takes place



when learners experience a problem, reflect on their action, form concepts on the basis of their reflection and apply these concepts in new situations. Therefore the “bolt-on” or assumption of tacit learning approach permits little opportunity for students to experiment and experience learning in a relevant or ongoing, iterative process.

Currently, there is a lack of framework for explicitly embedding these metacognitive skills into spatial and interior design education and linking them with learning the design process. Thus the impetus for this paper.

### **Applying a Thinking Methodology**

All four authors of this paper are qualified architects and designers who have considerable experience in teaching interior design at graduate and undergraduate level, as well as in design practice. Over the past decade, the authors began to see a pattern of noticeable ‘gaps’ in students understanding of their skills and abilities, particularly in terms of metacognitive and cognitive engagement in many aspects of their design outcomes.

One example of this ‘gap’ was that consistently students were producing designs and drawings, yet not able to conceptualise what they were drawing, or why they were drawing it, replicating images without actually engaging with the design process, despite in-depth detailed explanation provided by the teaching staff. Rather than critically thinking about what and why they were drawing the image, or disseminating metacognitive knowledge around the topic, they were producing the material in a ‘rote’-like manner. Put simply, they could not conceptualise two and three-dimensional drawings as potential real life spaces, nor could they reflect on errors in their designs and drawings. As such, student’s ‘knowledge’ around design process and design visualisation was presented superficially, at best.

Alternative ways to foster critical thinking, metacognition and a deeper engagement with information and their own drawings was essential if students were to understand relevant, contextual and complex issues in design and visualisation as future practitioners. It was through this experience that it was deemed necessary to seek alternatives to the current learning and teaching methods. After much reflection, discussion and deliberation, cultivating metacognitive skills in students was ultimately considered to be an appropriate response. Through a significant research process and ‘trial and error’ of various methods, the development of four separate, consecutive ways of thinking introduced to the class. The foundational roots of this were based on the philosophy which drove the development of the O-tutorial (see McAuliffe and Martin, 2014; McAuliffe and Winter, 2014), which a “process of handling material for oneself and of bringing together one’s own analysis, reflection, judgment in a form which is really a creation of individual thought” (Reeves, 1966, pp. 65-66).

In teaching metacognitive skills to first year undergraduate students, careful planning and explanation was necessary in order for the students to perceive the relevance and connection to design, design process and visualisation. The setting of this study is Interior Visualisation II,

delivered in the second semester of a four year design degree. Students had completed a pre-requisite unit Interior Visualisation I, which focuses on the development of hand drawing skills in the context of design and visualisation. Interior Visualisation II is focused on honing hand drawing knowledge and skills, and meshing these with digital design knowledge and skills (such as graphic and computer aided design packages).

So students understood why thinking skills are fundamental to learning design, the following was explained:

No skills learnt in design stand alone, and understanding the various mental, physical and digital skills in design require integration and intuitive thinking, whilst at the same time, engaging in the process of production and representation of drawings is essential. This is the process designers employ to structure their thinking and communicate ideas with clients, target audiences, other designers and specialists through visualisation. Through analysis of existing real world design projects, designers gain insight into how the selection of methods, media, materials and the application of design elements and design principles can create effective design for specific audiences and purposes. As such, a deep sense of awareness and consciousness in and about design and designing is required in order to become a designer who can analyse contexts, critique new and existing information, reflect on their own ethos and what motivates self as a designer, and last, but most critically, be able and will to empathise with the end user of the design.

Using six chosen images that the student produced from the final assignment for Interior Visualisation I, students were asked to apply analytical, critical, reflective, and design thinking skills to analyse, evaluate, reflect on, and critique information and ideas that they portrayed in each image. They were not to re-draw the images, but rather discuss key aspects of the four types of thinking to the image.

This is a four step process, where analytical thinking is designed to be as objective as possible, then critical and reflective thinking (completed consecutively) should progress to broader and deeper levels toward design thinking, where the students should be as immersed as possible in the 'design problem' (Figure 1).

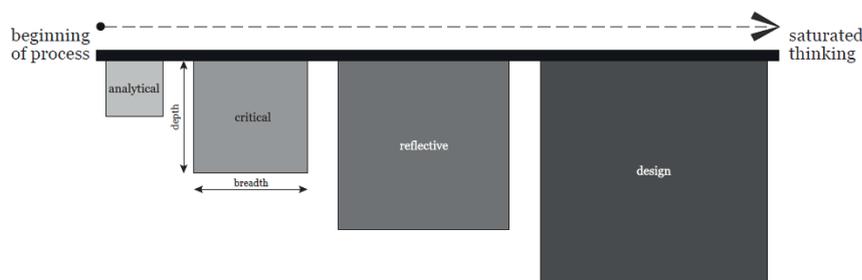


Figure 1. Progression of thinking types

## Thinking process

The process of asking students to apply analytical thinking was designed to form a line of enquiry that enabled the students to be open minded whilst being aware of personal bias prejudice in themselves and others, be open to new ideas, consider all possibilities/viewpoints, and willing to reassess their own views. They were asked to reflect and reason by thinking logically, developing a reasoned line of argument, using valid and reliable evidence, being objective, and avoiding emotion. The fundamental aspect of this line of thinking was to demonstrate a critique of the drawings honestly and without bias. This first step was a process of simply critiquing 'from afar', and not to become 'personal' about the drawings.

For critical thinking, students were asked to explore existing knowledge (in this case, design drawing, representation and communication) for issues which are not clearly defined and for which there are no clear-cut answers. In using reflective, reasonable, and rational thinking to gather, interpret and evaluate information in order to derive a judgment, students were to assess their own biases and assumptions about the drawing and the designs they were critiquing.

Reflective thinking required students to question their own design process and practice, and assess their current knowledge, what they need to know as future design practitioners, and how they bridge that gap. It aimed to provide students with the opportunity to step back and think about how they actually solve problems and how a particular set of problem solving strategies is appropriated for achieving their goal. This thinking required students to examine their own thought processes, practices, values, attitudes and ethos. This was a far more 'personal' reflection on the 'what' and 'why' of their own outcomes.

Design thinking required reflection and evaluation of the drawings and designs in the context of empathy, which balances analytical and intuitive thinking, combining an openness to explorative thoughts with an exploitative mentality, striking the balance between innovation and a systematic scalable process. In this thinking the students were asked to write several paragraphs thinking of design, thinking about design, and thinking through design, all key components of design thinking, as shown in Figure 2.

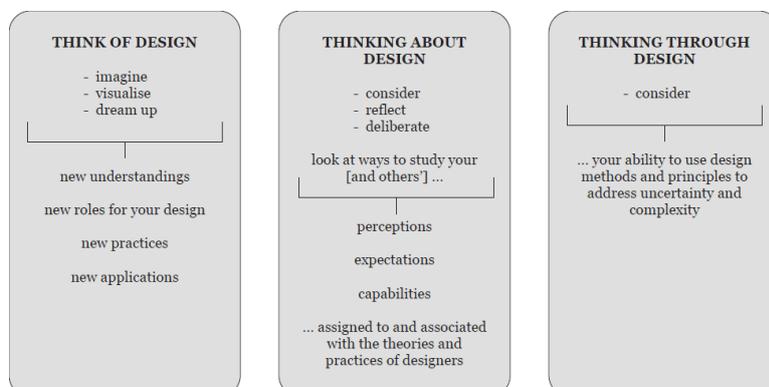


Figure 2. Formative foundational steps in design thinking.



### **Self as constructive critic**

Asking students to think about thinking allows them to act as their own constructive critic and assists them to sift through their design and drawings - not unlike an explorative and iterative design process. It aims to challenge bias in how students see the world around them and the complexities in it, how they evaluate evidence, and how they connect facts with each other. This thinking methodology also allows the growth of 'critical self' leading to implicit skills, such as intuitive knowledge and increased consciousness of the students' own skills and knowledge, cultivating higher order thought by engaging as a form of 'cognitive modelling' or 'making thinking audible' (Shulman, 1986 pp.4-14), although in this case, articulating it through text. This 'thinking out loud', or externalisation enables the design student to develop their capabilities of "reflection leading to self knowledge, the meta-cognitive awareness that distinguishes draftsman from Architect, bookkeeper from Auditor. A professional is capable not only of practicing and understanding his or her craft, but of communicating the reasons for professional decisions and actions to others" (Shulman, 1986, p.14).

This methodology of externalising metacognitive strategies through self as constructive critic is embedded in the designer's process of conceptualising an idea. The design world is increasingly demanding more 'fresh thinking', and presenting students with the key skill of being able to 'think about thinking' enables them to pursue design goals when "the path to that goal is uncertain. The role of metacognition requires the student designer to develop the skills of a design practitioner, who typically evaluates a proposal through thinking before advancing further to realisation. This approach sees it necessary to equip students with the knowledge to make a practical evaluation of their own skills and cognitive processes, enabling them to not only to solve the issue at present, but also to apply intuition and metacognition through their lives and develop this as a form of self-determining behaviour as a design professional.

### **Discussion and Conclusion**

Design education is a complex and detailed process, and many skills and theories are required in order to become a successful design practitioner. Design education typically teaches the physical skills (such as drawing) as a critical and fundamental component of the design process, but the implicit intuitive and tacit metacognitive skills are developed over time and with experience as fundamental components of the design process; they are not taught per se. Where physical skills are relatively easy to teach, other implicit and tacit learning is far more difficult to define, articulate and teach, but is critical to the design process (McAuliffe, 2013). Implicit learning takes place independent of both the process and products of learning and occurs without the intention to learn and largely without awareness of the nature of what has been learned, such as intuitive 'knowing' or hypersensitivity to something or someone. These are learned over time, but problematic to teach. Tacit skills, such as metacognition, consists of deep thoughts, intuition, feelings, fine motor skills and competencies that are either taken for granted or have not been discovered. In fact, in design education, these implicit and tacit factors are considered contentious and ill-defined, falling into the "I know it when I see it" category (Ronn, 2011).

The authors propose that introducing these skills and strategies in this innovative approach is necessary for interior design education; explicitly including metacognitive strategies in design education in a “built-in” approach benefits students, both now as well as in future design practice leads to a more considered design solution. Raising awareness of consciousness in tacit and implicit skills in the design process has the potential to add richness and complexity to the designed outcome.

(Figure 3).

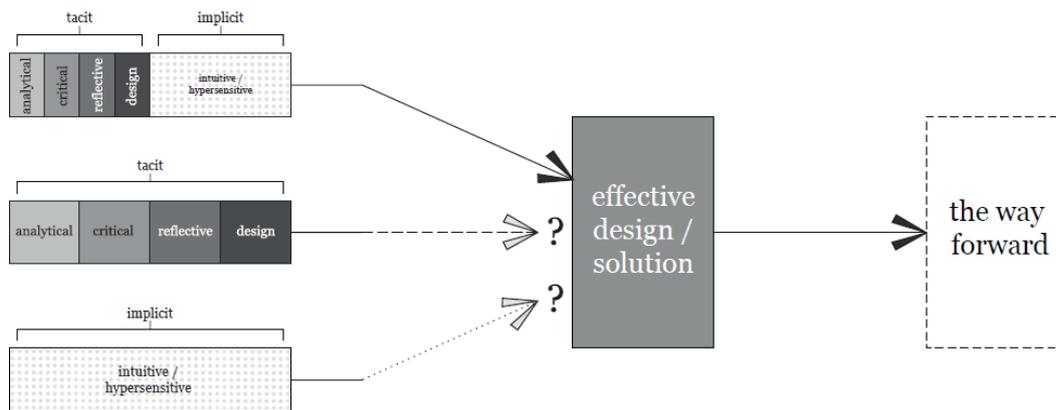


Figure 3. Consciousness in the design process - embedded combined tacit and implicit thinking. Teaching students ‘how to think’ also enables them to think critically about the practice of interior design, where problem solving is exercised frequently, which is relevant in today’s society where following established rules and procedures are simply not enough to succeed. Future studies will further explore the application of this methodology in other design contexts and disciplines.

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