IASDR07
INTERNATIONAL ASSOCIATION OF SOCIETIES OF DESIGN RESEARCH THE HONG KONG POLYTECHNIC UNIVERSITY 12TH TO 15TH NOVEMBER 2007

A PHENOMENOGRAPHIC INQUIRY INTO A TAXONOMY OF DESIGN LEARNING

Eva Yuen

School of Design, Hong Kong PolyU, Hung Hom, sdeva@polyu.edu.hk

ABSTRACT:

This paper sets out the phenomenographic approach to revealing design learning. It presents an inquiry into ways of obtaining a deep understanding of colour theory, and a comparison of the various levels of understanding and applications of colour theory among a group of undergraduate multi-media design students. Evidence of cognitive value in the students' design acts prevailed in their authentic construction of meanings, exhaustive inquiry, and value transformation. The type of intellectual activities involved a number of knowledge domains: the domain of theory, the domain of practice and application, and the domain of strategic operation. The domain-specific activities were also found to interact differently in the individual student's conceptualization of knowledge and that led to different problem-solving approaches. Variation of the students' cognitive models appeared to be composed of two distinct types of learning dimension.

Keywords: dimensions of design learning, conceptualization of domain-specific knowledge, problem-solving approaches

1. INTRODUCTION

The paradigm shift from product-oriented to human-centered approaches in design professions has challenged the traditional discipline-based design curriculum, and studio-based design learning is often found to lack connection between pedagogic strategies and learning sciences (Newstetter et al., 2001). Implications have been drawn from the contemporary educational view that learning takes place when students engage in the search for domain knowledge, generation of procedural skills and transformation of concepts with metacognitive awareness, the kind of intelligent interactivity needed for creation (Sternberg, 1987; Gardner, 1996; Reeves, 1999). The proposition in this paper about design learning is that students' understanding and the mental formation of their knowledge is continuously structured and re-restructured by them under external (objective) and internal (subjective) constraints.

Bruner (1973) was considered by Kolb (1984) and Bigge and Shermis (1992) to have described human beings as information processors, thinkers, and creators who learn from grasping experience and transforming knowledge. This implies that pedagogic practices in designing must bring about a confrontation between novice and expert approaches to problem solving. Design learning should thus be concerned with the information known by the students, how that information is elicited and processed for use, and how it affects students' problem-solving approaches. Research on problem solving and education suggests that without adequate domain-specific knowledge students have difficulties in transferring what they have been taught to new situations. More obviously expert problem solvers use a large amount of domain-specific knowledge including complicated algorithms and specific heuristics to recognize problems (Phye and Andre, 1986).

In cognition terms, designers act on their prior knowledge and engage in the business of constructing and modifying new mental representations relevant to the design goal. This process of conceptual change can lead to creativity (Ward et al., 2002). Presumably, the cognitive ability to make conceptual changes is directly related to ability in structuring imaginative thoughts, and the acquisition of domain-specific knowledge and application of perceptual heuristics become the major components of creative problem solving. Pedagogically, coaching students in idea development during problem solving is about strengthening their cognitive ability in making insightful conceptual changes. As Weisberg (Sternberg, 1999, p.248) said: “One may be able to understand creative thinking by determining the knowledge that the creative thinker brings to the situation he or she is facing”. To phenomenographic researchers, learning takes place when the learner experiences a new concept of the world and knowledge is then born. *Learning is mostly a matter of reconstituting the already constituted world* (Marton and Booth, 1997, p.139). This research was conducted mainly with this perspective concerning learning.

2. UNDERLYING THEORY

Phenomenography is fundamentally an empirical-based research approach to explore the qualitatively different ways in which people experience or understand phenomena in the world, and the core concept of “conception” or “way of experiencing” involves the referential aspect and structural aspect of learning (Marton and Pong, 2005). The referential aspect signifies the meaning of the conception while the structural aspect acts on the conception; these knowing what and knowing how aspects render the relationship between an individual and the surrounding world as contextually bounded by the internal and external horizons of a phenomenon (Marton and Booth, 1997).

In educational settings the experience of learning is concerned with the dialectically intertwined nature of the two aspects and the ways that the discerned aspects constitute a structure of awareness. The notion then arises out of the educationally critical aspects of a phenomenon in which the critical differences between learning experiences may lead to deep understanding of the phenomenon (Cope, 2000). The point of departure for the theoretical framework of this research was based on the theory of variation, that “qualitatively different ways of experiencing something could be understood in terms of differences in the structure or organization of awareness at a particular moments or moments” (Marton and Booth, 1997, p.100).

3. A STRUCTURE OF AWARENESS

Theoretically, a learner’s structure of awareness can be related to discernment, variation, and simultaneity (Marton and Pang, 1999; Pang, 2003). An individual’s perspective on learning or problem-solving tasks is the first thing to be taken into account in understanding changes in individual way/s of experiencing a phenomenon. Being knowledgeable in a subject involves a qualitative change to a deeper and more complex understanding of a phenomenon, and the qualitatively different levels of understanding a subject can be described, compared, and categorized in terms of different structures of awareness. The notion of "a structure of awareness" underpinning the theoretical framework was based upon two basic capabilities proposed by the phenomenographic views on learning: (a) we can discern entities and aspects, and (b) we can be focally aware of a few entities or aspects simultaneously (Marton and Booth, 1997, p.123).

3. 1. CONTEXTUAL THEMES AND DIMENSIONS OF VARIATION

In relation to designing, aspects of an experience refer to the problem-solving approaches that bring about different design ideas or contextual themes; whereas in learning, such aspects refer to the different levels of understanding that bring about the qualitative dissimilarities within conceptions. In phenomenography, conceptualization of a domain-specific knowledge is seen as the key learning-mechanism leading to logical complexity or levels of understanding. The theoretical discourse of different levels of understanding a phenomenon lies in the consistent definition of the critically discerned aspects or the hierarchical learning objectives (the two interchangeable terms used in this research), which can be experienced in learning or in different problem situations (Bloom, 1956; Fazey and Marton, 2002). Similar to Bloom's taxonomy of educational objectives, Fazey and Marton (2002, p.243) hold this theoretical view on the predictable performer's operations: "The progress from beginner to expert, from novice to skilled performer, involves a progression in accurately anticipating when and what will happen and matching that to appropriately selected actions. Such progress can be expressed, from the learner's point of view, as the change from something being difficult to it becoming easy. When it is easy, it is understood or when it is understood, it is easy." In other words, variation of discerned entities and aspects prevails in learners' contextual themes and hierarchical learning objectives. The entity of an experience is thus characterized by meaning and structure that can be expressed by words or through artefacts (Marton and Booth, 1997).

Variation was also found to be manifested in the form of contextual shifts which indicated a variation between students' living worlds and symbolic representations of the world, and in the form of conceptual shifts which suggested a variation of conceptual level between the general and the specific (Marton and Pang, 1999). The ability to bring all relevant aspects into focal awareness allows a variation of ways of experiencing a phenomenon. When certain aspects of an experience are invariant and others vary, a dimension of variation is opened. This means that conceptions are qualitatively different due to the way that the different aspects of an experience merge with each other, and that systematic description of the distinct constituents of awareness is made possible because the discerned aspects of a phenomenon represent the 'dimensions of variation' of a particular value (Cope, 2004). Theoretically, different structures of awareness correspond differently to the nature of an aspect, the interaction between the aspects, and the intimate relationship between the internal and external horizons of a phenomenon (Cope, 2002).

3. 2. SECOND-ORDER PERSPECTIVE AND LEARNING DESCRIPTIONS

Understanding the nature of dimensions of variation in learning is of important for students' learning, because they describe individual students' capabilities to simultaneously discern and relate parts to the whole (Svensson, 1984; Runesson, 1999). These qualitatively different ways of experiencing ares called the "second order perspective" (Marton, 1981; Marton and Booth, 1997). Second-order perspective involves the description of how things appear to the students' perspective but not the things as they are. A student's way of experiencing something is seen as internal relationship between her/him and the world.

Describing the experiencing of a phenomenon is about looking into the "values" of each dimension of variation, and interpreting different categories of describing a phenomenon is concerned with exploring the relationships between the dimensions of variation, which bring about the constitution of an outcome space (Gurwitsch, 1964; Marton and Booth, 1997; Marton, 1998; Bowden and Marton, 1999; Fazey and Marton, 2002; Cope, 2004). The theoretical view supports the framework of this research to analyse how different aspects of the subject content became the thematic focus; whether the aspects of variants and invariants opened up dimensions of variation within the contextual horizons for deep understanding. Fundamentally, the research took on a systematic mode of data collection based upon logical inclusiveness and increased levels of understanding.

4. COLOUR LEARNING IN DESIGN EDUCATION

In the foundation year of design programme, visual literacy subjects are included to nurture students' perceptual sensitivity to visual qualities and their conceptual understanding of visual structures (De Sausmarez, 1990). It is believed that visual analysis provides the structure of conception, and that visual language or elements, either tactile imagery or symbol systems, are used to reflect mutually exclusive modes of thought or intelligence (Arnheim, 1974). In studio practice, a teacher engages novice design students in abstract exercises of visual principles with the intent of advancing them from a novice position of unawareness to a senior position of proficiency. However, there is little consensus about how these learning experiences are connected to a specific design discipline such as product or multimedia design. The assumption is that visual principles provide students with the necessary vocabularies which are to be simulated in professional operations.

The assumption of 'automatic transfer of knowledge' becomes a problem when there is no defined appropriateness for beginning or advanced levels of subjects in the design curriculum or for the phases in which knowledge transfer should occur. For example, it is hard for students to connect colour in theory and colour for interior use (Miller, 1997). Basically, studio-based and project-based subjects require very different forms of knowledge and assessment methods. The former brings about students' expression of visual qualities by assigning extensive practices; it assesses students' levels of critical awareness of potential uses of appropriate media and tools for creativity. The latter brings contexts into students' projects as an educational strategy that addresses social and technological matters. Unless the content of both subject types is structured logically and sequentially, and assessment methods are in alignment with curriculum objectives, students may not develop basic visual principles for creative output and rely on personal preferences or intuition for a design solution.

4. 1. AN ORGANIZATION OF CONCEPTUAL HIERARCHY

Colour teaching has been reviewed in the broad field of art and design as an inseparable linkage between seeing and knowing. Some teachers emphasize the "seeing aspect" of colour learning (Zwimpfer, 1995), and some focus on the "knowing aspect" of colour learning (Tomcik, 1995). It is a fair assumption that there is a necessary connection between the making of artefacts and the development of the mind. It might also be more persuasive to suggest that making is not the only central activity, but that decision making is another essential activity. In reviewing a colour subject taught in a foundation year of design study, Yuen (1997) found that the teachers organized and presented colour theory to students in two ways: (1) colour properties- from simple and basic to more complex colour mixing for students to experience colour qualities; (2) colour relationship and application- from productive learning to receptive learning sequences for students to practice aesthetic criticism and demonstrate their growing awareness.

In Runesson's (1999) study on teachers' different ways of handling the mathematical topic "fractions and percentages", teachers were found to formulate different themes from certain aspects of the content and that opened up different dimensions of variation enabling students to discern critical aspects of the content. Apparently, learning may become deficient when conflicts occur between a teacher's presentation style and students' preference for conceptualization models and content hierarchy (Kaput, 1992). Subject content such as colour theory and its algorithms has in itself a preferred way or model of presentation. The levels of subject competence are thus concerned with both students and teachers in terms of task complexity and expectations.

4. 2. COLOUR TEACHING IN MULTI-MEDIA DESIGN

With an education in the nuances of colour in different contextual environments, design students need to 'experience' colour theory from multiple perspectives. In multi-media design, students need to see and understand colour with the use of computer software. The core question for design teachers is the nature of learner-human and learner-non-human interactions in a computer mediated learning environment (Moore, 1989), which is quite different from traditional studio setting. To multi-media design teachers, planning a subject is concerned with designing the pedagogical structures and determining the extent to which students are able to move (navigate), test (explore), and maneuver (self pace) through the manipulation of digital media.

Basically, studio-based design methods are about design-by-drawing, brainstorming, and prototype making; the learning-by-doing activities are often seen as being in conflict with systematic techniques such as cognitive analysis and synthesis (Green and Bonollo, 2003). This paper proposes that by studying sample practices of colour theory, some unifying order can be identified for the possible organization of a subject's conceptual hierarchy. It is about revealing students' ways of acquiring a deep understanding of the two major roles of colour (1) its causal role for colour perception; and, (2) its epistemological, aesthetic and emotional purposes (Thompson, 1995).

5. THE EMPIRICAL STUDY

The research question was studied with a group of 13 multi-media design students in actual problem solving processes. Data were collected from interviews as well as observation in naturalistic setting. The students worked on individual projects in three assignments of the colour course. The data obtained from each student were first analyzed and classified into patterns according to the various themes of focus. Then these patterns were codified into categories of description, viz., ways of conceptualization and problem-solving approaches. Some major patterns were identified in the students' use of cognitive strategies and domain knowledge abilities in different problem-solving approaches under the various design situations.

5. 1. FORMULATING THE RESEARCH TASK

The three assignments of the colour course were considered valid for structuring the interview prototype because they simulated different mental representation relevant to the design goals in the context of colour use in fashion, interior, and graphic design. In the assignments, the students superseded the 2-dimensional colour phenomenon of hue, value and chroma to represent object-space-emotion relationships. The research task entailed qualitative descriptions of the meaning structures which were domain-specific involving the hierarchical learning objectives of three domains: content structure (referential aspect), physical structure (structural aspect), and value structure (awareness aspect). Accordingly, contexts of operational definitions (Figure 1) and sample protocol of using operational definitions (Figure 2) were established for data collection.

The research question:

- What are the qualitatively different ways in which novice design students conceptualize colour theory in relation to their problem-solving approaches?

Context of Content Structure-

- Complementary colours
- Black and white
- Colour contrast
- Luminosity-dominant/sparing use of colours
- Tined up/sharp contrast
- Close value
- Value scale-10 steps of grays
- Tinted hue
- Contrast of value
- Light and dark contrast
- Tonal variation
- Dominant colours
- Figure/ground relationship
- Contrast of chroma
- Mono-chroma
- Adjacent colours

Context of Value Structure-

- Modern style/old style
- Lady's swimming suit
- Man's necktie
- Motifs/patterns
- Interior environment
- Pleasant living environment
- 2D depictions of realistic vision/ imitating realistic accuracy
- 3 different objects/geometric forms
- Light sources/shadows cast on floor
- Seasonal colour - Spring, Summer, Autumn, Winter

Context of Physical Structure-

- Make a series of design patterns
- Sketches on sketch book
- Visualizing ideas
- Testing computer effects
- Ways of producing colours
- Use of software
- Rendering for spatial effect
- Use the design of square-on-square for seasonal colour schemes
- Documents of idea development

Figure 1: Contexts dawn from the three assignments for operational definitions.

Complexity of Learning Objectives and Problem-solving Process	Sample Verbs	Sample Operational Definitions	Discerned Aspect (sample operation descriptions of content structure)
1. KNOWLEDGE (gathering data)	Name Recall	student *recalled* the use of blue and yellow for colour contrast in class	student *defined* hue, value and chroma and *drew references* from class exercises or personal experience
2. COMPREHENSION (understanding data)	Explain Describe	student *described* that the yellow advanced from the blue	student *explained* the different darkness of a colour was due to its value scale
3. APPLICATION (identifying constraints)	Select Solve	student *solved* a colour problem with a minimum of direction	student *constructed* a tonal variation to illustrate an interior environment
4. ANALYSIS (defining problem & possibilities)	Feel Define	student *defined* the feelings of a pleasant living environment	student *compared* her idea with the red used in the painting of Degas to suggest a distance
5. SYNTHESIS (generating solution)	Generate Integrate Plan	student was *inspired* by the spatial effects of Degas's painting and *generated* an idea of "pulling" 2 colours together that was *new* to her	student *produced* a 'happy' colour scheme to illustrate the figure/ground relationship of a chair in the room and *planned* to use the 3-D software to render the chair with some lighting effects
6. EVALUATION (assembling & criticizing solutions)	Check Assess Critique	student *assessed* her design with specific task criteria	student *judged* the effectiveness of the problem- solving approaches with the knowledge of colour theory

Figure 2: A sample of protocol- descriptions of hierarchal content structure in problem solving

5. 2. DATA COLLECTION AND ANALYSIS PROCEDURES

During data collection, the students were asked to verbalize their perceptions of each problem of the colour application series in their preferred sequences. Attention was paid to the students' responses to their personal experience of colour, and probe questions were asked to gain an understanding of the ways in which they related their colour concepts to the focused aspects of the problem-solving tasks. Some cited samples of raw data are listed in the following:

- Raw data of the content structure (referential aspect)-

  The value of orange and pink are very close. When yellow is put next to them, the contrast between orange and pink becomes bigger.

  It is easy to illustrate the feeling of spring…so I will use the colours of similar value…yes, I will use 'advancing colour' for summer, so it (the pattern) looks like jumping out; it is drawn towards you; it hugs you.

- Raw data of the physical structure (structural aspect)-

  If I found an empty space (in a composition), I would add something there; if I found it too crowded on one side, I would reduce the items or add more to the other side…perhaps it is about sensibility…the sensibility of manipulate 'the things' that I am going to draw.

  I have tried (working with software) different arrangements of the lighting in the environment. For this design, I put the light at the centre, between the television set and the sofa; that is why there is a big shadow for the television set…Later, I put the light near the back, creating these shadows. Making it more 3D…

- Raw data of the value structure (awareness aspect)-

  I believe…without any reference, one's thinking is limited…I am thinking about how to do the test. What colours should be used for the different parts? Whether these two colours can be put together? If not, I have to think it over again…I think until I feel satisfied, then I will stop.

  Sometimes many ideas emerge when reading the problem brief; when the key points that I have picked up become the focus of the project…I would keep on referring to them as ideas are developing.

In the preliminary coding stage, the initial segments were codified by means of the operational definitions and were marked on the typed transcripts for a provisional structure of the students' thinking, which were then represented in a retrieval form of protocol. When well organized, the segments of protocols were exhausted until episodes emerged into an obvious coding scheme within the context of the problem task. The coding scheme served as an explicit tool for documenting cognitive operations and as a guide for systematic protocol analysis (Figure 3). The coded schemes of the thirteen students were then compared for the complexity of their learning objectives of the domains and for the dominance of their problem-solving activities.

Characteristics of Analogue Approach and Dynamic Conceptualization Model

(knowledge-based towards external and internal contexts; motivated to redefine problems and take risks for unwarranted assumptions)

Multiple loops reaching level 6 of the content, value, and physical structures; reaching the state of evaluation, origination, and characterization:

- Analogous articulation of colour uses by the other artists
- Persistence in exhausting colour effects, pattern design, and ideas for originality
- Insightful problem solving with personal perspective on the design contexts and their underlying structures
- Intention of pursuing colour aesthetics with a knowledge of colour theory
- Development of media skills and aiming for complex symbolic representation
- The dimension of RA and SA strongly interacted with the dimension of AoEC and AoIC in a full learning cycle

Figure 3: A sample of coded scheme

6. FINDINGS

In principle, the data analysis was managed for individual and collective levels of description. To the extent that the group represents the variation of individuals in a wider population, and that 'categories of description' tell a logical relationship with one another, the relationship is frequently hierarchical (Marton and Booth, 1997).The data obtained from the individual student were first analyzed and classified into patterns according to the various themes of focus. Then these patterns were codified into categories of descriptions. The characteristics of the identified patterns were highlighted and categorized into different cognitive models reflecting variation in conceptualizations and problem-solving approaches.

6. 1. DATA-CATEGORIZING FRAMEWORK

Operationally, the two ways of depicting the dimensions of variation allowed the communicability that fulfilled the validity and reliability of a structure of awareness (Cope, 2002):

- *As a learning cycle depicting the dominant types of learning activities during problem solving*- depictions of the students' dominant problem-solving activities are presented as patterns of recursive nature.

- *As a hierarchy depicting the complexity of meaning structures characterized by levels of learning objectives*- depictions of the students' learning objectives are presented as continuums and a means of ordering and relating the aspects.

The data analysis mainly looked into the students' problem-solving processes while they conceptualized colour theory for thematic focus- a close examination of the interactions between the discerned aspects of learning; the interaction between referential aspect (RA) and structural aspect (SA), and the interaction between awareness of external context (AoEC) and awareness of internal context (AoIC). The diagrammatic interpretation of a structure of awareness is illustrated in Figure 4.

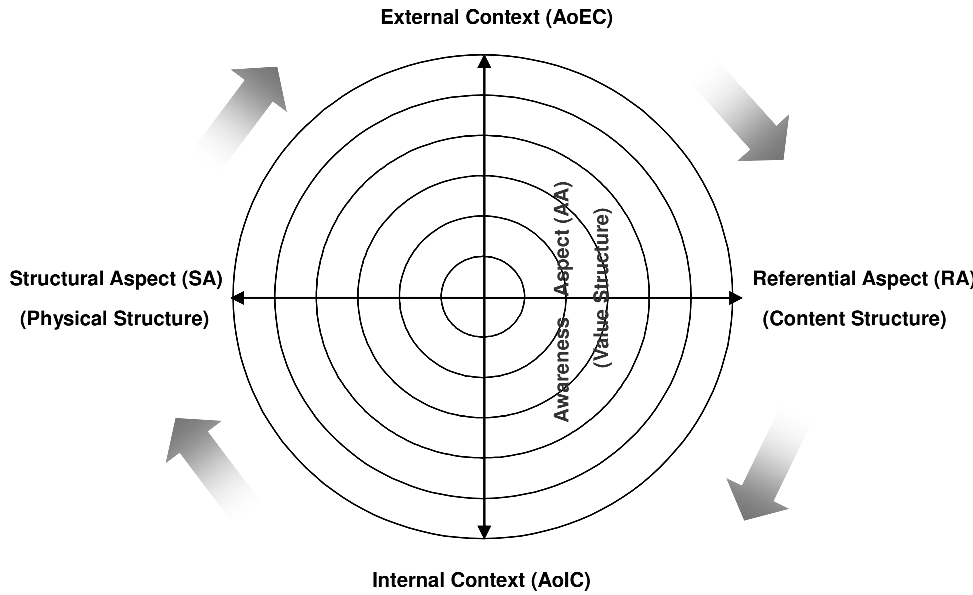


Figure 3: Diagrammatic interpretation of a structure of awareness

6. 2. CATEGORIES OF DESCRIPTION

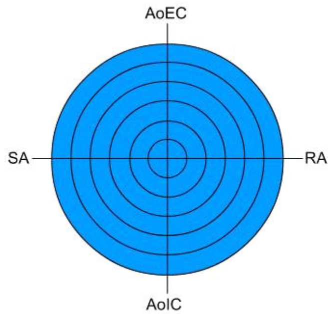
There were five problem-solving approach and conceptualization models identified: the Analogue Approach and Dynamic Conceptualization Model, the Means-ends Approach and Interactive Conceptualization Model, the Trial and Error Approach and Serial Conceptualization Model, the Task-oriented Approach and Static Conceptualization Model, and the Force-fitting Approach and Linear Conceptualization Model. These cognitive models depicted the dominant looping in the awareness construct, which represented the interactivities of various phases of the experiential learning path as well as the level of association of all the phases when the students applied their domain-specific knowledge.

The looping in a conceptualization model was the flow of problem-solving strategies within the various phases: while the individual students were engaged in different meaning structures, they embarked on the contextual platform either for non-variable loops, variable loops or multiple loops for solutions. Some students tended to forfeit or retrace particular steps along the path of the loop-like problem solving; some would stay on a particular area of the learning cycle, or loop constantly for new findings. These types of looping corresponded to the complexity of the students' learning objectives. The data categorization and the characteristics of the cognitive models are summarized below in Table 1 and Figure 5.

Conceptualization		I			II									III									IV						V											
	Problem solving (Dominated activities) / Student	**Jane**			**Donna**			**Helen**			**Simon**			**James**			**Laura**			**Kat**			**Kith**			**Cathy**			**Olivia**			**Bruce**			**Emily**			**Rennie**		
		C	V	P	C	V	P	C	V	P	C	V	P	C	V	P	C	V	P	C	V	P	C	V	P	C	V	P	C	V	P	C	V	P	C	V	P	C	V	P
1	**Encountering problem**	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
2	**Assessing data**	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√		√	√		√	√		√	√		√	√
3	**Seeking possibilities**	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√			√			√			√			√
4	**Defining problem**	√	√	√	√	√	√	√	√	√	√	√	√			√			√			√																		
5	**Generating solutions**	√	√	√		√	√		√	√	√	√	√																											
6	**Assembling/ Criticizing ideas**	√	√	√									√																											
	Characteristics	Dynamic			Interactive									Serial									Static						Linear											
		I-Content knowledge based: reached the level of evaluation, origination & characterization			**II-Information Based:** worked actively between the level of analysis, complex commitment & response and the level of synthesis, organization & adaptation									**III-Solution Based:** worked between the level of comprehension, responding, set to act and the level of application, simple acceptance, & guided response to mechanism									**IV-Problem Based:** focused on the level of comprehension, responding, & set to act						**V-Action Based:** remained at the level of knowing, attending selectively, & perception											

Meaning structures			
Level	**Content Structure (C)**	**Value Structure (V)**	**Physical Structure (P)**
1	knowledge	awareness	perception
2	Compre-hension	responding	set to act
3	application	value (simple acceptive)	guided response to mechanism
4	analysis	value (complex commitment)	complex response
5	synthesis	organization	adaptation
6	evaluation	Character-ization	origination

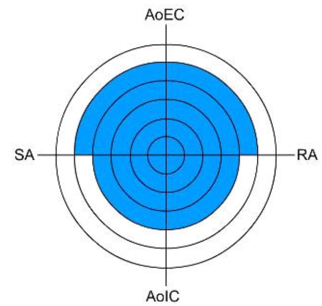
Table 1: Data categorization: problem-solving phases and hierarchal conceptualization.



I. Analogue Approach & Dynamic Conceptualization Model
(the biggest contextual plaform; SA/RA integrates with AoEC/AoIC)

Content Structure: 6
Value Structure: 6
Physical Structure: 6

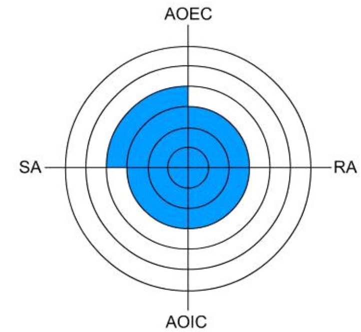
Figure 5. a



II. Means-ends Approach & Interactive Conceptualization Model
(a reasonably big contextual platform;
SA/RA interacts with AoEC/AoIC)

Content Structure: 4
Value Structure: 5
Physical Structure: 5

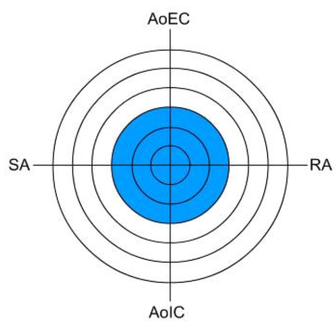
Figure 5. b



III. Trial and Error Approach & Serial Conceptualization Model
(a medium-sized contextual platform;
active SA/RA but interacts little with AoEC/AoIC)

Content Structure: 3
Value Structure: 3
Physical Structure: 4

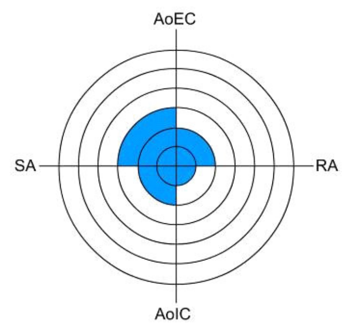
Figure 5. c



IV. Task-oriented Approach & Static Conceptualization Model
(a relative small contextual plaform; active SA/RA and interacts fairly with AoEC/AoIC)

Content Structure: 3
Value Structure: 3
Physical Structure: 3

Figure 5. d



V. Force-fitting Approach & Linear Conceptualization Model
(the smallest contextual plaform;
SA/RA rarely interacts with AoEC/AoIC)

Content Structure: 1
Value Structure: 2
Physical Structure: 3

Figure 5. e

Figure 5. a–e: The five cognitive models- the looping patterns and dominant activities

7. DISCUSSION OF FINDINGS

In the research, the perceptual heuristics of colour application were studied. Colour has a phenomenal quality as a property of physical bodies and a quality of experience; colour perceptions could be described in causual terms and in the context of epistemological, aesthetic and emotional purposes (Thompson, 1995). With the two types of descriptions of colour quality, the research was able to distinguish among the thirteen students the naive and critical colour concepts that they acquired during problem solving. It was through the study of their activities and practices in the acquisition and exercise of such concepts that the conditions under which certain principles of learning-mechanism were made clear. One such learning-mechanism principle involving the referential and structural aspects responded to the internal structured arrays of colour groupings. Another important learning-mechanism principle concerning the awareness aspect was found in the engagement of colour vision sensitive to the sorts of properties that were presented or represented in the perceptual experience.

7. 1. THE TWO DISTINCT DIMENSIONS AND CONTEXTUAL PLATFORM

The results pertaining to the research question postulated the foundation of design learning: the *contextual platform*. In the research setting, it was found that the processes of conceptualization were governed by the hierarchical learning objectives of the different domains and the different sets of problem situations. The principles of the learning-mechanism have indicated that the interactive mode of design learning appears to be composed of two distinct types of dimension of variation:

- The 1st dimension: Referential-structural Awareness Dimension (RA/SA: realizing and actualizing problem contexts)
- The 2nd dimension: Externalized Awareness Dimension (AoEC/AoIC: formulating contextual platform)

Analogously, the Referential-structural Awareness Dimension (RA/SA) divides the contextual platform into upper and lower quadrants: the upper ones deal with problem situations and tangible reality while the lower ones are more concerned with symbolic systems and an intangible world. The Externalized Awareness Dimension (AoEC/AoIC) separates the contextual platform into left and right quadrants: the left ones reflect the realm of activities which lead to the materialization of thoughts and the right ones handle generic abstractions which formulate hypotheses for knowledge transfer (Figure 6).

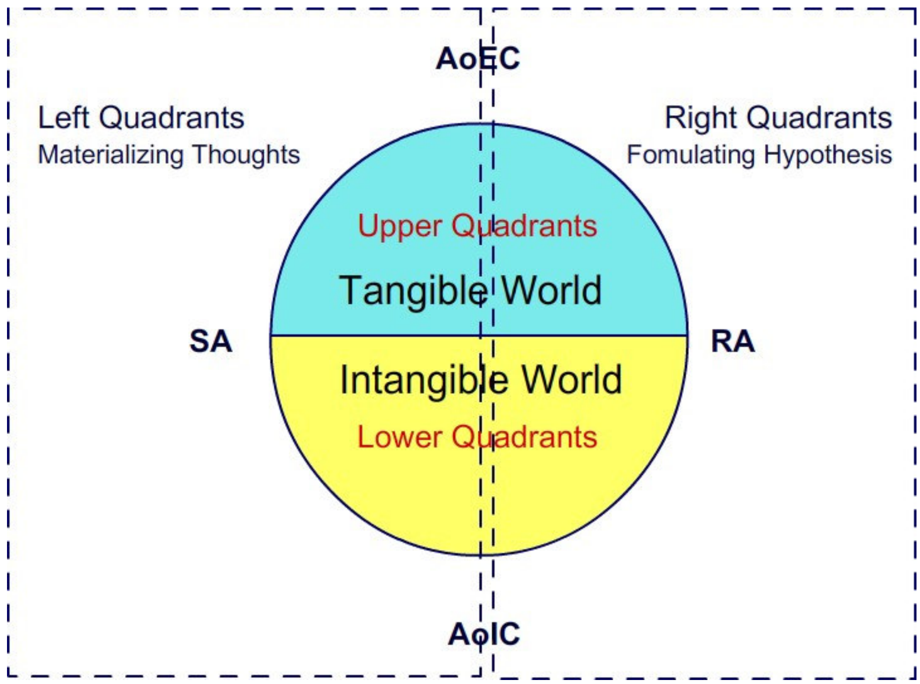


Figure 6: The contextual platform consisting of four distinctive quadrants.

7. 2. LEARNING GAPS AND CREATIVE PROBLEM SOLVING

When a domain dominates the mind set with its meaning structures and the hierarchical learning objectives of the other domains are relatively simple, the contextual platform created will be too small or inadequate for advancing knowledge or skills required for creative output. Such a phenomenon could be interpreted as having “learning gaps” during problem solving. This means that the hierarchical learning objectives of the domains are not synchronized or the levels of complexity are not in alignment for appropriate problem-solving strategies. The phenomenon is quite similar to having gaps between generative and exploratory phases of creative thinking. Creativity here has the meanings as defined by Finke, Ward, and Smith in their Geneplore Model; creativity results in mental synthesis (Finke, Ward and Smith, 1992).

Some students having difficulties in mastering the low-level description of phenomena seemed to have difficulties also in understanding and applying the generalization or abstraction to new problems and situations (Bloom, Madaus, and Hasting, 1981). On the contrary, the students who mastered the high-level description of phenomena were able to represent the content structure appropriately and worked efficiently to reach their goals. It is reasonable to believe that when consistent learning gaps occur in designing, the value or possibilities of a design idea will decrease for there is no modification of existing knowledge to advance the thinking skills required for the generation of creativity (Li, 1996). Increasing one's knowledge within a domain will also facilitate the construction of new strategies against the old ones (Siegler, 1996).

7. 3. THE GUIDELINES OF BUILDING A TAXONOMY OF DESIGN COGNITION

In order to empower students for self-efficacy in learning, this research recommends design teachers to plan instructional and tutorial strategies by acknowledging and drawing on the qualitatively different ways in which students constitute awareness of their design worlds. Some students may need more guidance and support, while others may work more independently and are able to possess mental representation of concepts in the domain. Therefore, subject content needs to be structured or modeled explicitly for students' appropriate learning strategies allowing integration and construction of knowledge in physical and conceptual settings. The basic guidelines of building a general taxonomy of design cognition are concerned with the cognitive abilities to produce a range of generalizations and applications in different problem situations. Some key points need to be emphasized:

- Domain-specific knowledge can be conceptualized into complex meaning structures enabling students to reason and work at a more sophisticated level of understanding.
- No single domain or its impacts on learning dimension can totally support or interfere with situated learning.
- Strong interaction between the first and second dimension of learning allows a good sized contextual platform for deeper cognitive processing.
- Hierarchal learning objectives determine the effectiveness of problem-solving approaches and are responsible for the foundation of a developing thematic focus.

7. 4. SUMMARY

The two dimensions of design learning found in this paper are concerned with the referential and structural aspects of knowledge acquisition, and are responsible for the awareness construct of contextual complexity. The discerned aspects of design learning are about the more enduring skills that form the meaning structures and problem-solving strategies for the greatest transfer of value. With respect to creative problem solving, representing and interpreting values cut across all design contexts including aesthetics, semantics, and reappraisal of appearance in visual experiments in relation to social, environmental, and technological contexts. Only when such concepts, ideas, or internal structures existing across time and disciplines are identified can a knowledge-based design curriculum be developed.

REFERENCES:

Arnheim, R. (1974). Art and Visual Perception- The New Version. Berkeley and Los Angeles, California, University of California Press.

Bigge, M. L. and S. S. Shermis (1992). Learning Theories for Teachers. New York, HarperCollins.

Bloom, B., Ed. (1956). Taxonomy of Educational Objectives, the Classification of Educational Goals. Handbook 1: Cognitive Domain. New York, McKay.

Bloom, B. S., G. F. Madaus, et al. (1981). Evaluation to Improve Learning. New York, McGraw-Hill.

Bowden, J. A., and Marton, F. (1999). The University of Learning: Beyond Quality and Competence in Higher Education. London, Kogan Page.

Bruner, J. (1973). Going Beyond the Information Given. New York, Norton.

Cope, C. (2002). Educationally Critical Aspects of the Concept of an Information System. Informing Science 5(2): pp.67-78.

Cope, C. (2004). Using the Analytical Framework of a Structure of Awareness to Establish Validity and Reliability in Phenomenographic Research. Qualitative Research Journal 4(2): pp. 5-8.

De Sausmarez, M. (1990). Basic Design: The Dynamics of Visual Form. Revised Edition.New York, Design Press.

Fazey, J., and Marton, F. (2002). Understanding the Space of Experiential Variation. Active Learning in Higher Education 3: 234-250.

Finke, R. A., T. B. Ward, et al. (1992). Creative Cognition: Theory, Research, and Applications. Cambridge, Mass., MIT Press.

Gardner, H., M. Kornhaber, et al., Eds. (1996). Intelligence: Multiple Perspectives. Fort Worth, TX, Harcourt Brace.

Green, L. N., and Bonollo, E. (2003). Studio-based Teaching: History and Advantages in the Teaching of Design. Asia-Pacific Forum on Engineering and Technology Education, Sydney, Australia.

Gurwitsch, A. (1964). The Field of Consciousness. Pittsburgh, Duquense University Press.

Kaput, J. (1992). Technology and Mathematics Education. A Handbook of Research on Mathematics Teaching and Learning. D. A. Grouws, NY: Macmillan**:** 515-556.

Kolb, D. A. (1984). Experiential Learning: Experience as the Source of Learning and Development. Englewood Cliffs, N.J., Prentice-Hall.

Li, R. (1996). A Theory of Conceptual Intelligence: Thinking, Learning, Creativity and Giftedness. Westport, USA: Praeger Publishers.

Marton, F. (1998). Towards a Theory of Quality in Higher Education. Teaching and learning in Higher Education. B. Dart and G. Boulton-Lewis. Camberwell, Vic., Australia: Australian Council for Educational Research**:** 177-200.

Marton, F. and S. Booth (1997). Learning and Awareness. Mahwah, New Jersey, Lawrence Erlbaum Associates.

Marton, F. and F. Pang (1999). Two Faces of Variation. 8th European Conference for Learning and Instruction, Goteborg, Sweden.

Marton, F. and W. Y. Pong (2005). On the Unit of Description in Phenomenography. Higher Education Research and Development 24(4): 335-348.

Miller, M. C. (1997). Color for Interior Architecture. New York, John Wiley & Sons.

Mok, A. H., Chik, P.M., Kwan, T., LO, L.M., Marton, F., Runeson, U., and Sze-To, H. (1999). The Atonomy of a Chinese Lesson. 8th EARLI Confrence, Goteborg, Sweden.

Moore, M. G. (1989). Three Types of Interaction. American Journal of Distance Education 3(2): 1-6.

Newstetter, W. C. and W. M. McCracken (2001). Introduction: Bringing Design Knowing and Learning Together. Design knowing and Learning: Cognition in Design Education. C. M. Eastman, W. M. McCracken and N. W. C. Amsterdam ; New York, Elsevier Science B.V.**:** 2-3.

Pang, F. (2003). Two Faces of Variation: On Continuity in the Phenomenographic Movement. Scandinavian Journal of Education Research 47(2): 145-156.

Phye, G. D. and T. Andre (1986). Cognitive Classroom Learning: Understanding, Thinking, and Problem Solving. San Diego, Academic Press.

Reeves, W. (1999). Learner-Centered Design: A Cognitive View of Managing Complexity in Product, Information, and Environmental Design. Thousand Oaks, Calif., Sage Publications.

Runesson, U. (1999). The Pedagogy of Variation - Different Ways of Handling a Mathematical Content, University of Goteborg, Sweden**:** (English summary retrieved December 1st, 1997 from http://www.ped.gu.se/biorn/ phgraph/civial/graphica/diss.su/runesson.html).

Siegler, R. S. (1996). Emerging Minds: The Process of Change in Children's Thinking. New York, Oxford University Press.

Sternberg, R. J. (1987). The Triarchic Theory of Human Intelligence. Student Learning- Research in Education and Cognitive Psychology. J. T. E. Reichardson, M. W. Eysenck and D. W. Piper. Milton Keynes, England; Philadelphia, Pass., Society for Research into Higher Education; Open University Press.

Sternberg, R. J., Ed. (1999). Handbook of Creativity. MA, Cambridge University Press: 248.

Svensson, L. (1984). Skill in Learning. The Experience of Learning. Ference Marton, D. Hounsell and N. Entwistle. Edinburgh, Scottish Academic Press: 56-70.

Thmopson, E. (1995). Colour Vision. London, Routledge.

Tomcik, A. M. (1995). Design and Color- Expanding the Scope. Aspects of Colour. H. a. H. Arnkil, Esa. Helsinki, the University of Art and Design Helsinki UIAH.

Ward, T. B., S. M. Smith, et al., Eds. (2002). Creative Thought: An Investigation of Conceptual Structures and Process. Washington DC, American Psychological Association.

Yuen, E. M. (1997). PBL: A Tool of Concept Learning in Design Education. Research and Development in Problem-Based Learning, 4: Integrity, Innovation, Integration. J. Conway, R. Fisher, L. Sheridan-Burns and G. Ryan. NewCastle, Australian Problem Based Learning Network.

Zwimpfer, M. (1995). Development of the Colour Sense- Basic Colour Education at the Basel Design School. Aspects of Colour. H. a. H. Arnkil, Esa. Helsinki, the University of Art and Design Helsinki UIAH.