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DIFFERENCES BETWEEN THE DISCERNING AND OPPORTUNISTIC MIND-SETS IN DESIGN LEARNING

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Abstract

Design learning can be improved by understanding the differences between individual characteristics of students and its connection with their learning processes and outcomes. This paper focusses on the differences between discerning and opportunistic mind-sets. 91 students from industrial, product or automotive design courses participated in a quasi-experiment where they were required to generate solutions for a design problem, answer a Q&A survey and fill in a questionnaire. The obtained data were analysed using qualitative and quantitative metrics. We found evidence of individual characteristics, processes and outcomes that differentiate the discerning and opportunistic mind-sets. Based on these findings the paper proposes and discusses potential implications for design education.

Keywords: Design education, Design learning, Early design phases, Design learning mind-sets

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1 INTRODUCTION

Human beings have unique cognitive characteristics that influence their learning processes (Huitt, 2003; Biggs, 2012) and therefore, by extension, their learning outcomes (Stump et al., 2009). For teaching students effectively, their learning might be improved by understanding the interactions and differences between their individual characteristics, learning processes and outcomes. In this paper, we present a study that focuses on students' mind-sets in design learning situations. Mind-sets encompass internal mental dispositions and external behavioural responses that determine an individual's reaction or approach in learning (Dweck, 2006). Therefore, we believe they could be a vantage point in the broader discourse about how to improve design teaching and learning.

Studies examining mind-sets are typically based on so-called self-implicit theories where mind-sets are propagated as either a growing or fixed entity (Dweck, 2006). Individuals can be categorised as having fixed or growth mind-sets depending on whether they view their intelligence and/or mental capabilities as a permanent trait that cannot be changed (the so-called “entity theorists”, see Mangels et al., 2006) or as a transformable trait that can be adapted and formed over time (i.e. “incremental theorists”). These differences in mind-sets have been found to influence the approach that students adopt in learning (Stump et al., 2009). Students who believe their intelligence as malleable were found to be more likely to address the complexities inherent in learning and achieve better outcomes (Dweck, 2006). These studies however, address learning in general and not specifically design learning and teaching.

In investigating mind-sets specifically related to learning in design, mind-sets of students have been categorised as either discerning or opportunistic (Hamat et al., 2015). Discerning mind-set students have been found to overcome challenges in difficult tasks and incline towards deep approaches in learning. This includes actively seeking meaning, relating ideas and using evidence to obtain deeper understanding of concepts that they come across. On the other hand, opportunistic mind-set students have been found to alleviate difficulty, taking convenient measures that includes compromising deeper levels of processing information. Furthermore, they incline towards surface approaches in learning such as memorising (unrelated) information and performing unperceptive, i.e. they routinely execute instructions with little personal reflection or scrutiny. Building upon this work, the authors strive to test the differences between these two types of mind-sets in design learning. Firstly, the relation between the discerning and opportunistic design learning mind-sets to students’ perceived self-efficacy, tolerance for ambiguity, view of their own intelligence and preferred learning approaches are tested. Next, the relation between the two mind-sets to their design activity and quality of design solutions are tested. In the following section, we briefly present the theoretical framework underlying this research, before presenting the conducted study and obtained findings in Sections 3 and 4. We present substantial quantitative and qualitative data exploring the specific relations between design learning mind-sets and inherent (behavioural) characteristics of students. Finally, in Section 5 we provide a discourse about the implications of our findings for design education and suggest directions for future research.

2 CONCEPTUAL FRAMEWORK

In this study, we rely on the 3P model of students' learning by Biggs (1993). The 3P model provides a general framework to test the differences between the two types of mind-set relevant to us: discerning and opportunistic (see Figure 1). The model consists of three levels: the *presage*, *process* and *product* levels. Distinct variables are selected and assigned on these three levels. Variables related to individual differences of students are examined on the presage level. These include students' preferred learning approach, self-efficacy, tolerance for ambiguity and view of their own intelligence. These variables encompass aspects of students' internal mental dispositions that is expected to relate to their external behavioural responses in design learning (Hamat et al., 2015). On the process level, we examine the types of questions students ask and the prevalence of difficulties they would face throughout the process of solving a design problem. On the product level, we examine the quality of solutions generated by students for the particular design problem. The three levels of the 3P model are described further in the following.

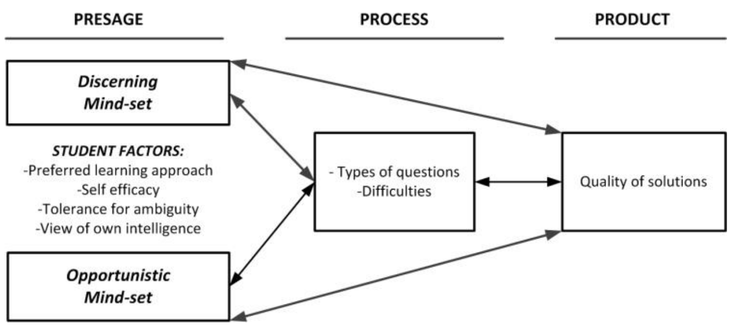

Figure 1. Connections between variables on the three different levels of the 3P model

2.1 Presage level variables

The first variable comprised on the presage level entails the students' preferred learning approaches. Learning approaches relate to "the level of engagement or the depth of processing that is applied during learning" (Cassidy, 2004, p. 433). It can be categorised into deep, surface and strategic approaches (Marton and Säaljö, 1976; Entwistle, McCune and Tait, 1997). Students who adopt deep learning approaches tend to relate ideas to previous knowledge and experience, look for patterns and underlying principles, and examine arguments critically (Chin and Brown, 2000; Entwistle, 2001). Conversely, students who adopt surface learning approaches tend to memorise facts and procedures in a routine manner and study without reflection on purpose. They have also been found to feel undue pressure and worry about work (Entwistle, 2001). Students inclining towards the strategic learning approach place importance on obtaining the highest possible grades. They are aware of assessment demands and organise their studying towards fulfilling these demands (Entwistle, 2001). Deep learning approaches (Stump et al., 2009) and strategic learning approaches (Rodriguez, 2009) have been found to positively correlate to students' achievement. The surface learning approach on the other hand, has been found to hinder the progress of greater levels of understanding (Marton and Säaljö, 1976; Islam, 2016).

The second variable examined on the presage level is related to self-efficacy. This pertains to students' evaluation of his or her capability to accomplish a task successfully (Pintrich and de Groot, 1990). Self-efficacy is proposed to have explanatory power related to the behaviour mechanisms of an individual to cope with complex situations (Bandura, 1982) and influence an individual's creative performance (Brockhus et al., 2014). An individual's level of self-efficacy been found to be mediated by their tolerance for ambiguity (Lane and Klenke, 2004). Students are faced with complex and open-ended problem solving situations in design learning (Buchanan, 1992). This means that students are constantly faced with situations of varying degrees of uncertainty and ambiguity. We thus examine tolerance for ambiguity as a third variable on the presage level. Students with a low tolerance for ambiguity have been stipulated to react aversively in ambiguous situations due to the difficulty to access risk and make decisions correctly (Furnham and Marks, 2013). Students with low tolerance for ambiguity have been reported to show signs of anxiety, evasion, rejection and deferring to putting an end to things (Furnham and Marks, 2013). In contrast, students that are highly tolerant towards ambiguity perceive ambiguous situations as "desirable, challenging and interesting" (Furnham and Marks, 2013, p. 718). The fourth variable examined on the presage level relates to how students view their own intelligence. Students may either believe that they can develop their intelligence, i.e. a growth view (see above), or believe that their intelligence is a permanent trait that is unchangeable, i.e. a fixed view. Students who adopt a growth view are more likely to overcome the complexities inherent to learning design and achieve better outcomes (Dweck, 2006).

2.2 Process level variables

On the process level, two variables are included to gain insight into students' problem solving process. Firstly we examine the types of questions that students ask and secondly, prevalence of difficulties they faced throughout. The type of questions students ask throughout the process of solving design problems are considered to be closely related to decisions that they subsequently make (Aurisicchio *et al.* , 2007). The activity of question asking also forms an essential component related to deeper levels of processing required in learning design (Graesser and Person, 1994). The types of questions asked can be categorised into low level, high level and generative design questions. These questions are classified in an incremental form, where the questions are ordered from lower to higher levels. Students that ask questions in the proper order i.e., formulates questions across the levels yield more reliable forms of knowledge (Dillon, 1984; Eris, 2002). Equally important is the level of difficulty of a problem perceived by students, which can potentially influence their performance when solving design problems (Frensch and Funke, 1995). It has been suggested that the average level of task difficulty as opposed to lower or higher levels of difficulty correlates highest with better performance (Frensch and Funke, 1995).

2.3 Product level variables

On the product level, we include the quality of solutions that students generate. The quality of a solution can be referred to by its *relevance* and *specificity*. *Relevance* includes the sub-categories of *applicability* and *effectiveness*. *Applicability* refers to "the degree to which the idea clearly applies to the stated problem" (Dean et al., 2006, p. 663). *Effectiveness* refers to "the degree to which the idea will solve the problem" (Dean et al., 2006, p. 663). *Specificity* includes the sub-categories of *completeness* and *implicational effectiveness*. *Completeness* refers to "the number of independent sub-components into which the idea can be decomposed, and the breadth of coverage with regard to who, what, where, when, why, and how" (Dean et al., 2006, p. 663). *Implicational explicitness* refers to "the degree to which there is a clear relationship between the recommended action and the expected outcome" (Dean et al., 2006, p. 663).

3 STUDY DESIGN

The goal of the empirical study presented here was to examine the relationship between factors within the presage level and also the relationship between variables in the presage, process and product levels (see conceptual framework). In other words, we want to examine what other variables can be used to describe the discerning and opportunistic mind-sets, and examine the processes and outcomes associated to the different mind-sets. The following research questions were formulated to guide this study:

1. How do students' perceived self-efficacy, tolerance for ambiguity, view of their own intelligence and preferred learning approaches relate to the discerning and opportunistic design learning mind-sets?
2. How do students' design process and quality of students' design solutions relate to these mind-sets?

3.1 Method

To observe the prevalent interactions between the relevant variables in the 3P model discussed above, data was collected from a cross-section of the design student population using a quasi-experimental study design (Cohen et al., 2007; Kumar, 2011). This experimental set-up is chosen as it enables us to collect the required data on all three levels at once. Although it has been suggested that change cannot be measured through cross-sectional studies (Kumar, 2011), it is the relationship of the variables at a given point of time that are of concern in this empirical study, and not the change that occurs over time.

3.1.1 Participants

91 students from two universities in Malaysia participated in this study. Data was collected from students in Malaysia for this study as it was practical to utilize our existing network. These students were enrolled in their first or final year of the industrial, product or automotive design courses in their respective universities. Out of the 98.9% of respondents that reported their age and gender, 49 were male and 41 were female. 87.8% of the respondents were between 20 to 23 years old while the remaining respondents were 24 to 27 years old.

3.1.2 Experimental Procedure

The duration of the quasi-experiments ranged from one and a half to two hours. Participants were given a design brief related to transportation problems in the city of Kuala Lumpur, Malaysia. They were also given a handout which contained information related to the design problem, e.g., issues related to public, private and non-motorised forms of transportation. Next, participants were asked to produce conceptual solutions to the given design problem. Students were required to develop around five solutions to completely solve the transportation problem. They were next asked to pick their best solution and suggest concrete ways for its realisation and implementation.
After solving the design problem, participants were subjected to a short Q&A session. Questions were asked by an interviewer and responses given by the participants were noted down on a prepared template.

This was done with participants in one university, while participants from the second university were asked to read through the questions individually and note down their responses on the prepared templates themselves, due to unavoidable logistical constraints. Questions in the Q&A session were formulated to elicit students' perception of the task. For example, students were asked about how they felt about the task, whether the task was difficult, and whether they learned anything new. Finally, participants were asked to fill in a 40-item questionnaire. Entwistle et al.'s (1997) ASSIST questionnaire was adopted to measure students' preferred learning approaches and perceived self-efficacy. Norton's (1975) MAT-50 was adopted to assess students' tolerance for ambiguity. And finally, questions inquiring about students' view of their own intelligence were adopted from Dweck (2006).

3.1.3 Scales for questionnaire

15 items on three scales were used to assess students' learning approaches. For the deep learning scale items such as "When I read, I examine the details carefully to see how they fit in with what's being said " and "When I am reading, I stop from time to time to reflect on what I am trying to learn from it" were used. These items assess inclinations to relate ideas, seek meaning and use evidence in learning. The surface learning scale assesses inclinations for unrelated memorising, syllabus boundedness and lack of purpose in learning. Items that assess this scale include "I concentrate on learning just those bits of information I have to know to pass", "I gear my studying closely to just what seems to be required for assignments and exams" and "Much of what I'm studying makes little sense: it's like unrelated bits and pieces". The strategic learning scale assesses inclinations to organise studying and manage time in learning. Items that assess this scale includes "I usually plan out my week's work in advance, either on paper or in my head", "I'm pretty good at getting down to work whenever I need to" and "I organize my study time carefully to make the best use of it". One item on a Likert scale of one to nine was used to assess self-efficacy. This item was "Finally, can you please indicate how you scored on your design work, so far?"

18 items were used to assess tolerance for ambiguity. These items were related to tolerance for ambiguity in interpersonal communication, problem solving and job-related situations. For example, items included "I prefer telling people what I think of them even if it hurts them, rather than keeping it to myself", "In a decision-making situation in which there is not enough information to process the problem, I feel very uncomfortable" and "If I am uncertain about my responsibilities in a design team, I get very anxious". Six items were used to assess students' view of their own intelligence. This includes the item "You can always significantly change how intelligent you are" and "Your intelligence is something very basic about you that you can't change very much".

3.1.4 Students' solutions and Q&A responses

285 solutions that were generated by the participants were assessed by the main author and 21% of the solutions were cross-checked by two independent coders. On the four scales of quality, high to moderate Pearson's correlations ranging from r=.58 to r=.90 are found between all three raters.

The responses provided by the participants on the Q&A template were qualitatively analysed by the main author. Responses were inductively coded into low level, high level and generative design questions. Furthermore, responses indicating any prevailing difficulties that were faced were also coded. These analyses were then processed quantitatively for further comparisons (see below).

4 RESULTS

Students were grouped into two separate clusters based on the quality of their solutions. These two clusters consist of top and bottom 25% scoring clusters. We used an independent T-test to compare between these two clusters (see Table 1). Students who scored in the bottom 25% (for quality of solutions) had significantly lower mean scores (M=10.03, SD=1.83), lowest scores (M=8.61, SD=2.33) and highest scores (M=11.43, SD=1.88) as compared to mean scores (M=14.41, SD=2.36); $t(29.28) = -7.05$, $p<0.001$, lowest scores (M=10.70, SD=4.03); $t(44) = -2.15$, $p=0.04$, and highest scores (M=18.65, SD=0.78); $t(44) = -17.03$, $p<0.001$, of students in the top 25%. The effect sizes of these scores were relatively strong (see last column of Table 1 for details of the effect sizes).

Students in the bottom 25% scored significantly lower in terms of applicability (M=2.36, SD=0.65), effectiveness (M=2.03, SD=0.41), completeness (M=2.85, SD=0.83) and implicational effectiveness (M=2.79, SD=1.09) of their solutions as compared to the applicability (M=3.80, SD=0.60); $t(44) =$ -

7.76, $p<0.001$, effectiveness (M=3.01, SD=0.72); $t(44) = -5.70$, $p<0.001$, completeness (M=3.63, SD=0.66); $t(44) = -3.51$, $p<0.001$ and implicational effectiveness (M=4.00, SD=0.82); $t(44) = -4.26$, $p<0.001$ of students in the top 25%.

This means that students in the top 25% were able to come up with solutions that were more relevant and specific. In terms of relevance, it means that their solutions apply more clearly to the stated problem (i.e., it is more applicable) and solves the problem to a better degree (i.e., is more effective). In terms of specificity, it means that their solutions covered more independent sub-components with regard to who, what, where, when, why, and how (i.e., it is more complete) and clearly conveys their recommended action to the expected outcome (i.e., it conveys more strongly the solutions' implicational effectiveness).

Table 1. Results of comparison between 25% top and bottom scoring students

Item/Scale	**Cluster 1: Bottom 25% N=43**	**Cluster 2: Top 25% N=36**	**Effect size, Cohen's D**
1. Presage variables			
Tolerance for ambiguity			
It really disturbs me when I am unable to follow another person's flow of thought. (interpersonal communication) *	3.04	3.74	0.46
A group meeting functions best with a definite agenda. (Problem solving) *	4.35	3.87	0.62
Self-efficacy			
Finally, can you please indicate how you scored on your design work, so far? *	5.90	4.90	0.71
2. Process Variables			
LLQ**	0.48	0.83	0.77
GDQ*	0.17	0.00	0.62
Faced difficulties*	1.04	0.83	0.70
3. Outcome variables			
Relevance*	25.06	29.45	1.20
Specificity**	25.11	36.35	1.83
Mean: Applicability***	2.36	3.80	2.29
Mean: Effectiveness***	2.03	3.01	1.68
Mean: Completeness***	2.85	3.63	1.03
Mean: Implicational Effectiveness***	2.79	4.00	1.26
Mean score of all solutions generated by student***	10.03	14.41	2.08
Solution with lowest score generated by student*	8.61	10.70	0.63
Solution with highest score generated by student***	11.43	18.65	5.02

*T-test on average scores over two clusters was significant at $p<0.05$.

**T-test on average scores over two clusters was significant at $p<0.01$.

***T-test on average scores over two clusters was significant at $p<0.001$.

4.1 Individual differences

Observations related to their tolerance for ambiguity and self-efficacy can be found. Firstly, students in the bottom 25% reported significantly lower scores for an item related to interpersonal communication (M=3.04, SD=1.11) as compared to students in the top 25% (M=3.74, SD=0.96), $t(44)=-2.27$, $p=0.03$ with regards to their tolerance for ambiguity. On the other hand, students reported significantly higher scores (M= 4.34, SD=0.78) on an item related to problem solving as compared to students in the top 25% (M=3.87, SD=0.76); $t(44)=2.12$,$p=0.04$. Medium to high effect sizes can be observed at Cohen's $d= 0.46$ and 0.62 respectively.

This means that students' in the bottom 25% tolerate ambiguity with regards to interpersonal communication better than they do compared to situations related to problem solving. More precisely, they prefer to have a definitive agenda when involved in group meetings as they are less tolerant of ambiguity in this situation. However, they perceive that it is less important for them to be able to follow another person's trail of thought, as compared to students in the top 25%, as they are more tolerant of ambiguity in this type of situation. Secondly, students' in the bottom 25% reported significantly higher self-efficacy scores (M=5.90, SD=1.44) as compared to the top 25% (M=4.90, SD=1.37); $t(39) = 2.28$, $p < 0.03$. This means that they rated their design works so far higher as compared to students in the top 25%.

4.2 Types of questions, prevalence of difficulties and quality of solutions

In terms of students' design process, it could be observed that students who were clustered in the bottom 25% asked significantly fewer low-level questions (M=0.48, SD=0.51) as compared to students in the top 25% (M=0.83, SD=0.39); $t(23)=-2.60$, $p=0.01$. Moreover, they also asked significantly more generative design questions (M=0.17, SD=0.51) as compared to students in the top 25% (M=0.00, SD=0.39); $t(23)=2.15$, $p=0.04$. In addition, students in the bottom 25% reported that they faced significantly more difficulties (M=1.04, SD=0.21) compared to students in the top 25% (M=0.83, SD=0.39); $t(23)=2.37$, $p=0.02$. Relatively strong effect sizes, Cohen's $d= 0.77$, 0.62 and 0.70 can be reported for these three observations respectively.

The relationship between the types of questions that students asked and quality of their solutions was tested using a Chi2 test. Questions were categorised as either low level, high level or generative design questions. The quality of students' solutions were categorised as either "high" or "medium and low". The results indicated that such a statistically significant relationship exists between the quality of students' solution and the type of low level questions that they asked ($x2(1) = 9.052$, $p<0.01$, $n=91$). An inspection of the standardized residuals show that it was less likely for students who did not ask low level questions to generate higher quality solutions.

4.3 Higher quality solutions by participants categorised as discerning in mind-set

The relationship between mind-set in design learning and quality of students' solution was also tested using a Chi2 test. Students' were assigned either into the opportunistic or discerning mind-set category and their solutions were categorised as either high or low in quality. The results show that indeed such a statistically significant relationship exists ($x2(2)= 6.181$, $p<0.05$, $n=87$). An inspection of the standardised residuals showed that students who were categorised as having an opportunistic mind-set were less likely to come out with solutions that are of higher quality. The relationship between the quality of students' solutions and whether they received the hand-out related to design theories was also examined with a Chi2 test. However, no statistically significant relationship was found ($x2(2)=1.667$, $p>0.005$, $n=91$). This means that the related design theories that students read did not have a significant effect on the quality of their solutions.

4.4 Relationship between variables on the presage, process and product levels

The relationships between variables on all three levels are summarised as follows (see Figure 2). The attributes or individual differences that can be observed within students categorised as the discerning mind-set category (i.e. tolerates ambiguity in problem solving situations, lower self- efficacy and asking more low level questions) are associated to higher quality of solutions. On the other hand, students categorised as the opportunistic mind-set type are associated to a contrasting set of attributes. Firstly, they rate themselves as having higher self-efficacy compared to their counterparts. Secondly, they rated higher tolerance for ambiguity in situations that are related to interpersonal situations. Further evidence related to their design process shows dissimilarities between the opportunistic and discerning mind-set types of students.

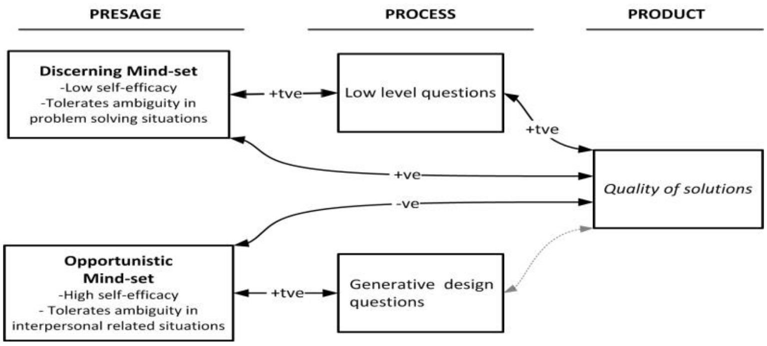

Figure 2. Relationships between variables on the three different levels of the 3P model

Students categorised as the opportunistic mind-set type reported that they faced difficulties throughout the Q&A session. However, there was no evidence to indicate that asking generative design questions were positively or negatively related to the quality of students' solutions. Nevertheless, attributes connected to the opportunistic mind-set type have been found to be associated with lower quality of solutions i.e., they produce lower quality solutions (see Section 4.1).

5 DISCUSSION AND CONCLUSION

Profound differences can be observed between students categorised as either discerning or opportunistic in mind-set. However, it is important to take into account that these results were obtained from a controlled experimental condition and that there are limitations to generalising these results to the actual design studio setting (Cohen et al., 2007). Furthermore, although it would be anticipated that these results can be collectively attributed to design students from similar backgrounds or training, such an estimation should be cautiously attempted due to the limitations of the sampling method that was used (see Section 3.1.1). Apart from that, students were not informed to reflect on specific phases of their design process during the data collection sessions. Hence, learning approaches adopted by students throughout or at specific points of the complex design process could not be captured. Still, the information obtained was very rich and allowed detailed analysis which raises our confidence in the findings. Future studies should take into consideration the possibility of isolating distinctly different parts of the design process. This would then enable comparisons between the different phases to obtain a clearer delineation of students' design learning.

5.1 Mind-sets and tolerance for ambiguity in design learning

In our study, opportunistic mind-set students showed higher tolerance for ambiguity. More specifically, they tolerated being unable to follow another person's flow of thought. This is in contrast to the discerning mind-set students who reported low tolerance for the same abovementioned situation. In a problem solving or design based situation, it is highly likely that a tolerance for such a situation would impede the seamless course of the project, as related ambiguity or uncertainty that needs to be clarified are left unattended. Individuals with low tolerance for ambiguity tend to avoid ambiguous stimuli (Furnham and Ribchester, 1995). This suggests that it is likely for discerning mind-set students to avoid the ambiguity by clarifying the situation i.e., possibly by facing confrontations during interpersonal communication in order to avoid the ambiguity. This indicates that students with a discerning mind-set would be more analytical in a design or problem solving situation.

The design process is an iterative logical process that is realised by different modes of reasoning i.e., throughout the different stages of design, different modes of reasoning are required. Thus, in an idea generating phase where creativity and judgements should be deferred, a high tolerance for ambiguity is highly likely to be of value. It can then be anticipated that opportunistic mind-set students would fare better in this stage of the design process. However, it might prove to be a disadvantageous attribute to adopt in a detail design phase where higher analytical modes of reasoning are required. It is necessary that students manage their tolerance for ambiguity throughout the different stages of designing.

5.2 Mind-sets and self-efficacy in design learning

Higher self-efficacy scores are associated to the opportunistic mind-set students. This demonstrates that these students are able to regulate their coping behaviours (Bandura, 1982) when dealing with complexities associated to design learning. Design learning is associated to dealing with complex problems that require high reasoning capabilities. It is highly likely that opportunistic mind-set students cope by organising their time and learning activities towards memorising information and fulfilling course requirements. This is demonstrated by the significant correlation between students' surface and strategic learning approach scores. It is highly propagated that students who formulate high expectations about their prior performance perform better (Bandura, 1982; Pintrich and de Groot, 1990; Richardson et al., 2012). However, this is not the case in this study. Students who had rated higher levels of self-efficacy generated solutions that were of lower quality (i.e., less relevant and specific to the problem given). Coupled with their inclinations towards surface learning approaches (e.g., unrelated memorising, being bounded to syllabus and not being able to connect knowledge, concepts or information), it is possible that these students are actually unaware of the complex reasoning processes that are required of them. On the other hand, discerning mind-set students had reported lower levels of self-efficacy, although they had generated better quality solutions. Students rating lower levels of self-efficacy have been found to perform better (Christensen et al., 2002).

5.3 Types of questions and quality of solutions

Discerning mind-set students have also been found to ask more low level questions, while opportunistic mind-set students asked more generative design questions. More notably, it was statistically significant that opportunistic mind-set students rarely asked low level questions compared to their counterparts. No significant differences could be observed between these two clusters of students with regards to the high level questions that they asked. The amount of high level questions for both opportunistic and discerning mind-set students were comparable. More reliable forms of knowledge can be established only when high level and generative design questions have been preceded by sufficient low level questions (Dillon, 1984; Eris, 2002). Discerning mind-set students that asked significantly more low level questions had indeed generated higher quality solutions. In other words, discerning mind-set students did not jump to generative design questions without establishing a strong foundation of the design problem through low level questions first. Opportunistic mind-set students on the other hand jumped to generative design questions without formulating such lower level questions. Although no statistically significant results can be reported with regards to generative design questions to the quality of solutions, the low level questions that were asked had enabled students to generate better quality solutions.

5.4 Recommendations

Findings from this study provide potential implications for design education. Students possessing a discerning mind-set have been found to generate design solutions with higher quality. Contrastingly students with an opportunistic mind-set generate lower quality solutions. Students should be made aware of their own inclinations in terms of: (1) specific mind-set types and subsequently encouraged and trained in a way that helps them develop a more discerning mind-set towards learning in design; (2) view of their own intelligence and capabilities to develop positive views of themselves; (3) ambiguity in solving design problems and be trained to manage these situations (4) types of questions they formulate so as to train better formulation of questions in an incremental way; and (5) levels of self-efficacy so that they can regulate their own learning activities. Whether they are optimistic or pessimistic of their own performance, they should be made aware of these conditions in order to be able to manage these situations.

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