Look at this: imagery training for technology students

Roy Barnes, Griffith University, England

Abstract
This paper outlines a training program based on the regular practised generation and manipulation of neural images that has been used to improve the visual mental imagery (VMI) of design students. Most people can produce mental images, although there is variability in terms of the vividness, detail and control that can be achieved. Research indicates that VMI is an important feature of activities such as inventing and solving complex problems. Perceived images such as sketches or diagrams facilitate creative problem solving and therefore VMI should facilitate problem-solving within design activities. Further research has found that professional designers have varying degrees of imagery generation and manipulation that correlates with their level of expertise. Studies have found that it is possible to improve people's ability to create mental images and others have improved the control of neural images. This research has developed strategies to concurrently improve design students' vividness and control of their VMI. The application of the program within the Design and Technology learning environment and the influence on students' design ability is discussed.

Keywords: *visual mental imagery, training, problem solving, design ability*

Background

Imagery theory defines a visual mental image as a mental representation of information about a concrete object, stored and manipulated in short term, or working memory (Finke, 1989, Kosslyn, 1997). There is variability across people in terms of preferred modes for representing information in working memory. That is, some people have a preference for representing information in memory in abstract language-like codes, while others will represent most information about concrete objects and events as visual mental images (Richardson, 1994). A number of research studies including Richardson, (1994) have demonstrated that most people can create and manipulate visual images in the mind although there is variability in terms of the vividness, detail and control that can be achieved. Some people, who can produce and control vivid mental images, habitually do not generate them or use them for tasks where they would appear to be useful. According to cognitive theory (Anderson, 1993; Glaser, 1989), the capacity to solve new problems, such as design challenges, involves the application of conceptual knowledge and problem-solving procedures in order to conceptualise and represent the problem, apply specific procedures to sub-problems, and to monitor progress and bring the problem to solution. These procedures are called second order procedures to differentiate them from specific (first order) procedures developed through practice over time to solve familiar problems (Stevenson, 1991).

The thinking involved in designing, involves the use of second-order procedures, and appears to be most productive when knowledge is represented in working memory, in particular ways. Creative thinking seems to be facilitated when thinkers represent problems in working memory as visual mental images (Ward, Smith, & Vaid, 1997; Finke, & Slayton, 1988). The use of visual mental representations of knowledge has been shown to be an important component of creative thinking in the sciences, arts and invention (Weber, Moder & Solie, 1990) and solving complex problems (Kaufmann, 1990). In addition visual mental images have properties equivalent to perceived images. Perceived visual images such as sketches or diagrams facilitate problem solving and therefore visual mental images should facilitate problem solving (Finke, 1989).

The application of the use of visual mental imagery towards improving design ability was originally discussed by Galton, (1883) who argued that "visual imagery would be particularly beneficial for planning and problem-solving in every handicraft and profession where design is required and in all technical and artistic occupations" (cited in J. Richardson, 1999:21). It is known that imagery practice can contribute to improved performance in a range of activities such as motor skills in sport (Abernathy & Wood, 1992; Denis, 1985). The use of visual mental images has been found to improve the problem-solving performance of primary school children when presented with complex problems where

psychological blocks would normally occur (Antonietti, 1991). Middleton, (1998) examined the visual imagery used by practising architects and high school technology education students when engaging in an architectural design task. That study found that practising architects employed imagery to represent the problem as defined, to generate images of solution proposals and to transform aspects of proposed solutions. High school students employed imagery in a more limited way to represent problems and generate solutions. The architects had varying degrees of control of image generation and manipulation that correlated with levels of expertise.

Improving visual mental imagery ability

Walsh, (1976) developed a successful imagery training procedure which focused on vividness of all seven sensory modalities. This unpublished study was used as the basis of work by Richardson & Patterson, (1986) who initiated an evaluation of the effectiveness of three training procedures for increasing imagery vividness. One procedure focused on the training of participants in the single modality of visual imagery. Their intervention was based on a series of activities involving the practised visualizing of objects in the mind with and without perceptual reference. The results of this intervention indicated that regularly practising the generation of neural images increased a participant's visual imagery vividness.

> ...the overall evidence is consistent with the view that imagery is a common human capacity which requires little more than sustained attention to be paid to it for its potential to be actualised as a functioning ability. Imagery training is not designed to teach a new skill but to release a latent ability (Richardson & Patterson, 1986:183).

To date the work of Richardson and Patterson, (1986) has not been replicated to the knowledge of the writer despite extensive searches of current electronic databases.

The control of visual imagery is associated with the area of visual-spatial ability. Lord, (1985:396) defines visual-spatial ability as "the ability to form and control a mental image". Visual-spatial ability is commonly sub-categorized into spatial orientation and spatial visualization. Spatial visualization is the ability to imagine a transformation of the neural image. This may include viewing the image from a different viewpoint or manipulating the physical attributes of the image. Spatial visualization and therefore by association, control of visual mental images, was successfully improved in Lord's, (1985) seminal study which used the practised interaction with a planes through solids intervention. This intervention has since been used as the basis for various similar studies that have all demonstrated an improvement in spatial visualization through practice (Alias, Black and Gray, 2002; Sorby and Baartmans, 1996).

Pre and post testing using self-reporting questionnaires can be used to measure improvements in imagery ability. Vividness can be measured using the Vividness of Visual Image Questionnaire (VVIQ) (Richardson, 1994) and the degree to which people are able to manipulate images is measured using the Controllability of Visual Imagery Questionnaire (CVIQ) (Ashton & White, 1974). Both of these tests have been validated previously.

Visual Imagery Training Program

The approaches to imagery training that were used by Richardson and Patterson, (1986) and Lord, (1985) were synthesised to develop a training program to concurrently improve both vividness and controllability of students' visual imagery. The imagery activities were contextualised to suit the subject/course in which the design students were enrolled. An analysis by LeBoutillier & Marks, (2001) of the self-reporting vividness of visual imagery questionnaire found that participants' vividness of visual imagery is statistically significantly different depending on the context of the visualized scene or object. Selection of appropriate contextualised reference for the visualization activities therefore maximizes the likelihood of a positive response by students to the material. This required variation in the activities delivered to various design classes and an integration of the activities into the teaching and learning strategies of the design course.

The tasks chosen involved the visualization with and without perceptual reference of objects and scenes, which were described by the researcher while being viewed by the participants. The context varied from the everyday household environment to subject specific themes. The perceptual reference used in the vividness activity was manipulated to provide a concurrent contribution to the participants' controllability of imagery. Further activities utilised reference objects similar in form to the original simple solids used by Lord, (1985). These three dimensional geometric forms were easily and inexpensively

prepared for the planes through solids activities. The participants viewed these objects prior to a request to imagine a cutting plane sectioning the object. Instructions were given to visualise various parts of the remaining object and or the surfaces. Subsequently they were required to sketch their visual images. This reinforced the equivalency of the mental image and the perceptual representation. These perceived visual images (sketches) facilitate participants' problem-solving and enrich the learning experience (Finke, 1989; Middleton, 1998). Each task concluded with the presentation of the three dimensional solution. This formative feedback allowed participants to quickly and easily evaluate their sketches prior to the next activity. Finally each session culminated in tasks for students to practise prior to the next class. The activities proved to be easily and efficiently presented to small groups of design students within the existing curriculum and were able to be altered simply to suit the context of the learning environment.

Results

The training program was initially trialled with a ceramics class of thirteen students, eleven females and two males. This subject was taught over a 17 week semester and involved the creation of three dimensional artefacts. The training program was run over seven weeks and was contextualised to suit the learning experiences in the subject. Unfortunately the program had to be altered to remove the reinforcement of visual imagery through the transfer to a perceptual image. The planes through solids intervention requires students to transpose their visual mental image to a perceptual image thus providing formative feedback of performance throughout the training program. The teacher considered that many of the students would feel threatened by the right and wrong connotations of the activity. He explained that he told students that drawing can be anything and may not look like a real object. He reported that students say "I cannot draw" and he replies "If you can make a mark on a piece of paper with a pencil then you can draw, and that there is no right or wrong in what you produce". Therefore it was negotiated that students would be provided with paper and pencils for the activity and it would be suggested that they may wish to draw their mental image but that it wasn't necessary.

The intention was to integrate the visual imagery training program into the curriculum of the subject, however this was not able to be negotiated with the teacher. A compromise was reached and the researcher was asked to present the training program at the start of the classes while the teacher was setting up for the lesson. The class was held in an open plan workshop. Within this environment there were three and sometimes four classes running simultaneously. The students gathered around high desks which were situated in an alcove off the main thoroughfare between the front and rear class areas in the workshop. When there was a full class, the students would often be standing in the walkway. The environment was noisy and distracting for the students and presenter. Further, in every session the students were aware of their teacher preparing materials for the lesson and waiting for the researcher to finish. As a consequence their responses were rushed and the implied message that was actually voiced in later sessions was "let's get this over with quickly so the real class can begin". This was particularly evident during the post-testing phase. The teacher started talking to the class while some students were completing their questionnaires. The researcher observed these students quickly write final responses without taking the required time to visualise the images.

Analysis of the visual imagery questionnaires responses indicated that of the thirteen students, two students demonstrated an improvement in both vividness and control. Two students only improved in the vividness of imagery and five recorded similar performance scores in both factors. The remaining four students did not satisfactorily complete the program. These results were disappointing but perhaps not surprising given the alterations to the program and the environment in which it was delivered.

The training program was refined and implemented in a rigid materials design class that had an engineering focus. The fourteen male students were required to identify an industrial need that required the design of a mechanical device. Prior to the intervention the researcher met with the teacher, observed classes and explained the possible contribution of the training program to student learning. The teacher was very interested in the project and willing to integrate the training program into the teaching and learning experiences of the subject. He therefore communicated the importance and relevance of the activities to the students and encouraged students to use imagery to assist them with their design conceptualization.
The researcher visited the class in the first week of the semester and pre tested the students' VMI.

The training sessions were run every second week throughout the semester thus allowing an extra week of practice of the activities between sessions. Each week the researcher attended the class and sat as a member of the class for the first session. During this session students discussed their projects, shared ideas, detailed the activities they had undertaken during the week and were given positive feedback and tips on possible future direction. The teacher facilitated the process, prompting students and generating discussion, he included the researcher in this process as he often sought his opinion on discussion points. Prior to the mid-morning break the teacher introduced the training session which the researcher delivered. On alternative weeks this was in the form of a refresher of the previous weeks' activities and encouragement to continue practising the exercises. At the end of the semester the researcher post tested the students' imagery ability for vividness and control of mental imagery. Students were able to complete the questionnaires at their own pace during the morning class.

Analysis of the responses to the visual imagery questionnaires indicated that of the fourteen students, four improved in both vividness and control, four improved in vividness only and two had no change. One student had reduced vividness and control although this student attached a note to their questionnaires indicating that they were too stressed due to the project deadline to concentrate on the visualization tasks. The remaining three students did not satisfactorily complete the program. These results indicate a general improvement across the class of increased VMI ability. In comparison with the trial this was an integrated approach that was fully supported by the teaching staff. Students received instant formative feedback on their imagined solutions throughout the program and were given extra time to engage with the activities and practise the generation of images outside of the short training sessions.

Throughout the semester student design activities were videoed. At the conclusion of the project, narrative interviews were undertaken with each student. They were encouraged to tell their design story in their own words. An initial analysis of this data indicates a possible relationship between students' improved VMI and design ability.

Student A

> *"With the things that you've taught us... I've learnt that now I can get the bits that I don't quite get, pull them apart, and then if I pull them apart I can visualize them by themselves, fix them to what I know it is and then put it back."*

Student D

> *"I'd... sort of set it out in my head, ... I started with the complete car in my head, and then went backwards. Took the tyres off, not my department, I don't have to design tyres, so then I was left with a cart with rims, ... they didn't seem what I needed so I took the rims off and then stuck the cart to one side of my head, it doesn't make sense, but this is what I did, put the cart to one side and concentrated on the rim."*

Student C

> *"I'm finding it easier to visualize. So I think that's the biggest thing, I had to sit down for two hours just to think about how I would draw that, I'd be a bit quicker now."*

Summary and Future Directions

It is important for teachers of design-based subjects to develop instructional practices that improve students' problem solving ability. The thinking involved in designing, which involves the solving of complex problems, requires the use of second order procedures. VMI is used by expert designers to facilitate complex problem-solving through the manipulation of objects in working memory. For this reason a training program was developed that would improve students' vividness and control of their VMI. Pre and post testing of students was undertaken using validated self-reporting questionnaires to ascertain improvements in VMI ability.

In a learning environment where the activities were not valued, and there was limited opportunity for students to evaluate their imagined responses to the tasks, the results did not indicate an improvement of students' imagery ability. However, when the program was fully contextualised, valued and integrated into the teaching and learning strategies of the subject, students' imagery was improved. In addition students reported that the activities assisted their conceptualisation of the design outcomes. These preliminary results indicate a correlation between improvement in VMI and students' perception of design performance. In the future this project will seek to expand the analysis of student design outcomes as a result of improved VMI. There is a strong case for the continued investigation of the role of VMI in the development of design ability.

References

Abernathy, B. & Wood, J. (1992). *An assessment of the effectiveness of selected visual training programs in enhancing sports performance*. Canberra: Australian Sports Commission.

Alias, M., Black, T. & Gray, D. (2002). Effect of instruction on spatial visualisation ability in civil engineering students. *International Education Journal*, 3, 9-21.

Anderson, J. R. (1993). Problem solving and learning. *American Psychologist*, 48, 35-44.

Antonietti, A. (1991). Why does mental visualisation facilitate problem-solving? In R. H. Logie & M. Denis, (Eds). *Mental images in human cognition*. Amsterdam: North Holland.

Ashton, R. & White, K. (1974). Factor analysis of the Gordon test of visual imagery control. *Perceptual and Motor Skills*. 38, 945-946.

Denis, M. (1985). Visual imagery and the use of mental practice in the development of motor skills. *Canadian Journal of Applied Sport Sciences*, 10, 4-16.

Finke, R. A. (1990). *Creative imagery: discoveries and inventions in visualisation*. Cambridge Hillsdale, New Jersey: Lawrence Erlbaum.

Finke, R. A. (1989). *Principles of mental imagery*. Cambridge MA: MIT Press.

Finke, R. A., & Slayton, K. (1988). Explorations of creative visual synthesis in mental imagery, *Memory and Cognition*, 16, 252-257.

Glaser, R. (1989). Expertise and learning: how do we think about instructional processes now that we have discovered knowledge structures? In D. Klahr & K Kotovsky (Eds.), *Complex information processing* (269-318). Hillsdale, NJ: Erlbaum.

Kaufmann, G. (1990). Imagery effects on problem solving. In P. Hampson, D. Marks, and J. Richardson (Eds) *Imagery: current developments*, London: Routledge.

Kosslyn, S. M., Thompson, W. L., & Alpert, N. M. (1997). Neural systems shared by visual imagery and visual perception: a positron emission tomography study. *NeuroImage*, 6(4), 320-334.

LeBoutillier, L. & Marks, D. (2001). Mental imagery and creativity: a meta-analytic review study. *British Journal of Psychology*, 94(1), 29-42.

Lord, T. (1985). Enhancing the visuo-spatial aptitude of students. *Journal of Research in Science Teaching*, 22(5), 395-405.

Middleton, H. E. (1998). *The role of visual mental imagery in solving complex problems in design*. PhD Dissertation. Brisbane: Griffith University.

Richardson, A. (1994). *Individual differences in imaging: their measurement, origins, and consequences*. New York: Baywood Publishing.

Richardson, A. & Patterson, Y. (1986). An evaluation of three procedures for increasing imagery vividness. *International review of mental imagery*, Vol. 2. New York: Human Science Press.

Richardson, J.T.E (1999). *Imagery*. Hove, East Sussex: Psychology Press.

Sorby, S. & Baartmans, B. (1996). A course for the development of 3-D spatial visualisation skills. *Engineering Design Graphics Journal*, 60(1). 13-20.

Stevenson, J.C. (1991). Cognitive structures for the teaching of adaptability in TAFE. In G.Evans, (Ed.), *Learning and teaching cognitive skills* (144-163). Hawthorn, Victoria: Australian Council for Educational Research.

Walsh, F. (1976). *An imagery training procedure: The development and experimental evaluation*. Unpublished honours thesis, University of Queensland, Brisbane.

Ward, T. B., Smith, S. M. & Vaid, J. (1997). *Creative thought: an investigation of conceptual structures and processes*. Washington DC: APA.

Weber, R. J., Moder, C. L. & Solie, J. B. (1990). Invention heuristics and mental processes underlying the development of a patent for the application of herbicides. *New Ideas in Psychology*, 3, 321-336.