The Understated Value of Freehand Sketching in Technology Education

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Abstract

As education plays such a vital role in economic competitiveness, it is no surprise that the focus for many governments is to invest in educational initiatives. Innovation in pedagogy, refined curriculum and much research into the science of teaching and learning is hoped to promote a knowledge economy. In recent years the Irish education systems have been particularly proactive in the area of technology education. Four new subjects were drafted at Senior Cycle level, all with a common philosophy grounded in design and technology. This clear shift in focus from the traditional craft based subjects to a more creative design-based suite of subjects has brought with it an unprecedented need for continuous professional development.

This paper focuses on the shift in skill set from teaching in a predefined drawing mode to that of a conceptual mode that fosters creativity. As technical sketching is a fundamental building block of all design-based activities, it formed the core of this study. Focusing on the learning process under the descriptors of presage, process and product enabled a linear exploration of an otherwise complex dynamic learning experience.

Although the perception of innate ability restricts the level of application of many teachers in terms of sketching, it proved a valuable attribute as a comparative criterion when selecting contributors. The study included participants that subjectively claimed an average standard of sketching capabilities and a polar group with a prerequisite mindset governed by the phrase "I cannot sketch". All participants completed a purpose designed five-week course of study. The course included much psychomotor skill development; however the significant value of the course content centred on the cognitive development that progressed from knowledge acquisition to synthesis.

The paper concludes by highlighting the value of "Process" based education over the traditional "Product" approach and presents empirical evidence that illustrate enhanced cognitive capabilities of the participants. The use of pre and post intervention data and qualitative commentary validates the suggestion that there is a greater cognitive value to sketching than a completed composition.

INTRODUCTION

The purpose of this study was to investigate if sketching is more than a physical activity which some people excel at and enjoy, while others find difficult and frustrating. It forms part of initial research that is being carried out as part of a greater study at the University of Limerick, which aims to determine how freehand drawing can be taught and applied in technology subjects not only as a means of communication but as a greater cognitive tool.

Technological subjects at pre-university level in Ireland have a broad aim directed towards developing fundamental design skills and aptitudes in pupils. Problem solving, creative thinking and practical skills are integrated into a unique set of subjects with a common philosophy grounded in design. "Designing is a demanding and complex problem solving activity of great economic importance and sketching has an integral part in this" (Schutze, 2003). A central focus is placed on sketching and the influence that technological education has in the development of pupils' ability to sketch. The importance of sketching will be explored under three facets which are cognitive implications, educational significance and the economic benefits.

EDUCATIONAL SIGNIFICANCE

The value of freehand drawing in technology education cannot be underestimated. It has been found that "drawing episodes in design and technology are problematic" and that children are not introduced to the fundamentals of freehand drawing which can help them "develop designerly thinking and behaviours"(Newcomb, 2007). The ability of students differs significantly in the way they learn and process information. The manner in which students respond to their learning environment, approach their studies and their attitudes to different pedagogical styles are something which teachers of Engineering Education must be aware of. They will be much more capable of devising suitable inclusive pedagogical approaches if they have an in-depth understanding of preferential learning styles (Felder, 2005).

It could be argued that sketching is exclusively a communication tool which some people are innately competent at and that it has no other significance. However the syllabus produced by the Department of Education and Science emphasises the value of freehand drawing and the role that it plays in "explaining as well as solving problems" (DOE, 2007). The connection between freehand sketching and the cognitive processing and development of spatial ideas needs to be understood and developed by teachers of engineering education (Gaughran, 1990). Therefore, freehand sketching must become more than a psychomotor skill that is just exploited by the few innately talented pupils in communicating their design composition in technology subjects.

Underlying the ability to manipulate a pencil and sketch a composition are cognitive aptitudes and characteristics which are core to the process. Teachers need to appreciate that appropriate pedagogical approaches required to help pupils "mentally create and edit graphic information" (Contero, Naya, Comany, Saorin, & Conesa, 2005). Once these approaches are applied in technology subjects the benefit will disseminate into other subjects such as mathematics and sciences. This increased awareness of cognitive processing and capacities should result in pedagogic structures that "employ trans-disciplinary knowledge to advance the learning process" (Seery, 2003).

COGNITIVE IMPLICATIONS

The links between freehand drawing, cognitive activity and the development of spatial ideas needs to be developed and encouraged in technology education. In order for this to occur it is important to describe the cognitive aptitudes which are being applied and developed concomitantly during the sketching process. In order for students to develop capability in design and making they must first of all "learn the relationship between sketching and thinking, and how to use sketches to clarify and show details of their design thinking" (Welch, 1999). So not only is it important for educationalists to identify these cognitive aptitudes, it is also important for the pupils themselves to understand how they think themselves.

The global importance of freehand drawing merits investigating whether a link exists between it and spatial ability and whether the product of the two can be developed. Spatial ability is "the mental manipulation of objects and their parts in 2D and 3D space" (Olkun, 2003) and this is governed by the capacity to "perceive the visual world accurately" (Gardner, 1993). Spatial abil-

ity is "not innate but can be developed with appropriate tuition" (Gaughran, 1990) and training provided the appropriate resources are used (Olkun, 2003).

Freehand drawing is an invaluable tool in Engineering Graphics education as it encourages the exploration of ideas and concepts and the development of solutions to complex problems in plane and descriptive geometry. It is used to communicate and manipulate information in learning and problem solving activities (Olkun, 2003). The importance of recognising, measuring and developing spatial ability can be undervalued in educational systems due to a mindset fixated on the end product which is terminal examination.

As a result of both pressure to improve overall school performance and excitement and interest about education that could be brain based, many myths and conceptions have grown outside the scientific community with regard to the mind and brain (OECD, 2002). Both cerebral hemispheres of the brain have unique functions in determining the behaviour of people with the right hemisphere generally having non- verbal and spatial characteristics while the left hemisphere generally has verbal, logical and linear characteristics (Edwards, 1989). The developments that are taking place in cognitive neuroscience cannot be underestimated and the application of these findings is required for a reorganisation of the education system (OECD, 2002).

As far back as 1964, it was outlined that procedures used for admittance to educational institutions are heavily weighted to those with superior verbal intelligence (Smith, 1964). Smith argued that a considerable proportion of students with advanced spatial abilities are being prevented from partaking in advanced educational courses where this ability can be nurtured and developed. The Irish education system has taken cognisance of this research and the assessment of project based work in all technology based subjects now forms approximately forty percent of the overall grade. An example of this change in focus is evident in Design and Communication Graphics. Forty percent of marks are weighted towards an assignment which is a design investigation with a conceptual element. It aims to assess elements of design and communication graphics which "cannot be readily assessed through the terminal examination" (DOE, 2007).

ECONOMIC BENEFIT

It has now been established that freehand drawing can help develop pupils' spatial ability, communication skills, problem solving skills and their ability to be creative. These resultant factors have potential to have great implications outside the classroom environment. As education is seen as a driving force in delivering economic benefits to nations, it is appropriate to analyse the advantages that the people who possess a unique cognitive skill set enhanced by freehand sketching have over others.

(Pink, 2006), gives an insight into why countries like Ireland need to move from the knowledge based economy to that of a conceptually driven one. The effects of outsourcing of jobs, automation and abundance are being felt worldwide and countries now need a new type of person to lead. This type of person will have the essential "high concept" aptitude of "symphonic thinking" which is a right brain characteristic (Pink, 2006). According to Pink, this is the ability to synthesise in addition to the ability to analyse; it is the ability to detect broad patterns in addition to specific answers and to see links between things that were never thought possible. The downturn in the global economy indicates that a significant change is needed and this needs to be sparked by the education system.

METHODOLOGY

During the sketching process underlying cognitive activity is undoubtedly occurring contemporaneously and this needs to be qualitatively and quantitatively measured. Future research will focus on developing the key aptitudes which cause this concurrent cognitive activity and how

these can be developed and applied in a broader educational context.

Participants

Participants were divided into two separate groups – an investigative focus group (which aimed to classify the cognitive aptitudes of sketchers) and an applied test group (through which a strategy was applied and tested).

The focus group was composed of eighteen people all who classified themselves as having an innate ability to sketch. These were student teachers of technology education at the University of Limerick.

Seven people formed the test group, all of whom were qualified teachers of technology subjects. Five of the participants were undertaking post-graduate research at masters and doctorate level and the remaining two were academics who are lecturing in the department of Manufacturing and Operations Engineering (M&OE). The group was made up of six males and one female with ages ranging from 21-36 with a standard deviation of 5.44.

The test group was composed of two kinds of participant, those who claimed an average standard of sketching and a polar group who claimed they "cannot sketch". All participants were predominantly right handed except for the sole female participant who was left handed.

Design

The research was set out in two stages. The first stage aimed to establish the skill set, key aptitudes and characteristics of people with an innate ability to sketch through am investigative focus group. Once these were determined, the second stage involved designing and implementing an approach using the applied test group which aimed to determine if sketching is teachable.

The approach aimed to develop the following aptitudes with a specific purpose:

Recognition – A perception proof exercise (figure 1) was devised to encourage the recognition of outline edges of irregular geometries. In order for the geometries to be recognised purely as lines the drawing was inverted so it had no meaning.

Figure 1. Perception Proof Exercise

Enquiry – A perception enhancement exercise was applied so that geometries which are not instantly recognisable could become part of the greater picture. A picture plane device (as shown in figure 2) was used to record intricate detail and this was then transferred to paper.

Figure 2. Exercises using the picture plane

Enlightenment – A space enlightenment exercise was devised so that areas which appear to have no value in a composition suddenly became important. These empty spaces are bounded by edges which are recognised in the previous exercise. A chair was used together with picture plane and a proportion finder in order to draw the given composition.

Application – An amalgamation exercise brought together the aptitudes of recognition, enquiry and enlightenment. This was achieved by drawing a composition which was of interest to the participants using the skills learned in previ-

ous exercises. An element was removed from the composition and drawn from memory. The abilities to recognise angles, relationships and light and shadow were developed at this stage.

Synthesis – A conceptual challenge exercise was devised so that the previous skills could be brought together in the composition of a self portrait. A challenge was given where an imaginative element was to be included in the drawing.

Procedure

Three sets of focus groups were formed with the intention of engaging the group in discussions about their early sketching background, preferential learning styles, personal characteristics, influences and their personal approach to sketching. Each focus group session was recorded using dictaphone and results collated. A unique set of characteristics and aptitudes were then identified.

The participant group for the testing were introduced to the unique set of sketching exercises over five evening's with each session lasting three hours. Each exercise aimed to engage and develop a cognitive aptitude which the focus group identified as being necessary for sketching. Questionnaires, critique exercises and group discussions were used throughout the course to evaluate both data and participant opinions.

Findings

Two sets of findings are outlined in this section. The key findings of the investigative focus group are outlined as well as the findings of the applied test group who undertook the exercises to develop the key aptitudes as outlined earlier.

Findings of Focus Group

The following is a summary of collated findings from the focus groups

- All sketched for fun from an early age.
- There was a variance in the environments in which these participants sketched.
- Something always caught their interest before beginning a sketch.
- 64% of participants categorised themselves as being fidgety people.
- 76% didn't notice time when sketching.
- Everybody described themselves as being thinkers with a tendency to notice unusual patterns.
- 52% of participants reported periods of anxiety
- 45% of the group described themselves as being dyslexic
- 43% of participants preferred to draw intricate detail while the 57% appreciated outline edges and relationships

Findings of Applied Test Group

Prior to any instruction, the applied test group were required to draw a self portrait to determine their current ability to sketch. This information was then used as a covariant at the end of the study to determine if any improvement took place. A selection of these drawings is shown in figure 3.

Figure 3. Selection of Pre Instruction drawings

Pre Instruction Drawing

1. 43% of participants expressed their "reasonable satisfaction" with their drawing while 57% "not happy".
2. The consensus was that there was a definite need for improvement.
3. The main part of the face that caused greatest difficulty was the nose, while the proportions between features were easier to communicate accurately.
4. The intricate geometries which make the facial features unique to each individual are very difficult to communicate accurately.

Perception Proof Exercise

This was devised to encourage the recognition of outline edges of irregular geometries. The drawing was inverted in order to reduce the chance of participants relating the shapes to symbols. A selection of participant drawings is shown in figure 4.

Figure 4. Selection of Perception Proof Drawings

Findings

1. All participants expressed a feeling of being "very pleased" with their drawing.
2. They stated that their focus was on proportionality and drawing the picture in parts rather than as a whole.
3. Turning a drawing upside down and dividing it into a number of parts made the participants focus more on shapes and not symbols. They were forced to draw only what could be seen.

Perception Enhancement Exercise

This exercise was applied so that geometries which are not instantly recognisable could become part of the greater picture. A picture plane device (as shown in figure 2) was used to record intricate detail and this was then transferred to paper.

Findings

1. The physical manipulation of the picture plane caused problems
2. The task of drawing edges was difficult for some participants in particular varying the weight and thickness of lines.
3. Participants were able to draw in perfect proportion due to the use of the picture plane and their ability to draw intricate and abstract information was much improved.
4. It was also very interesting to observe the different compositions which people drew, ranging from an open hand with great detail of shadow and shade to an intricate bunch of keys being held in a hand.
5. It is notable that some of the participants expressed surprise in saying "so this is what the picture plane is all about" when using it to determine the composition of their sketch. A selection of these drawings is shown below in Figure 5.

Space Enlightenment Exercise

This exercise was devised so that areas which

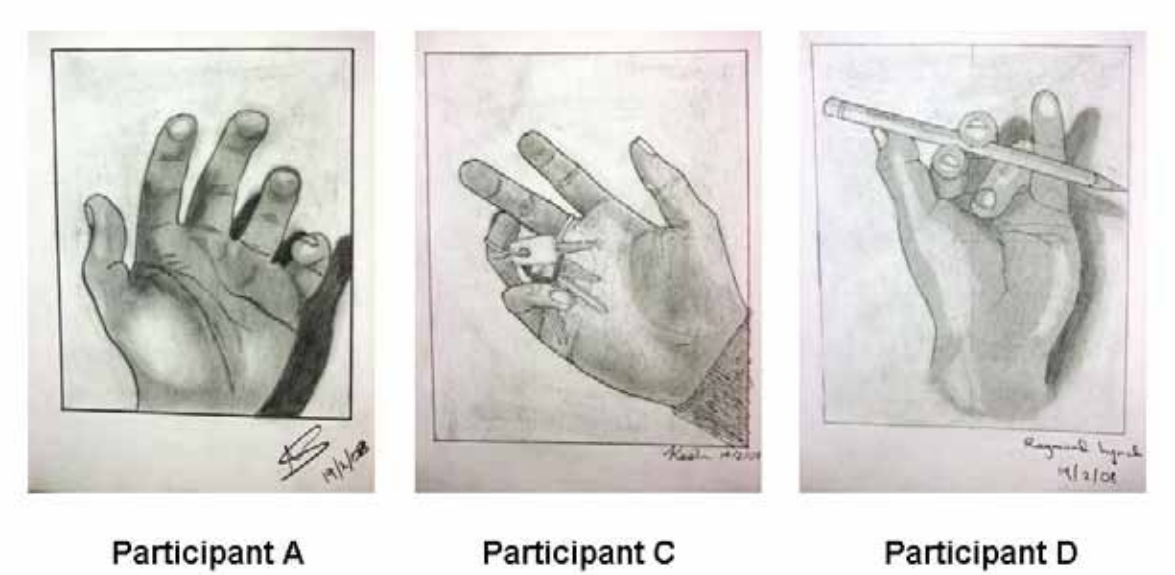


Figure 5. Selection of participants Perception Enhancement Exercises

appear to have no value in a composition suddenly became important. These empty spaces are bounded by edges which are recognised in the previous exercise. A chair was used together with picture plane and a proportion finder in order to draw the given composition. A selection of these drawings is shown in figure 6.

Findings

1. The use of a picture plane to measure the composition of the required solution was used along with a proportion finder to calculate relationships between various elements in the composition.
2. Participants found drawing on the picture plane difficult.
3. Difficulty was expressed in sighting relationships and scaling these to suit the format being drawn upon.
4. 32% of participants found it difficult to see more than one relationship and were overcome by the dexterity in manipulating the equipment being used.

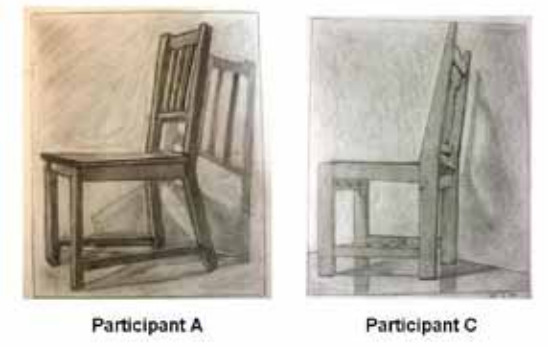


Figure 6. Space Enlightenment exercise

Amalgamation Exercise

This brought together the aptitudes of recognition, enquiry and enlightenment. An element was removed from the composition and drawn from memory. The abilities to recognise angles, relationships and light and shadow were developed at this stage. The element that was removed from the composition is highlighted in figure 7.

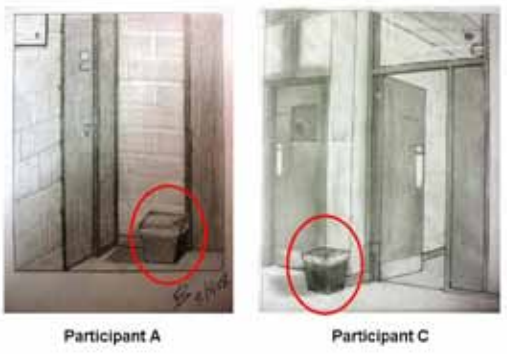


Figure 7. Amalgamation Exercise

Findings

1. Participants seemed to have trouble in finding an interesting composition.
2. Intricate detail such as door handles and skirting boards were difficult to measure and communicate.
3. 84% of participants found that they were able to overcome the size of the intricate shapes by relating them to something more regular in the composition.

Conceptual Challenge Exercise

This was devised so that the previous skills could be brought together in the composition of a self portrait. A challenge was given where an imaginative element was to be included in the drawing.

Findings

1. Significant improvement in participants ability was noted all round.
2. 66% of the group expressing a feeling of being "very pleased" with their progress.
3. 34% were "reasonably happy".
4. All participants reported having positive feelings and enjoyment during their experience.
5. Finally, all participants reported a "significant improvement" and their outlook on freehand drawing had totally been changed (see figure 8 below).

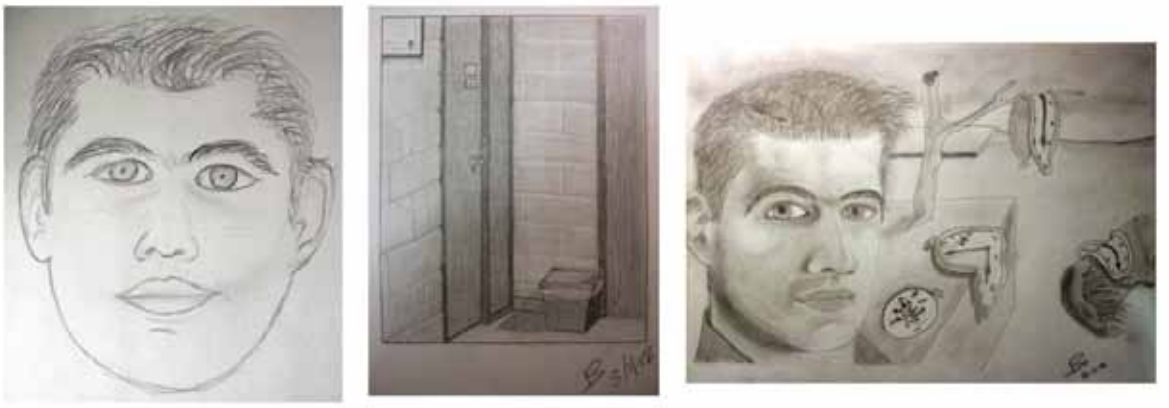
DISCUSSION

In an Irish context, it is notable that pupils who study technical graphics for the first time become so concerned with the dexterity of manipulating the equipment that they fail to understand basic concepts and principles of what they are doing. It can be argued that freehand drawing is just as important in understanding plane and descriptive geometry as well as communication graphics.

Engineering Graphics education with particular reference to freehand sketching has great potential for developing pupil's cognitive, psychomotor and affective domains. The ability to engage in "mental manipulations" and solve problems through freehand sketching will help in the transition from Piaget's "concrete operational" stage to the "formal operational" stage of cognitive development (Snowman, 2006).

It is evident from the results that a significant improvement has occurred in the participant's ability to communicate perceived and conceptual imagery. It is clear that this will have a profound effect on the following areas -

Figure 8. Cognitive challenge exercise



Pre-instruction Exercise | Amalgamation Exercise | Conceptual Challenge Exercise

Figure 9. Selection of drawings completed by Participant A

- Pupil's visuo-spatial ability and their ability to mentally manipulate spatial problems will be greatly enhanced.
- Pupils will be able to utilise a comprehensive skill set in communicating conceptual design ideas.
- Pupils will be able to analyse mathematical, verbal and written information and represent it graphically.

The work of Participant A is shown in figure 9 below. In relation to engineering graphics the value that this participant has taken from these exercises cannot be underestimated. Some of the key outcomes are as follows –

After completing the course the participant is now able to...

1. Communicate various line-types and line weightings.
2. Identify both regular and irregular geometries in compositions.
3. Analyse proportionality between geometries.
4. Differentiate between shadow and shade and communicate this in rendered drawings.
5. Value the principles and importance of the picture plane when drawing in perspective.
6. Represent perceived 3D imagery on a 2D surface.
7. Create novel designs stemming from external influential factors.

The results of the cognitive challenge exercise prove that the participants were able to produce novel and creative drawings while being influenced by external factors. Participant C, who drew the conceptual challenge exercise in figure 8, was influenced by the famous da Vinci drawing of the Mona Lisa and this is clear from the gestalt of the drawing. These results prove that pupil's ability to communicate design ideas and engage in graphic ideation will improve significantly when exposed to a specific set of cognitive exercises through freehand sketching.

Figure 10. Mona Lisa inspired composition

CONCLUSION

It has now been established that sketching is more than a communication tool and that it has a greater educational significance coupled with cognitive implications which will ultimately be of economic benefit. The philosophy of the Irish education system is to educate individuals so that they may achieve their full potential and contribute to Ireland's social, cultural and economic de-

velopment. There is a need for increased spending and improved efficiency of education systems in order to meet the "rising demand for more and better education" (OECD, 2008). Therefore the investment that the Irish Government has placed in introducing a new suite of technology subjects is something which must be commended. However, is this monetary investment alone going to advance the pupils who participate in these new subjects at senior cycle? It must be acknowledged that a magnitude of work needs to be done to advance the knowledge and ability of teachers.

Is sketching a teachable skill that can be learned and applied by people who believe they have no innate sketching ability whatsoever? The participants who participated in this study made a significant improvement in their ability to sketch, therefore we can hypothesise that the process used was successful. However, it must be acknowledged that a considerable amount of what was sketched was perceived and was carried out for communication purposes. The research also demonstrates that something deeper is occurring on a cognitive level which involved increased levels of enquiry, recognition of patterns and synthesis between unrelated elements. Further research will reinforce that sketching as a cognitive tool for problem solving, application and understanding can be can be taught and applied successfully.

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