Curriculum Planning for the Development of Graphicacy

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Abstract

The paper describes the importance of graphicacy as a key communication tool in our everyday lives. The need to better understand the development of graphicacy and its use in the school curriculum is emphasised. The need for a new research tool is explained and the development of a new taxonomy of graphicacy is described. The use of this tool within a methodology researching the significance of graphicacy in the curriculum is introduced. An overview of prior research concerning how children deal with graphicacy is also provided. The paper then discusses the results reported in the context of this prior research. The paper illustrates how graphicacy can affect children's learning; identifies cross-curricular links involving different areas of graphicacy and consequential transfer opportunities; illustrates how the implementation of a curriculum policy for graphicacy could influence students' learning; demonstrates the magnitude of the research opportunities in relation to graphicacy within general education curricula and suggests the need for collaboration in order to effectively pursue these substantial research agendas.

Key words

graphicacy, curriculum, policy, strategy, development

Introduction

The ability to imagine a better future and work towards realising this is 'key' to economic development and technological change in every country. Previous research has demonstrated the importance that graphicacy has in these developments as well as in our everyday life; professionally, socially and culturally (Considine, 1987; Stokes, 2002; The Senate Standing Committee on Education and the Arts in Australia, 1981). Graphicacy concerns the ability to communicate through still visual images, such as maps, diagrams, graphs and symbols (Danos, 2012). The cognitive requirements that accompany such skills, such as modelling 'in the mind's eye' and critical thinking, help people excel in numerous fields. Important 'life skills' are introduced through education from an early age, often with associated curriculum policies e.g. for competences such as literacy, numeracy and articulacy. However graphicacy, which is used extensively in the early years and later through school and beyond, has yet to be introduced in the curriculum through a structured strategy (Hope, 2008; Danos, 2012; Anning, 1997; Wilmot, 1999). The main reasons for this are believed to be; the low significance attached to graphicacy skills for the development of an intellectually well-balanced human; and the high complexity level involved in analysing and defining the areas of graphicacy, which are both related to a lack of research effort in this area (Danos, 2012; Fry, 1981).

Images can be powerful with unlimited potentials, affecting people regardless of their academic, economic, cultural or religious status (Poracsky et al, 1999). They can educate, inform and inspire; affect one's perception and decisions; be used as a tool for communicating, learning and recording ideas. Baynes believes they are fundamental to all peoples and cultures; an intellectual activity that links sensing, feeling, thinking and doing. 'They can be used to effectively model core aspects of future reality which cannot be adequately modelled through language or numbers, such as colour, space, shape, distance and scale amongst others' (Baynes, 2011:4).

This paper reports research with two aims:

- to demonstrate the wide-ranging role that graphicacy plays throughout general education curricula;
- to demonstrate the role that Design and Technology (D&T) can, and should play in developing this essential capability.

The importance of design and technology and/or technology education has been the subject of many curriculum reviews, conferences and papers over the last two decades and it is not the purpose of this paper to revisit these positions. Its purpose is to illustrate that design (and technology) education can play a key role in developing graphicacy capability, which is fast becoming an important life skill for all people to possess.

Research approach

In order to be able to complete the above research goals, the research progressed through the following key stages.

- The development of an up-to-date taxonomy for analysing graphicacy use within the curriculum.
- The use of the validated taxonomy to analyse graphicacy use within three schools in different countries.
- A detailed literature review concerning children's development of graphicacy.
- The development of teaching interventions to show the potential contribution that D&T can play in different areas of the taxonomy.

Taxonomy of graphicacy

A tool was required that would enable graphicacy within the curriculum to be clearly identified and defined. A number of diverse descriptions for graphicacy and some taxonomies offering different perspectives were identified through literature review (Balchin, 1996; Baynes, 2008; Aldrich & Sheppard, 2000; Hope, 2008; Wilmot, 2002; Van Harmelen & Boltt, 1995; AEB, 1984; Finson & Pederson, 2011; Boardman, 1983; etc). These have been collected, collated and analysed (Danos, 2012).

Fry's taxonomy (1974) was the closest research tool identified to that needed for this study; enabling the classification of the still visual images used for teaching and learning across the curriculum. Fry categorised images according to the type of information represented, i.e., quantitative, spatial, lineal, etc, from both an incoming and outgoing perspective i.e. when reading and understanding information illustrated through still images and when creating an image to convey information (Danos & Norman, 2009; Danos & Norman, 2011).

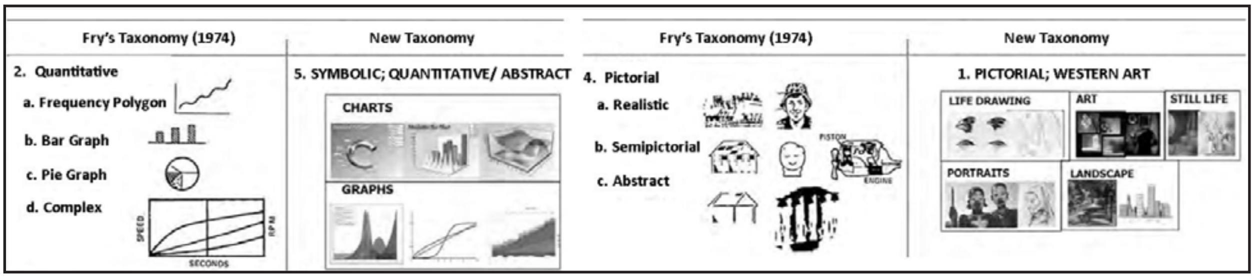

Figure 1. Images from Fry's taxonomy (1974) alongside corresponding images from the new taxonomy

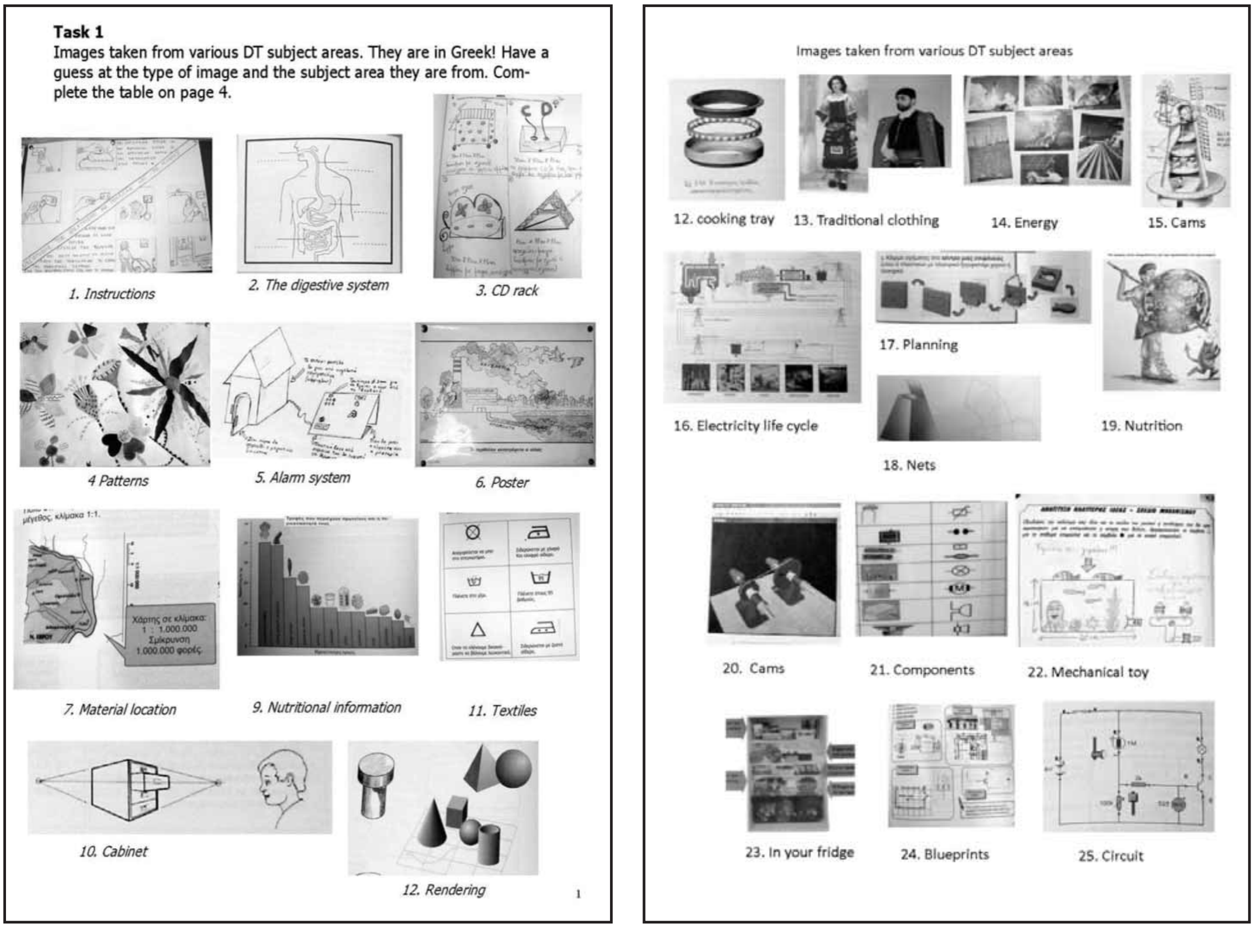

Figure 2. Images used to help with assessment of the inter-rater reliability of the taxonomy of graphicacy

Subsequently, images were grouped according to types of thinking required to organise the information such as images designed to allow identification of patterns through graphs, or illustrating a sequence through a chart. The examples used in Fry's taxonomy to illustrate each category were probably taken following the most commonly used images within education at the time. With the advent of the Internet and the increasing use of computer drawing tools in schools, the nature of images within school curriculum provision has changed. For these reasons, the new taxonomy was founded on Fry's initial taxonomy with further additions derived from the literature review. Examples from the new taxonomy of these more recent elements are shown in Figure 1.

The new taxonomy of graphicacy (Figure 4) was developed through five stages:

- Stage 1: Developing categories from the literature review.
- Stage 2: Identifying learning skills and purposes of images.
- Stage 3: Visually representing the emerging concept of graphicacy.
- Stage 4: Articulating the meaning of the main categories.
- Stage 5: Defining the new taxonomy of graphicacy.

The taxonomy is considered to be a constant work in progress. However, in order to analyse its effectiveness, it has been put through various tests, and been subjected to analysis and scrutiny on a number of occasions during its development and use.

Subject Areas Vs Types Of Image matrix

Identify the type of each image and write the relevant number in the table below

			Resistant materials	Graphic products	Electronic products	Textiles	Food technology
PITCORIAL	GRAPHIC ARTS	Art				4	
		Life drawing					
		Still life					
		Portraits					
		Landscapes					
	DRAWINGS	Drafts					
		Sketching	3		5		
		Drawing		11			
	DIAGRAMS	Annotated					2
		Architectural					
		Exploded					
		Engineering/ Technical					
		Projections					
		Perspective	10				
SEQUENTIAL		Cartoons					
		Storyboards			1		
		Flow diagrams					
SYMBOLIC	ABSTRACT	Charts & graphs					8
		Symbols		6		9	
	SPATIAL	Maps	7				
		Photographs					
		Advertisements		6			
CAD		Computer Aided Design					
		3D virtual images					

Figure 3. The initial part of the task used to assess inter-rater reliability

Initially, three experienced academics within design and technology education challenged the categories of version 1 of the taxonomy until they were satisfied with the reasoning behind them. The category that was under scrutiny for the longest was the category of CAD (Computer Aided Design). The main argument was that computer aided images did not necessarily form a different type of images from the ones already categorised. They were merely completed using different media. The main differences come when creating the image (using outgoing skills). The skills, abilities and thinking required to create the image depend heavily on the sophistication and complexity of the software package used. When reading information from an image made using CAD, the skills, abilities and thinking required would be essentially the same as if the image was created using a different media. It was agreed that it is too important to ignore the category as it is so widely used predominantly in the subject areas of design and technology and somewhat in the other subject areas.

Version 1 of the taxonomy was then used during a pilot study, in a school in Cyprus (ages 12-15, textbooks from 13 subject areas were analysed) and in a case study in a school in the USA (ages 15-18, textbooks from eight subject areas were analysed). Textbooks from across the curricula were analysed in order to identify graphicacy use. The effectiveness of the taxonomy as a research tool was analysed. A new category of images emerged, that of miscellaneous visually based items, such as puzzles, crosswords, and games, which was named 'Other'.
The element of graphicacy labelled as 'annotated' was removed from the taxonomy (forming version 2 of the taxonomy). Looking at the type of understanding required for one to read and understand or to create such an image, 'annotated diagrams' did not offer sufficiently unique characteristics to be classified as a graphicacy element.

The taxonomy (version 2) was published, presented and used in workshops at the Design and Technology Association Education and International Research conferences, where current teachers and experienced researchers had the opportunity to study, analyse, use and discuss the taxonomy. The instrument used to test the inter-rater reliability of the taxonomy is shown in Figure 2 (the images) and Figure 3 (the task). The images were taken from textbooks written in Greek so that the task was evaluating the classification of the images without written explanations, as the participants were not Greek speakers.

In order to make the taxonomy available to a larger number of teachers it was also circulated through a UK education magazine (*Designing*, Danos, 2009) alongside the 'Quick on the draw exhibition' (Baynes, 2008) and teachers where invited to comment on the taxonomy and,

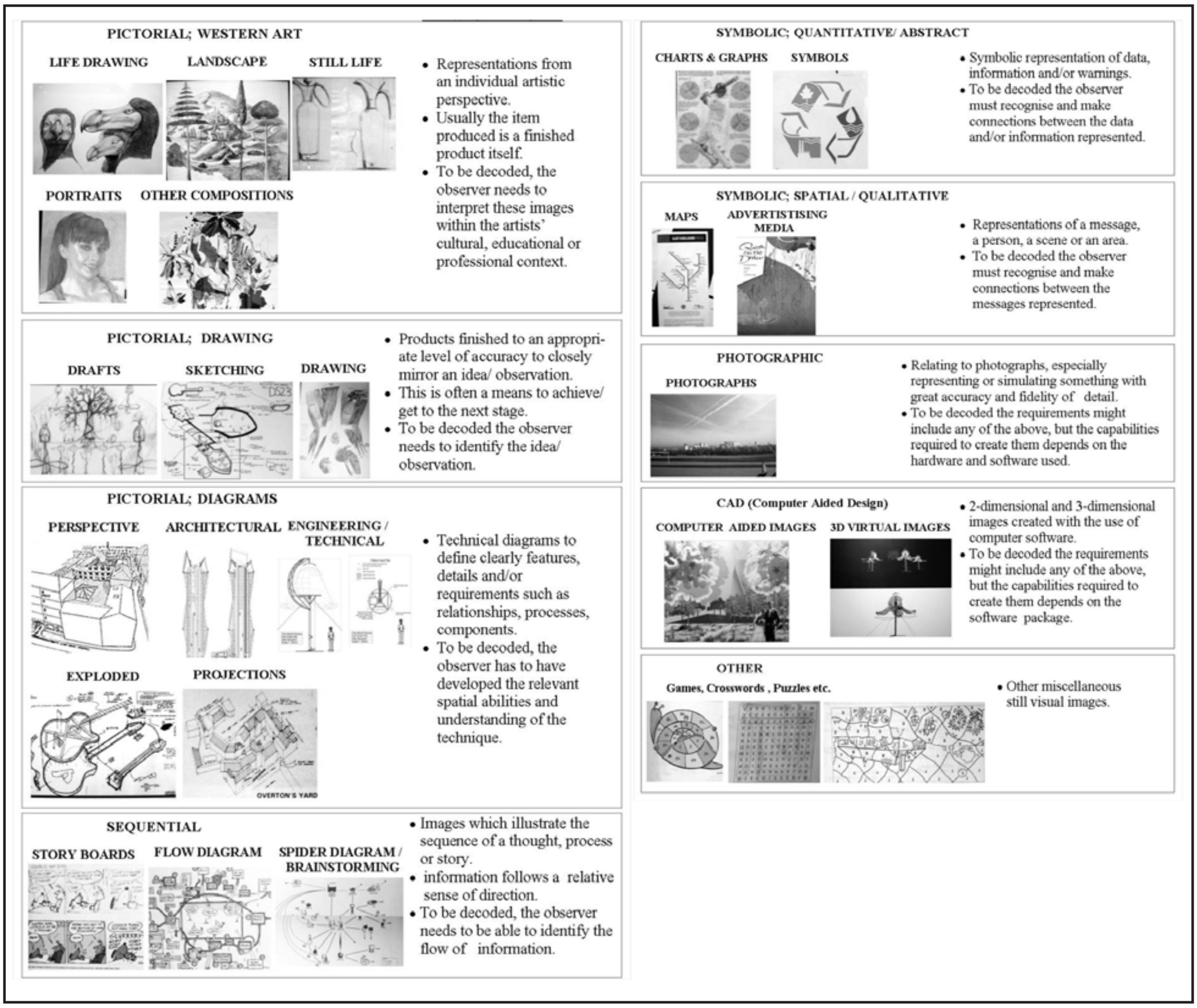

Figure 4. The taxonomy of Graphicacy designed to be used for research of image use within an educational context (Danos, 2012)

		PICTORIAL														SEQUENTIAL				SYMBOLIC								
		Graphic arts					Drawing			diagrams						Sequential				Abstract		Spatial			CAD			
		Art	Life drawing	Landscape	Portraits	Still life	Drafts	Sketching	Drawing	Annotated	Architectural	Engineering / technical	Exploded	Perspective	Projections	Cartoons	Story board	Flow diagram	Spider diagram	Charts & graphs	Symbols	Maps	Photographs	Advertisement	CAD	3D	Other	No. of types of images
CYPRUS	Subject 1								/	/		/			/		/	/	/	/	/	/	/		/	/	/	14
	Subject 2								/						/		/	/	/	/	/	/	/		/	/	/	12
	Subject 3	/						/	/	/		/		/	/				/	/		/	/		/			10
	Subject 4								/		/	/		/	/	/	/	/	/	/		/	/					11
	Subject 5	/						/	/	/	/	/	/	/	/		/	/	/	/	/	/	/	/	/	/	/	18
	Subject 6	/		/	/	/																						4
		3	0	1	1	1	0	2	5	3	2	4	1	8		1	4	4	5	5	3	5	5	1	4	3	3	

Figure 5. Investigating where graphicacy fits across the curriculum in one school

if interested, to use it in their own teaching or research. In order to ensure the validity of the taxonomy beyond the UK, it was also published through a USA based international association, the International Visual literacy Association (IVLA). The taxonomy was presented and used during the IVLA conference held in Cyprus, and was then published in the selected readings of those proceedings (Danos & Norman, 2010).

Finally, a formal Delphi study group with experts on visual literacy from the UK, Cyprus, Sweden and America was conducted. There was a positive reaction form the participants relating to the taxonomy of graphicacy. The feedback from the Delphi study group suggested the approach to be 'interesting and useful', and (also) because the taxonomy is, and should be a work in progress. This is an efficient way of gathering a variety of up-to-date views on the subject. The thrust of the categories is clear as (it is) complete in terms of categories and the category description explains the distinction between the categories.

All the stages described above helped shape the taxonomy to its current state (version 3), and evidence of its use suggests it provides a comprehensive and appropriate tool for research in a Western educational context with regards to the types of images and the graphicacy skills (the ability to communicate [code & decode] information through still visual images) required to deal with them. Including the images used within education in Eastern cultures would be expected to require further development of the taxonomy.

Investigating graphicacy's significance in the curricula of three schools

As stated above the use of graphicacy across the curriculum was investigated in three schools, following the same method.

Stage 1 – Photographs taken during the interview were cropped and the lighting balance was corrected using Photoshop.

Stage 2 – Individual images were tagged (on the computer) using the relevant categories from the taxonomy.

Stage 3 – All files (images) were grouped in relevant folders (on the computer) according to their type and in categories defined by the taxonomy of graphicacy.

Stage 4 – The number of types of images used across each of the subjects in the curriculum were counted and mapped. The number of subject areas using each type of image was also counted. An example of this method is illustrated in Figure 5.

Stage 5 – Images per subject area were placed in the taxonomy.

Stage 6 – Images were clustered into the types of image. All images of the same type that had been gathered were placed together and tagged according to the subject area they were gathered from. Examples of these are shown in Figures 5 and 6.

Using the analysis of all results gathered, comparative studies were also conducted, where patterns of graphicacy

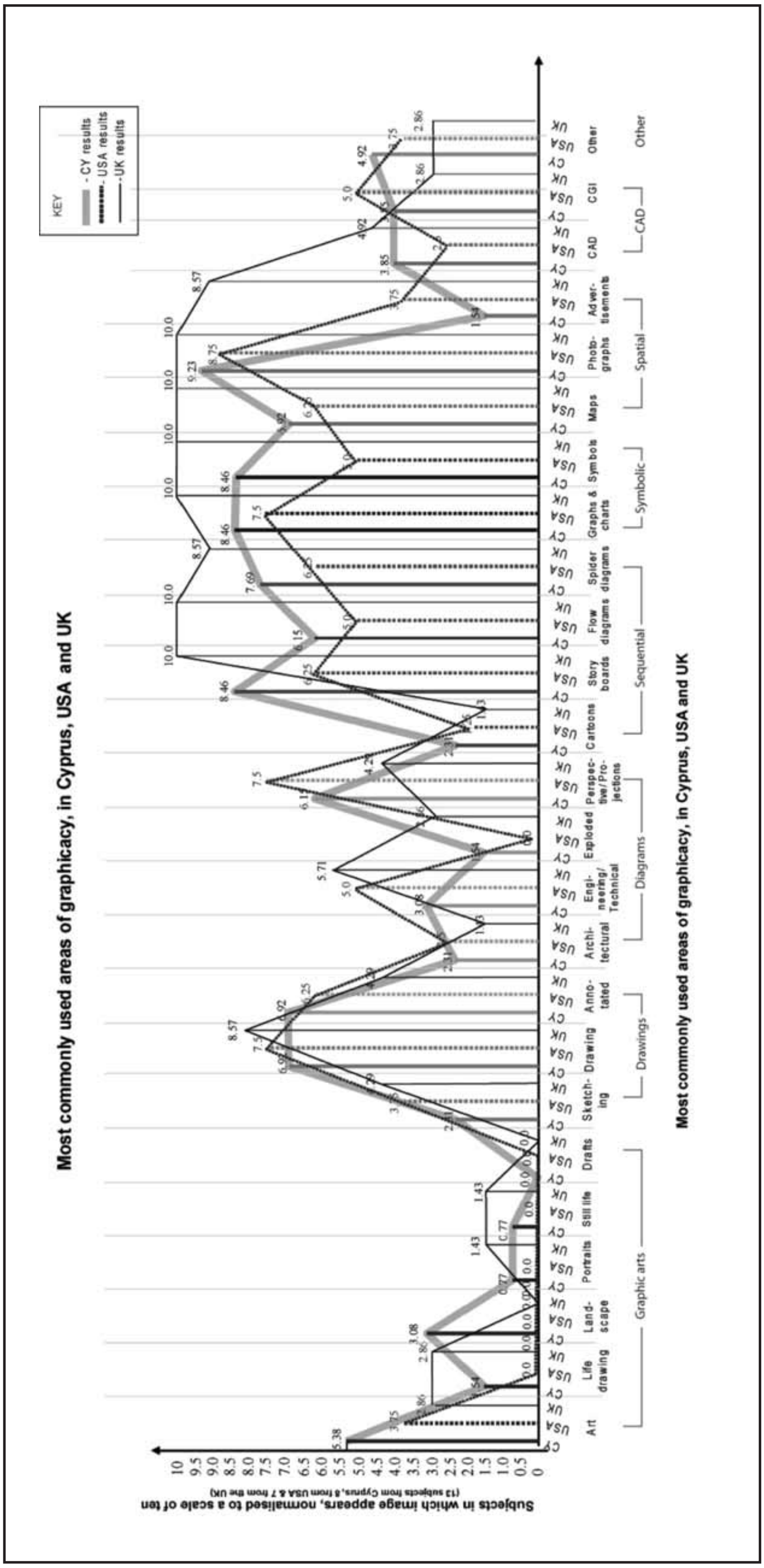

Figure 6. Graph comparing graphicacy use in three schools

use emerged. Figure 6 illustrates the patterns created based on the popularity of image use across the three schools. The three different types of lines are drawn for easier pattern recognition, having colour co-ordinated bars relating to each type of image (graphicacy element). The results on the x axis are placed according to each graphicacy element; starting on the left hand side with the Cypriot school results, followed by the USA and the UK results. All results have been normalised out of 10 for fair comparison. The results suggest a great similarity in the pattern of the image use (Figure 6).

Of the three schools, the UK school uses the most graphicacy elements with an average of 13 types (value has been rounded off to the nearest decimal number) of elements across the subjects studied. The Cypriot school follows with an average of 12 and then the USA school with an average of 9. These averages were calculated by counting the different graphicacy elements used across all the subject areas studied within each school, and dividing by the number of the relevant subject areas. The study identified the subject areas related to particular aspects of graphicacy (Danos & Norman, 2010) and has indicated that graphicacy is very widely used in all the subject areas analysed.

However, there were evident inconsistencies in the use of graphicacy within these three school curricula. For example, sequential images have been identified as one of the most popular elements of graphicacy used across the curriculum. However, within the physics textbooks analysed, sequential images were completely missing within the Cypriot textbooks. This might suggest that there is no clear published information on the benefits of using such images. The teachers (or textbook writers/designers) of physics in Cyprus are possibly unaware of the benefits of using sequential images which seem to be apparent to the teachers or the textbook designers in England and the USA. This is a fair reflection of the results of how graphicacy is used in the textbooks used in the Cypriot schools, since all the schools use the same textbooks.

The inconsistent use of graphicacy that was identified made the similarities within the pattern of graphicacy use across the three schools hard to interpret. It is very unclear as to how such similarities arose, when it is clear that there is no shared policy or strategy suggesting the best way of using graphicacy within education. The most commonly used image overall in the textbooks analysed in all three schools was photographs. As with all elements of graphicacy, there are numerous different types of image under each category. However, most photographs used in the textbooks were the typical realistic imprint of whatever was photographed in real life. One of the explanations for the selection of such popular elements of graphicacy used in textbooks might lie in the textbook designers' preferences. For example, textbook designers might like photographs as they can 'liven-up the book'. In a similar way, graphs and charts might have been popular because they can save space in a book, and considerable information can be communicated through them.
In addition, the fact that those images are found in the textbooks, does not translate to the way in which each individual teacher uses images during the class. Some teachers often put more (or less) emphasis on them than others.

Some of the least used elements of graphicacy appear to be subject-specific. For example drafts, life drawing, portraits and still life are often used in art and design and technology, but are not significant in learning mathematics. This provides an indication towards the subject areas which could carry the main responsibility in teaching particular areas of graphicacy. The subject area, within the range of subjects analysed, which used the biggest variety of images in teaching in England and Cyprus was design and technology (22/25 and 18/25 equivalent). (The opportunity to conduct research within this subject area in the USA was not available).

The potential offered by graphicacy, within pedagogic strategies, was well recognised across the curriculum, as all textbooks analysed used images to enhance learning in a number of ways. The results gathered formed the basis for an initial indication towards cross-curricular links relating to graphicacy. The results focused on the inbound (reading and understanding/ decoding) graphicacy skills, illustrated in Table 1. The table illustrates the cross-curricular links between subject areas within each school, as well as a general outcome within all schools for each individual element of graphicacy.

Literature review concerning children's development of graphicacy

A literature review revealed some prior research concerning children and graphicacy use in different subject areas. Research has been conducted concerning the relationship of graphicacy to cognitive development (e.g. Spencer et al., 1989), in particular spatial ability (e.g. Wilmot, 2002) and gender differences (e.g. Boardman, 1990). Prior studies have also explored the importance of graphicacy in education e.g. the balance of text-based and visually-based resources within educational materials and its importance for learning (Verdi et al., 1996), the significance of graphicacy in the presentation of quantitative information in an educational context (Jones et al., 2000) and the emerging research agendas associated with computer generated images. Research has also been completed on cartography and graph reading (Boardman, 1976, 1983, 1985, 1986, 1890; Finson and Pederson, 2011; Sandford, 1972; etc.). Some of this research fits into two contradictory groups; studies supporting the advantages of using visual aids and those highlighting the disadvantages of using them.

The literature discussed a range of stages and levels of drawing and mark making abilities that children go through at various ages. Existing knowledge on developmental stages was brought together, covering a range of ages relating to visual literacy. The development appears to be rapid, as clear progression has been noted within approximately every 6 month interval, starting from the infant stage to around 8 to 9 years of age. Some information has been gathered providing a more general progression between the ages of 10 to 16 years and beyond.

The literature review also revealed the limited amount of information which currently exists regarding human development and progression in drawing and more specifically children's' abilities to create images. Detailed work was conducted by Kellogg in the 1970s, which describes the stages children go through in drawing, from ages 1½ to 8 years old. Other academics and scientists have looked at this in a more generic way, identifying stages covering longer periods of development time (2 years and more). Academics, scientists and other authors have described stages children go through during the years from 11-14 covering different aspects of development, but the information found has been rather vague. Detailed work focused on the 11-14 age range is needed.

			UK school								Cyprus school														USA school									
Graphicacy elements			Maths	Science	DT	English L.	French L.	Geography	RE	Out of 7 subjects	Maths	Biology	Chemistry	Physics	DT	Art	English/ French/ German L.	Greek	Geography	History	Music	ICT	RE	Out of 13 subjects	Calculus	Geometry	Biology	Chemistry	French/ German L.	ICT Java	History	Art	Out of 8 subjects	Out of 28 subjects over 3 schools
PICTORIAL	Graphic arts	Art	X		X					2				X	X	X		X		X	X		X	7					X		X	X	3	12
		Life drawing			X					1							X						X	2									0	3
		Landscape								0						X			X			X	X	4									0	4
		Portraits	X							1						X								1									0	2
		Still life		X	X					2						X								1									0	3
	Drawings	Drafts			X					1						X								1									0	2
		Sketching	X	X	X					3				X	X		X							3	X				X		X		3	9
		Drawing	X	X	X	X		X	X	6	X	X	X	X	X		X			X	X	X		9	X		X	X	X	X			5	20
	Diagrams	Architectural			X					1										X	X		X	3	X	X							2	6
		Engineer-ing/ techni-cal	X	X	X			X		4	X	X		X	X									4	X	X			X	X			4	12
		Exploded		X	X					2					X									1									0	3
		Perspective		X	X		X			3	X			X	X		X		X	X			X	7	X				X				2	12
		Projections	X	X	X			X	X	5	X	X	X	X	X		X		X				X	8	X	X	X	X	X		X		6	19
SEQUENTIAL	Sequential	Cartoons		X						1	X				X		X	X						4							X		1	6
		Story board	X	X	X	X	X	X	X	7	X	X	X		X		X	X	X	X	X	X	X	11		X	X	X	X	X	X		6	24
		Flow dia-gram	X	X	X			X		4	X	X	X		X		X	X	X	X		X		9	X		X	X		X			4	17
		Spider dia-gram		X	X	X	X	X	X	6	X	X	X	X	X		X		X	X	X	X	X	11	X			X	X	X	X		5	22
SYMBOLIC	Abstract	Charts & graphs	X	X	X	X	X	X	X	7	X	X	X	X	X		X	X	X	X	X	X	X	12	X	X	X	X	X		X		6	25
		Symbols	X	X	X	X	X	X	X	7		X	X		X		X	X	X	X		X	X	9	X				X		X		3	19
	Spatial	Maps	X	X	X	X	X	X	X	7	X	X	X	X	X		X	X	X	X	X	X	X	12	X	X			X		X		4	23
		Photo-graphs	X	X	X	X	X	X	X	7	X	X	X	X	X		X	X	X	X	X	X	X	12	X	X	X	X		X	X	X	7	26
		Advertise-ments	X	X	X	X	X		X	6					X		X							2	X				X		X		3	11
CGI	CGI	CAD		X	X			X		3		X	X	X	X			X				X		6			X	X					2	11
		3D		X	X					2		X	X	X	X				X					5	X	X		X					3	10
		other	X	X			X		X	4		X	X		X		X	X		X				6				X	X	X			3	13
Out of 25 elements			14	19	21	8	9	11	10		11	13	12	12	19	5	15	10	11	12	8	10	12		14	8	7	10	13	7	11	2		

Figure 6. Graph comparing graphicacy use in three schools

Furthermore, skills and abilities related to the developmental stages as described by a number of academics (Kellogg, 1970; Arizpe & Styles, 2003; Schweizer, 1999; Lowenfeld, 1964; Ehrenzweig, 1965) were gathered and analysed. Research studies providing evidence on the technical limitations of children's ability to represent three dimensional (3D) shapes in two dimensional (2D) drawings have been identified. Constraints on their ability to represent overlap, acute angles, oblique lines, spatial relationships and scale must inevitably dictate the type of design drawings we can reasonably expect children to produce at the ages of 5, 7, 9 and 11 years old. This re-enforces the need for research around graphicacy and students' potentials, as it became clear that little has been established about the outbound graphicacy skills of children. Research concerning children's response to images (i.e., picture-books) indicates similar research opportunities as a range of perspectives were found on developmental differences identified when analysing and understanding images (Aldrich & Sheppard, 2000; Verdi et al., 1996; Arnold & Dwyer, 1975; Booher, 1975; Rigney & Lutz, 1976). For example, some authors suggest that these responses are age related (Winn, 1993; Singer & Donlan, 1982).

The review also suggested that where nature stops and nurture takes over remains unresolved. Strong indications are provided however, as many authors agree that around the age of 8 years old children have to 'make an effort to learn how to draw', or else they 'give up drawing' (Kellogg, 1970; Cox, 1992; Lowenfeld, 1964). This might be the primary reason that developmental stages and progression become apparently ill-defined around and after that age. However, no empirical evidence has been found to support that view.

Relating to issues around nature versus nurture, some academics conducting research under the discipline of geography, have observed that children's map abilities improve as they grow older, indicating the developmental nature of mapping abilities (Hart et al, 1991; Boardman, 1990). However, Ghuman and Davis (1981) found performance depended more on general intelligence rather than on age. Boardman reported that there is always the possibility that children may know far more about their spatial environment than they are actually able to draw on paper. It was also supported that the interconnectedness and interdependency of spatial perceptual skills and spatial conceptual understanding are

RESEARCH

important and should therefore not be underestimated. Research by a number of authors has also identified free-recall sketching to be an effective way to help children recall spatial information (Boardman 1990; Matthews, 1985; Hart, 1981).

Exercises to enhance elements of graphicacy drawn from this review are focused mainly on spatial abilities. This is primarily due to the discipline-perspective of the investigations. Balchin's (1996) suggestions follow closely Glasgow's (1994) belief, referring to dealing with semiotic images. Balchin focuses his view on more everyday uses of symbols and map reading, which could aid in practical situations. Glasgow on the other hand took a broader view, as he was looking to develop graphicacy skills through any semiotic images used in advertising. Glasgow believes that decoding and interpreting semiotics is a very important visual literacy skill, a view shared by many other authors (Wilmot, 2002; Van Harmelen, 2002; Boardman, 1983; Balchin, 1996; Matthews, 1985; Riding, 1979; and others). Boardman (1976, 1985 and 1990) and Sandford (1972) described a range of map-related exercises, and related them to relevant levels of difficulty. The concept of contours appeared to be a difficult one for pupils to grasp, and the fact that third-year pupils performed better than first-year pupils suggested that understanding on this matter develops with age.

Gender issues have also been investigated (Sharkey, 1963; Linn & Petersen, 1985; Fairweather, 1976; Pearson, 1968, etc.). Correlations were made with gender, personality traits as defined in psychology and verbal imagery learning style. Differences were found between groups but no explanation was given as to which elements of each characteristic was responsible for these. Riding and Boardman (1983) concluded that the findings of their study indicated that map reading performance in tasks typical of those learnt in school do not depend on a single ability, nor is there a simple overall difference between boys and girls. This also supports Willmot's (2002) findings which suggested that having a strategy and incorporating a number of skills when working, is a key element in the successful completion of such tasks.

A number of authors have described in more depth some of the skills and abilities required to deal with certain graphicacy elements. The methodology adopted by Wilmot when dealing with graphicacy, led to the gathering of information on the skills, abilities and understanding of the students at the specific time-span at which the tests were administered. The data collection methods included direct observation, diagnostic activities, field notes and interviews, which enabled the researchers to also use their judgment to draw conclusions. This allowed the researchers to draw information on successful and unsuccessful strategies used during the tasks. This is important as it clearly illustrates the complexity of graphicacy. Many of the skills and graphicacy elements have to be incorporated together along with a broad conceptual framework of the task at hand, in order to complete it successfully.

Research has been conducted around different intelligence and abilities tests which use children's drawings as a means of measurement (Wilmot, 2002; Van Harmelen & Boltt, 1995; Satterly, 1964; etc.). Different authors' opinions on the reliability of such tests have been analysed in order to explore the positives and negatives of such practices. Even though no conclusion was reached as to the validity of the tests described, it offers a range of views and interpretations of children's drawings of varying quality and sophistication levels. The discussion on prehistoric art versus child art (Kellogg, 1970) provides one example of how children's art can be misinterpreted to have symbolic or other meanings.

Key realisations drawn from the literature review were:
- the recognition that graphicacy requires strategies for the combined use of skills;
- that further development of graphicacy elements through nurture is possible;
- that there were few prior research studies that shed light on children and graphicacy.

Designing teaching interventions to explore the potential role of Design and Technology

As a result of these realisations it was decided to explore graphicacy through practice-based research within which the complexity of these agendas could be accomodated. Five studies were completed, each focused on a different element of graphicacy from the taxonomy; portrait drawing, rendering, perspective drawing, symbolic representations and star profile graphs. Each study was focused on identifying the level of knowledge and abilities of students regarding their outbound communication skills, i.e. communicating information by creating the images. Pre-tests, tasks during the studies and post-tests illustrated students' abilities before the intervention; their potential while having guidance and support; and the outcomes indicating how many such interventions can affect their learning and ultimately their graphicacy skills. The design and outcomes of all five of these teaching interventions will be reported in detail in a future journal paper. However, brief descriptions of their contexts and relationship to teaching and learning in D&T are shown below, and the results of one such study (star profile graphs) then reported.

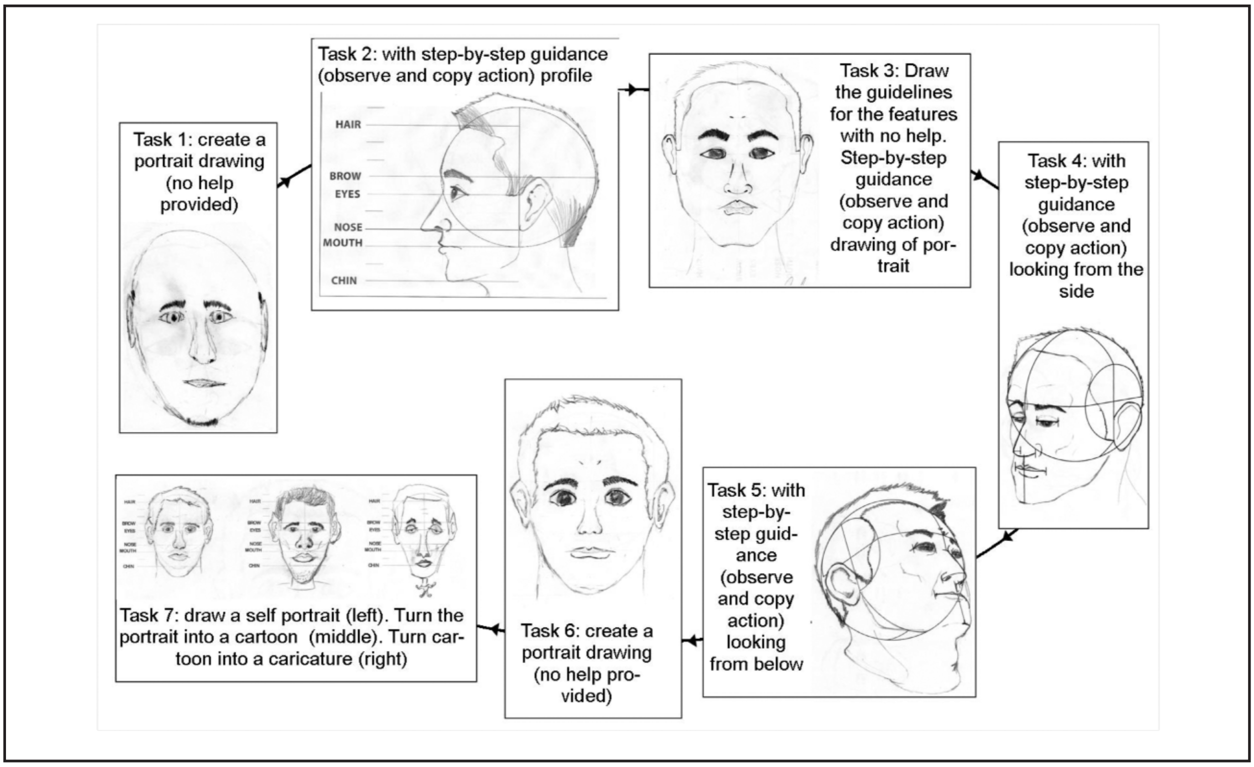

Figure 7. Portrait drawings study

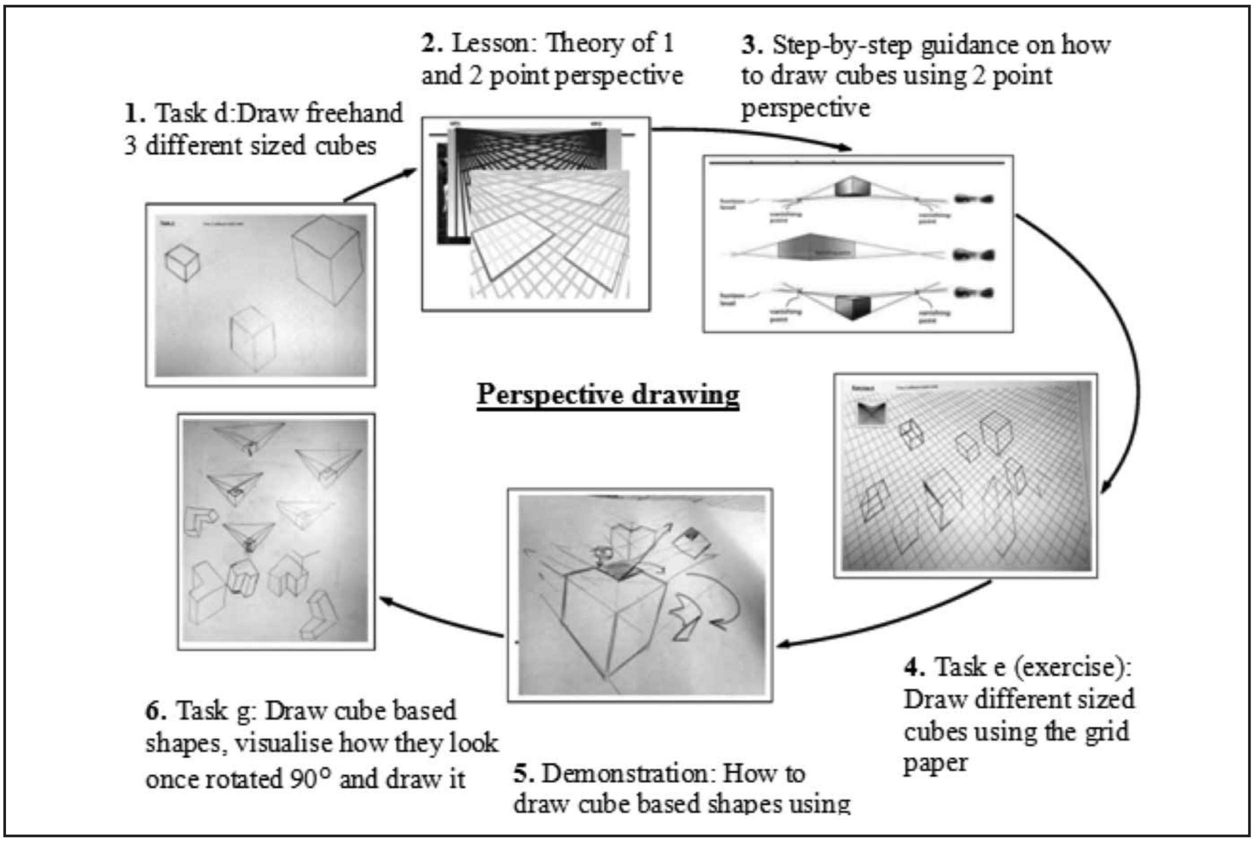

Figure 8. Perspective drawings study

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• Portrait drawing
The study conducted on portrait drawings offerrred a good example of an area where the point at which nature stops and nurture takes over is clear. This study was conducted with a group of 11 year old students as well as a group of adults from 15 to 18 years old. Participants were asked to initially draw a portrait of a man or woman. During the lesson, a range of step-by-step guided drawings were completed where explanations and information on the ratio of facial features based on a generic portraits were taught, from different viewing angles. Then the lesson progressed towards creating a self-portrait, and turning those into a cartoon and then a caricature. Figure 7 illustrates the sequence of tasks completed during this study.

• Perspective drawing
Perspective drawing is usually taught during graphic design or resistant materials as part of the design and technology lessons within secondary education. The understanding of perspective appears to develop through nature to a certain degree and then nurture is required to develop it further. As in the next two examples, the study involved 15 year old design students from a range of disciplines such as resistant materials, graphic products and art and design.

Figure 8 illustrates the sequence of tasks completed during the sessions, to identify the knowledge of students before the lesson, their potentials when working with guidance and their understanding and the impact the lesson had at the end of the lesson.

• Rendering
The study on rendering (Figure 9) began with a task involving 3D geometrical shapes. Such tasks can illustrate the level of knowledge of the area as well as the potential cognitive abilities of the students. Being able to visualise where and how the light will be reflected off differently shaped surfaces illustrates the ability of visualising the shape within the mind's eye. The sessions began by asking the students to colour in basic 3D shapes; a lesson followed on a rendering technique with exercises for the students and it ended by asking the students to render without help the same 3D shapes that they were given at the beginning of the session, in order to provide points of comparison of their skills and potential.

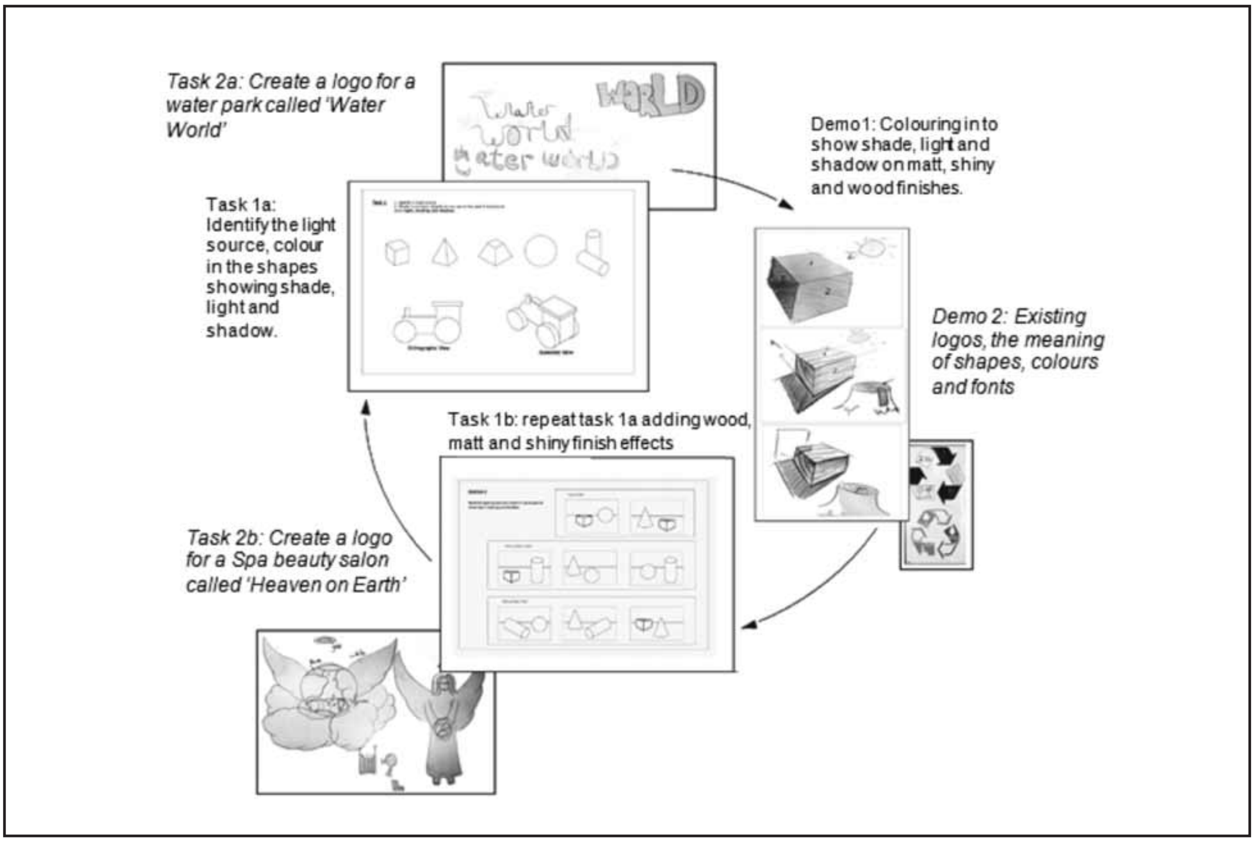

Figure 9. Rendering and logo design studies

• Symbolic representations
Students were asked to create a logo based on a given theme. A lesson on techniques suitable for logo designing followed along with exercises. At the end students were asked to complete a similar task to that set at the beginning, following a different theme (Figure 9). Symbolic design of a concept or information is an area requiring complex and advanced graphicacy skills as well as creativity. Finding a new, unique way of representing something, which is then clearly communicated to others is a skill which can be developed through practice and knowledge. It is an area taught primarily in graphic design, where students are dealing with the design of logos, branding and advertising material.

• Star profile graphs
One study conducted as part of a Food Technology lesson explored the use of the star profile graph. The study was conducted with two separate classes of 11 to 12 years old children (Year 7) and was part of the food technology lesson. The tasks prepared for this session increased in an assumed level of difficulty as the lesson went on (Figure 10). For each task, the students were firstly asked to draw the star profile individually without adult help. The area was then discussed and the correct solution illustrated and explained. The students where then asked to draw the correct solution. Help was provided where necessary.
The first task related to a four elements star profile and was different from the others as it was an area that had been previous taught to the students. Task 2 was focused on creating an eight elements star profile using set squares. Task 3 was focused on drawing a six elements star profile and Task 4 was a comparative star profile, where multiple product evaluations were drawn on a four elements star profile.

Through the analysis of the students' work, a Continuity and Progression (CaP) descriptors list has been drawn up. The CaP descriptors lists are building blocks towards a library of instructions concerning the teaching and learning

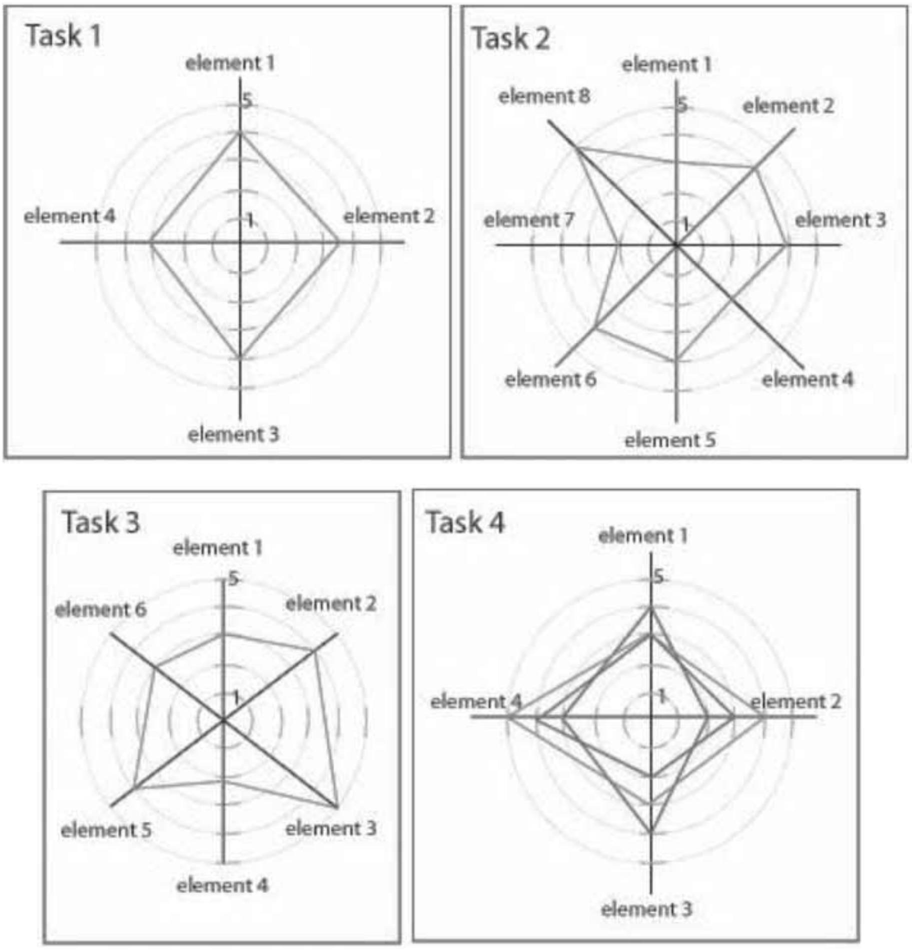

Figure 10. Star profile tasks

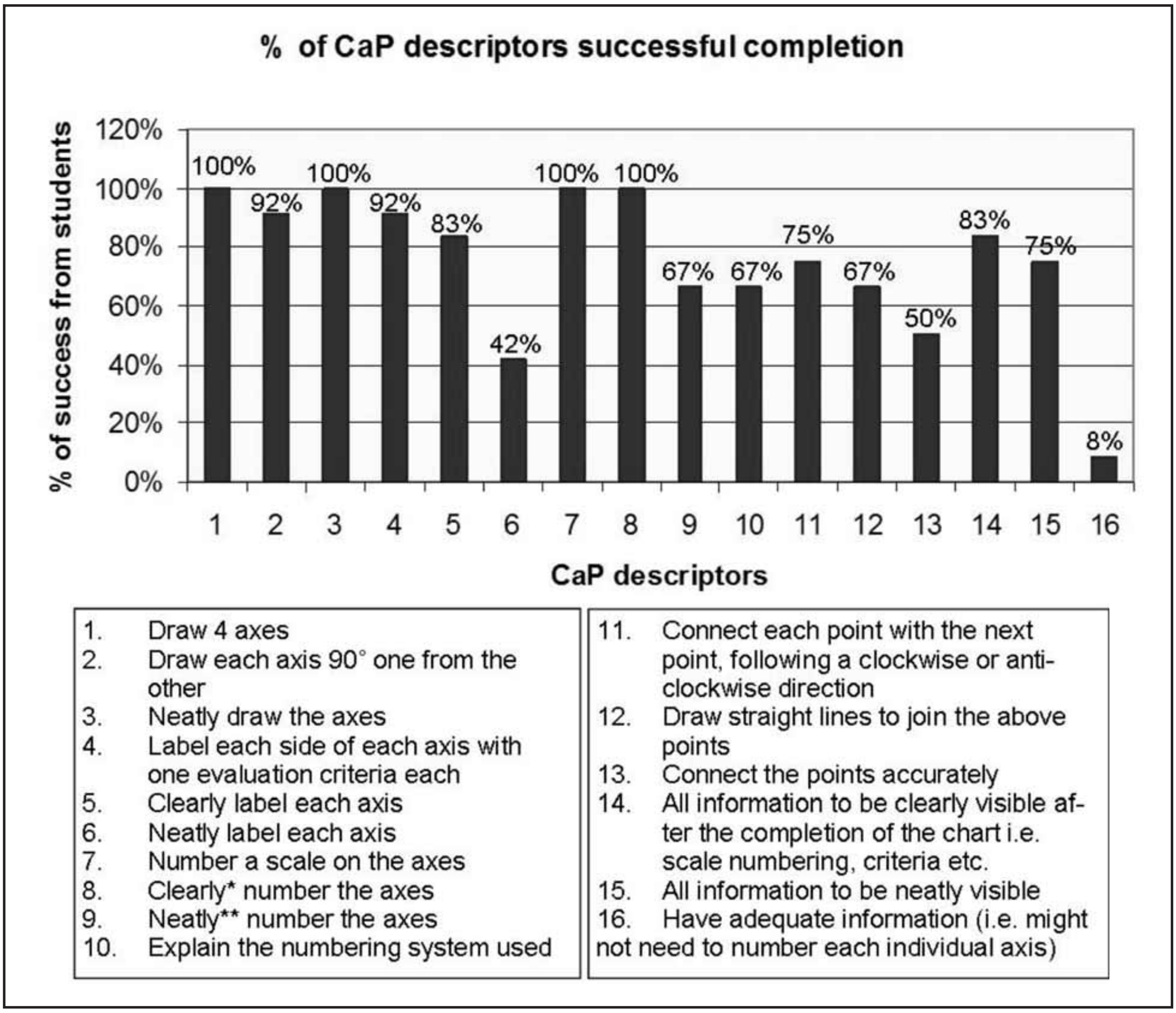

Figure 11. Rate of success for each of the continuity and progression descriptors

of graphicacy elements in a structured and organised manner. In this way, teachers using for example a star profile in History to plot various expeditions in order to visually compare the most/ least successful ones; can build on the knowledge gained during the Food Technology lesson. Figure 11. shows an example of the analysis conducted, illustrating the rate of success on the CaP descriptors achieved by the students of one class, for Task 1 (four element star profile). The above results as well as the CaP descriptors list drawn for the other four elements of graphicacy studied are reported in Danos and Norman (2010).

Discussion: How graphicacy can affect learning

In general, most of the views expressed through the literature on the area of graphicacy share the same beliefs on the importance of graphicacy as a basic skill and the need for it to be included in the school curriculum along with literacy, numeracy and articulacy. A very successful analogy used by Balchin to describe its importance was 'graphicacy should be the fourth ace of the pack' (Balchin & Coleman, 1965:85). The fact that it has been identified and studied in numerous different countries, including Australia, South Africa, Ireland, the UK and the USA; many of which have asked for Balchin's 1965 journal paper to be reprinted at some stage, indicates the strength of the common-ground surrounding the concept of graphicacy and its potential to support curriculum development. An effective taxonomy that can capture the modes of thinking that each element of graphicacy embodies i.e., its epistemological roots is key to articulating this importance. Such articulation is not so much a matter of describing each category in words, although that is a useful step, as recognising that individual graphicacy tools enable particular kinds of thinking to occur and subsequent actions to take place. A star profile allows one to compare the preferences from a survey during a mathematical problem; compare the success of battles through time in a history lesson or aid towards defining the best suited material for a product in a design related subject area.

This is also supported by the graphicacy cross-curricular links identified in all subject areas analysed in all three schools. For example, the analysis of the UK school's textbooks has identified links between mathematics, science, design and technology and geography through the use of engineering and technical drawings. In the Cypriot textbooks, all subject areas analysed except art and Greek language, use spider diagrams. In the USA textbooks, all subject areas expect ICT Java and art use charts and graphs. This evidence suggests that graphicacy is a key element within the curriculum in much the same way that literacy and numeracy are, but the thinking modes that graphicacy supports are less understood. The visual representation of data in order to facilitate pattern recognition has been long-established, but its significance is increasing with the emergence of computer-based visualisation tools. The lack of a graphicacy policy has now started being visible and talked about. One such talk has been created through the New York Times Centre by a designer, McCall (2011) who works for large organisations, illustrating information to facilitate its visualisation and analysis. McCall discusses the imbalance which exists in the curriculum, by incorporating literacy and numeracy, but not graphicacy.

Accepting the fact that certain graphicacy elements allow analytical thinking and pattern recognition i.e. star profile graphs, it is important to map out the continuation of this research appropriately. There is clearly a need for CaP descriptors within the curriculum, as illustrated by the large number of cross-curricular links formed by the common practice of graphicacy use, together with the lack of existing research on the area. The next step would be to look at the epistemological considerations of how knowledge from one subject area can be transferred to another; how these tools (graphicacy skills) help students to think, process information and what those enable them to do. In what ways is a child who has become expert in an element of graphicacy then more empowered to think and do certain things that they were not able to do before?

There is a wide range of different variations in images that each graphicacy element covers. This research has been focused on a small percentage of the existing graphicacy elements available. This notion is illustrated in Figure 12. The red balloons illustrate the elements of graphicacy studied in this research, against the map of all the potential elements of graphicacy available and used currently within education. It would be unrealistic to expect one researcher to analyse all, or even a large percentage of those images in order to create CaP descriptors, in a short time frame while keeping the work updated and current. The aim of this research is to help teachers and educationalists understand the importance of graphicacy

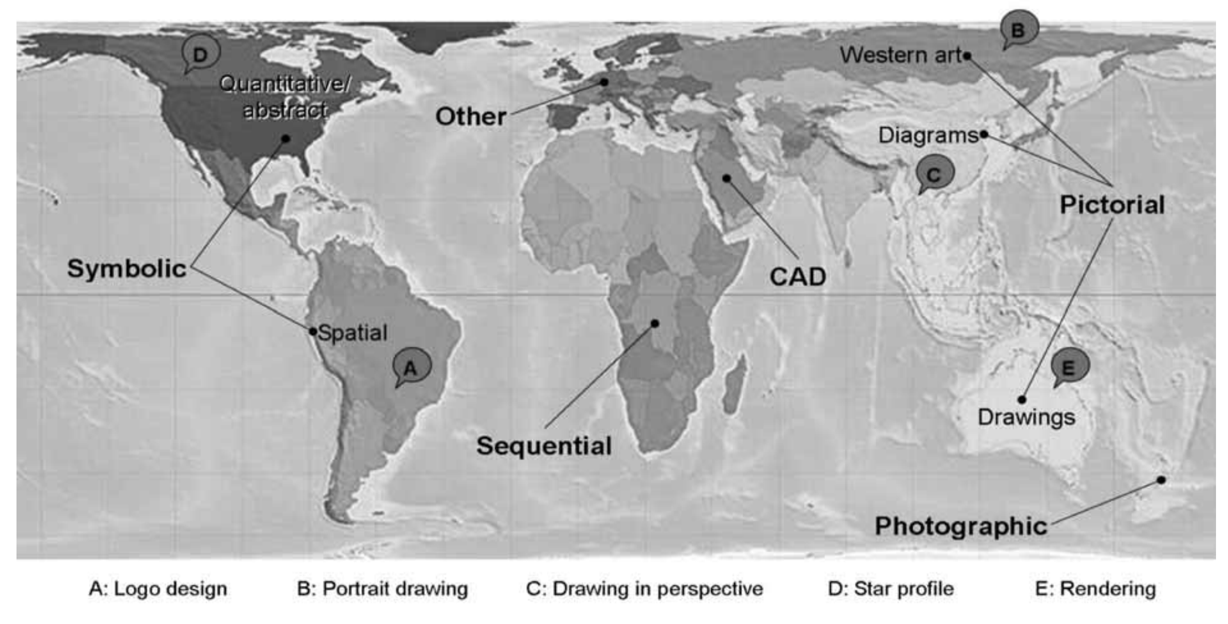

Figure 12. A representation of the graphicacy elements covered by this research

and what it takes for that to be taught successfully. In order for that to be achieved and be helpful for current practices, a number of graphicacy elements will have to be researched and analysed.

Because of the vast amount of work required in this field, collaboration methods such as co-research are required.

The tools to support a drive towards such a policy have yet to be developed fully, but the overall skeleton structure as well as samples of what can be done and how, has been completed. An up-to-date research tool has been developed; a taxonomy of graphicacy, which is essential as a starting point to this process. The next step requires working within each area of the taxonomy independently. Through the analysis of children's work, continuity and progression (CaP) descriptors have been developed in five different areas. These can be used as guidelines during the teaching and learning of those graphicacy elements. Having descriptors in each area of the taxonomy will enable teachers to talk about what happens in each subject area and make comparisons and connections between subject areas, potentially leading towards a systematic and co-ordinated teaching approach. This can lead towards a large-scale data gathering strategy, finally creating strong foundations for the teaching and learning of graphicacy.

Through the literature, diverse opinions in regards to the ability to develop spatial abilities and consequently graphicacy skills after a certain age were found. These ideas are also supported by the results of recent research conducted by various academics. Lane et al (2010) have introduced modules enhancing the sketching abilities of teacher trainees, to help them in becoming better communicators. Sorby (1999) has developed university modules to develop 3 dimensional spatial visualisation skills. The immediate need for having a curriculum policy in place is evident, as the lack of graphicacy development within the general education curriculum is obvious from the successes of these higher education initiatives. This means that graphicacy can be nurtured, instead of ignored after its natural development comes to a halt.

Graphicacy is believed to be used in all subject areas, in most lessons, in schools across the world. Analyses of school textbooks in schools from Cyprus, UK and the USA have started the validation of that belief and have shown cross-curricular links across all subject areas studied. The introduction of a graphicacy policy would therefore bring nothing essentially new within a curriculum; it would merely introduce and develop existing practice through an improved, more effective and systematic strategy. This would enable teachers to share information across subject areas on their practice and the subject's needs and share common terminology. In other words, teachers will start taking advantage of each other's pedagogy rather than working in isolation.

Conclusions

Existing taxonomies of still visual images for curriculum use have been identified; with a range of different taxonomic dimensions. A new, up-to-date taxonomy has been created based on updating and extending Fry's taxonomy. This new taxonomy of graphicacy has been established through this research and the Delphi study as a valid instrument for analysing graphicacy use across the curriculum through the analysis of textbooks.

With the use of the new taxonomy, practice-based research conducted has established that lessons and tasks can be created to collect student's work, analyse it and create continuity and progression descriptors. These have been used to study some elements of graphicacy within the curriculum effectively.

In the English and Cypriot schools, all subject areas studied had graphicacy links with design and technology at KS3 (design and technology was not studied in the USA). Graphicacy is linked across all subject areas for KS3, KS4 and KS5 levels as indicated by the research based on the analysis of textbooks. However, there is no current established methodology for measuring graphicacy within the curriculum.

A number of authors' work on studying graphicacy within the curriculum has been identified through the literature review. A number of researchers have conducted research on developmental stages of children's drawings. These have either been age specific or subject specific. However links have been identified concerning understanding the progression in the development of graphicacy, as well as cross-curricular links. There is a relatively large body of literature on graphicacy with its origins in different disciplines and a key first step was identifying gaps within prior knowledge, before deciding the next area in which to focus graphicacy related research (Danos, 2012).

This research has established that Year 7 students have the mental ability to learn how to use and map information visually using a star profile graph of four, eight and six elements. This is a clear indication that children can develop graphicacy skilsl through nurture.

The cross-curricular links identified through this research provide an initial indication as to how fundamental graphicacy can potentially be to students' progress. Further research is required for more specific answers as to how graphicacy affects students' learning, but an interim conclusion must be that it is 'fundamental' and in ways that have yet to be developed within curriculum planning.

References

Anning A., 1997. Drawing Out Ideas: Graphicacy And Young Children, *International Journal Of Technology And Design Education* 7, 219–239.

Aldrich F., Sheppard L., & Hindle Y., 2002. First Steps Towards A Model Of Tactile Graphicacy, *British Journal Of Visual Impairment*, 20(2), 62-67.

Arizpe E., & Styles M., 2003. *Children Reading Pictures: Interpreting Visual Texts*, London: Routledge/Falmer.

Arnold T., & Dwyer F., 1975. Realism In Visualized Instruction, *Perceptual And Motor Skills*, 40, 369-370.

Aldrich F., & Sheppard L., 2000. 'Graphicacy': The Fourth 'R'? *Primary Science Review*, 64, 8 – 11.

Ehrenzweig A., 1965. *Towards A Theory Of Art Education*' (A Report), Goldsmiths College University Of London.

Balchin W., 1996, Graphicacy and the primary geographer, Primary Geographer, January.

Balchin W., & Coleman A., 1965. Graphicacy – The Fourth 'Ace' In The Pack, *Times Educational Supplement*.

Baynes K., 2008. Quick On The Draw, *Exhibition*, 17 January – 29 March 2009, Harley Gallery Welbeck, Worksop, Nottinghamshire.

Baynes, K., 2011. *Vision, Modelling And Design*, International Design And Technology Educational Research And Curriculum Development Conference (IDATER Online), 17-26.

Boardman D., 1976. Graphicacy In The Curriculum, *Education Review*, 28,118-125.

Boardman D., 1983. Graphicacy and Geography teaching, Croom Helm, London.

Boardman D., 1985. Cartographic Communication With Topological Maps, In: D. Boardman (Ed.) *New Direction In Geographical Education*, London, Falmer Press.

Boardman D., 1986. Relief Interpretation, In D. Boardman (Ed.) *Handbook For Geography Teachers*, Sheffield, Geographical Association.

Boardman D., 1990. Graphicacy Revisited: Mapping Abilities And Gender Differences, *Educational Review*, 42, 57-64.

Booher H., 1975. Relative Comprehensibility Of Pictorial Information And Printed Words In Proceduralized Instruction, *Human Factors*, 17, 266-277.

Considine D., 1987. *Visual Literacy And The Curriculum: More To It Than Meets The Eye*. Language Arts, 64, 634-640.

Cox M., 1992. *Children's Drawings*, Penguin, Harmondsworth.

Danos X., 2009. Graphicacy in the curriculum, The *Design and Technology Magazine for Schools, Colleges and Universities*, Number 84, Autumn.

Danos X., 2012. *Graphicacy within the secondary school curriculum, an exploration of continuity and progression of graphicacy in children aged 11 to 15*, PhD Thesis, Loughborough University, Loughborough Design School, UK.

Danos X., & Norman E., 2009. The Development of a New Taxonomy for Graphicacy, *D&T – A Platform for Success: The Design and Technology Association Education and International Conference*, E. Norman and D. Spendlove (eds), The Design and Technology Association, Wellesbourne, UK, 69-84

Danos X., & Norman E., 2010. Graphicacy and students' learning, *Selected Readings of the International Visual Literacy Association*, Visual Literacy in the 21st Century: Trends, Demands, and Capacities, Maria Avgerinou et al (eds), The International Visual Literacy Association, 59-68.

Danos X., & Norman E., 2011, Continuity and progression in graphicacy, *Graphicacy and Modelling IDATER 2010*, Design Education Research Group, Loughborough Design School, 103-120.

Finson K., & Pederson J., 2011. What Are Visual Data And What Utility Do They Have In Science Education? *Journal Of Visual Literacy*, 30(1), 66-85.

Fairweather H., 1976. Sex Differences In Cognition. *Cognition*, 4, 231-280.

Fry, E., 1974. *Graphical Literacy*, Cited In; Journal of Reading, 1981, 24 (5), 383-390.

Fry E., 1981. Graphical Literacy, *Journal Of Reading*, 1981, 24 (5), 383-390.

Glasgow N., 1994. Teaching Visual Literacy For The 21st Century. *Journal Of Reading*, 37(6), 494-500.

RESEARCH

Ghuman S., & Davis R., 1981. An Assessment If Adolescent Comprehension Of Some Geographical Concepts Using Peel's Theoretical Framework, *Educational Review*, 33, 213-240.

Harmelen U., & Boltt G., 1995. *Primary Teachers And Science And Technology. The Role Of Graphicacy In An In-Service Programme For South African Teachers.* Unpublished Paper, Education Department, Rhodes University, Grahamstown.

Harmelen U., & Boltt G., 1995. *Primary Teachers And Science And Technology. The Role Of Graphicacy In An In-Service Programme For South African Teachers.* Unpublished Paper, Education Department, Rhodes University, Grahamstown.

Harmelen U, 2002. *Lego; The missing link in the spatial conceptual chain? Investigating graphicacy in the Southern African Context*, Rhodes University, Grahamstown, Private communication.

Hart R., 1981. Children's Spatial Representation Of The Landscape: Lessons And Questions From A Field Study, In L. Liben, A.H. Patterson And N. Newcombe (Eds.) *Spatial Representation And Behaviour Across The Lifespan* (Pp. 195-233). New York: Academic Press.

Hart R., Iltus S., & Katz C., 1991. The Participatory Design Of Two Community Elementary Schoolyards In Harlem, *Children's Environments Research Group*, City University Of New York, New York.

Hope G., 2008. *Thinking And Learning Through: Drawing In Primary Classrooms*, Sage, London.

Jones S, Tanner H., & Treadaway M., 2000. Raising Standards In Mathematics Through Effective Classroom Practice, *Teaching Mathematics And Its Applications*, 19(3), 125-134.

Kellogg R., 1970. *Analyzing Children's Art*, Palo Alto, CA: Mayfield Publishing Company.

Krane H., & Dyson L., 1981. *Graphics Communication*, Education Department Victoria.

Lane D., Seery N., & Gordon S, 2010. Utilising freehand sketching to amplify concept driven copmetencies. *Education & International Research Conference*, D&T Ideas Worth Sharing, The Design and Technology Association, 67-78.

Linn M., & Petersen A., 1985. Emergence And Characterization Of Sex Differences In Spatial Ability: A Meta-Analysis, *Child Development*, 56 (6), 1479-1498.

Lowenfeld V., 1952. *The Nature Of Creative Activity: Experimental And Comparative Studies Of Visual And Non-Visual Sources Of Drawing, Painting And Sculpture By Means Of The Artistic Products Of Weak Sighted And Blind Subjects And The Arts Of Different Epochs And Cultures.* London, Routledge And Kegan Paul.

Lowenfeld, V., 1964. *Creative And Mental Growth*, 4th Edition, New York, Macmillan Publishing Company.

Matthews H., 1985. Environmental Ability Of The Very Young: Some Implications For Environmental Education In Primary Schools, *Educational Review*, 37, 227-239.

McCall Tommy, 2011. Literacy, Numeracy, Graphicacy. May 9, 2011, *NY Times Center.* http://www.youtube.com/watch?v=D7Y4Ev7ml-w accessed on November 23, 2012.

Pearson M., 1968. *An Investigation Into The Use Of Large And Medium Scale (1:200,000) Or Larger Topographical Maps And Plans In Geography Teaching In The Field Of Secondary Education In Britain From 1885 To 1966*, Unpublished Mphil Thesis, University Of London.

Poracsky J., Young E. P. & Judy P., 1999. The Emergence Of Graphicacy, *The Journal Of General Education*, 48(2), 103-110.

Sandford A., 1972. Perceptual Problems, In Graves, N. J. (Ed), *New Movements In The Study And Teaching Of Geography*, Temple Smith.

Senate Standing Committee On Education And The Arts, 1981. The University Of British Columbia, 2329 West Mall, Vancouver, B.C., Canada.

Sorby.S.A, 1999, Developing 3-D Spatial Visualization Skills. *Engineering Design Graphic Journal*, V.63 (2), 21-32.

Riding R., 1979. The Effect Of Extraversion And Detailed Content Of The Recall Of Pose By Eleven-Year-Old Children, *British Journal Of Educational Psychology*, 49, 296-303.

Riding R., & Boardman D., 1983. The Relationship Between Sex And Learning Style And Graphicacy In 14-Year-Old Children, *Educational Review*, 35 (1), 69-79.

Rigney J., & Lutz K., 1976. Effect Of Graphic Analogies Of Concepts In Chemistry On Learning And Attitude, *Journal Of Educational Psychology*, 68, 305-311.

Satterly J., 1964. *Skills And Concepts Involved In Map Drawing And Map Interpretation*, New Era, 45.

Sharkey S., 1963. Mathematics, *Sexism In The Secondary Curriculum*, London, Harper & Row.

Singer H., & Donlan D., 1982. Active Comprehension: Problem-Solving Schema With Question Generation For Comprehension Of Complex Short Stories, *Reading Research Quarterly*, 7, 166-186.

Spencer C., Blades M., & Morsley K., 1989. *The Child In The Physical Environment: The Development Of Spatial Knowledge And Cognition*, Chichester, Wiley & Sons.

Stokes S., 2002. Visual Literacy In Teaching And Learning: A Literature Perspective, *Electronic Journal For The Integration Of Technology In Education*, 1 (1), 10-19.

The Associated Examining Board, 1984. *Test in basic graphicac.*

The Associated Examining Board, 1996. *Basic Test Syllabus: Graphicacy*, AEB, Stag Hill House, Surrey.

Verdi P, Kulhavy W, Stock A, Rittschof A, & Johnson T, 1996. Text Learning Using Scientific Diagrams: Implications For Classroom Use, *Contemporary Educational Psychology*, 21, 487-499.

Winn D., 1993. *A Conceptual Basis For Educational Applications Of Virtual Reality*, Human Interface Technology Laboratory Technical Report, Seattle, WA: Human Interface Technology Laboratory.

Wilmot D., 2002. Investigating children's graphic skills: A South African case study, *International Research in Geographical and Environmental Education*, 11 (4).

Wilmot D., 1999. Graphicacy As A Form Of Communication, *South African Geographical Journal* (Special Issue June) 81 (2), 91-95.

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