INTERNATIONAL DESIGN CONFERENCE - DESIGN 2016
Dubrovnik - Croatia, May 16 - 19, 2016.

INDIVIDUAL DISPOSITIONS AND THE ADOPTION OF SURFACE LEARNING IN DESIGN

B. Hamat, P. Badke-Schaub and J. Schoormans

Keywords: mind-set, design learning, design education

1. Introduction

The question of how motivational processes affect students' approaches in learning have been investigated among students and college students [Dweck 1986], [Bråten and Olaussen 1998], [Yan et al. 2014]. These studies reveal that motivation influences the adoption of specific learning approaches. Students' approaches towards learning have been categorised into deep, surface and strategic learning approaches [Marton and Säaljö 1976], [Schmeck and Geisler-Brenstein 1989], [Entwistle et al. 1997]. Additionally, the question of the correlation of these approaches with the performance have been investigated in correlational studies on learning approaches to students' achievement. These studies demonstrate that deep learning approaches [Pintrich and de Groot 1990], [Miller et al. 1996], [Grant and Dweck 2003], [Stump et al. 2009] and strategic learning approaches [Rodriguez 2009] are positively correlated to students' achievement.

Chin and Brown [2000] compared deep and surface learning approaches of students in learning science and highlighted several differences. This study reported that students adopting the deep learning approach asked relevant questions on reasoning, causes, speculation and resolve incongruities, elaborate explanations with cause-effect relationships, and theorize at conceptual and analytical levels. In contrast, students adopting the surface learning approach would provide reformulated questions as explanations; make observations that are focussed on physical phenomena; and rarely reflect on their own performance and new processes or information encountered.

In psychology, a concept of self-implicit theories coined "mind-sets" by Dweck, [2006] has been developed to measure the individual's learning beliefs. These self-implicit theories of intelligence are categorised into either *entity* or *incremental* theories where intelligence is viewed as either a fixed or transformable trait. Dahl et al. [2005] and Stump et al. [2009] reported deep learning approaches to be negatively correlated to the fixed mind-set. Additionally, Stump et al. [2009] found that deep related learning approaches were positively correlated to the growth mind-set.

In an empirical study, Daalhuizen et al. derived from the data that students' design learning was influenced by their "method mind-set" [Daalhuizen et al. 2014, p. 134] and how they initially assess their task at hand. This "method mind-set" is defined as "the proper understanding of a method's use in accordance with the designer's reality (interpretation of task, situation, execution, validation, etc.), and the method's background and proper use." [Andreasen et. al 2015, p. 57]. With reference to Bloom's Taxonomy of educational objectives [Krathwohl 2002], the "method mind-set" calls for a fluid interplay of knowledge dimensions beginning with factual knowledge through to conceptual and procedural knowledge. Additionally, simple to complex cognitive processes such as recalling that arises from the act of memorizing through to understanding, applying, analysing, evaluating and creating will be required for appropriate application of methods. Subsequently, a deep learning approach that consist of

reflecting activities such as to seek meaning, relate ideas and examine evidence should logically be adopted as opposed to a surface learning approach.
Nonetheless, a students' individual disposition may additionally be associated to the learning approach that they choose to adopt. Apart from mind-sets, studies have shown that self-efficacy which pertains to how students evaluate their expected performance could further contribute to students' inclination of learning approaches. Self-efficacy has majorly been accounted as positively correlated to the deep learning approach [Pintrich and de Groot 1990], [Miller et al. 1996], [Bråten and Olaussen 1998], [Stump et al. 2009] and strategic learning approach [Rodriguez 2009]. However, similar findings to the surface learning approach [Miller et al. 1996] was not significant. In addition, students' tolerance or intolerance for ambiguity have been reported to be positively correlated with self-efficacy [Buhr and Dugas 2006].
Nevertheless, studies have demonstrated that incongruities in the adoption of proper learning approaches could possibly occur among college students [Kornell and Bjork 2007], [Hartwig and Dunlosky 2012]. Additionally, students' adoption of learning approaches may also be influenced by the assessment methods that they are presented with [Yan et al. 2014]. In design learning, students are faced with numerous challenges that largely consist of solving ill-defined and wicked problems. They are required to develop psycho-motor and thinking skills to empower their decisions throughout the increasingly complex process of designing. Consequently, in encountering these uncertainties, how would motivational processes, tolerance for ambiguity and perceptions of self-efficacy relate to students' learning approaches in a design learning context?

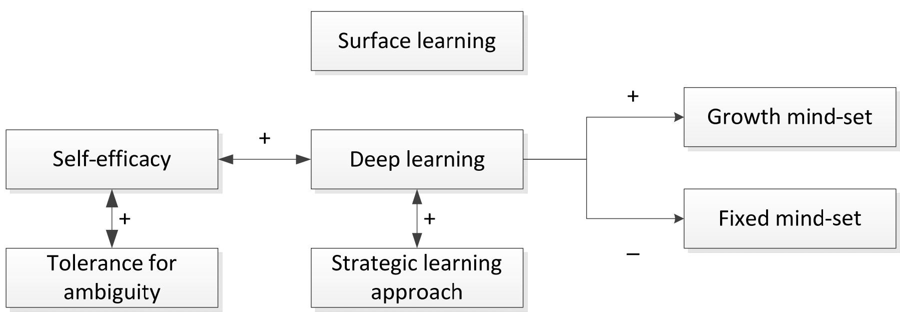

Figure 1. Correlations between different constructs and learning approaches from literature

In this paper, we investigate how students' mind-sets, perception of self-efficacy and tolerance for ambiguity would relate to the learning approaches that they adopt, particularly the surface learning approach. We report the inter-relations between students' mind-set, self-efficacy and tolerance for ambiguity to their learning approaches. In Section 2, the theoretical background of these constructs will be further discussed. Next, details of respondents from two different undergraduate industrial design courses in Malaysia and the set-up of the survey that was used is presented in Section 3. In Section 4, the correlational analyses of the four interrelating constructs and a comparison of students that have been grouped using a cluster analysis based on their learning approaches is presented with an independent T-test. Finally, the results in relation to its general implications to design education is discussed in Section 5.

2. Theoretical background

This study investigates the relation between students' learning approaches, self-efficacy, tolerance for ambiguity and mind-set. Firstly, we discuss the construct of "learning approaches" which refer to "the level of engagement or the depth of processing that is applied during learning" [Cassidy 2004, p. 433]. Learning approaches can be categorised into deep, surface and strategic approaches [Marton and Säaljö 1976], [Entwistle et al. 1997]. Entwistle [2001] proposes that deep learning approaches arises from students' intention to understand ideas. This leads them to relate ideas to previous knowledge and experience; look for patterns and underlying principles; and examine logic and argument critically. In contrast, surface learning approaches are motivated by the intention to cope with course requirements. This leads students to memorise facts and procedures in a routine manner; study without reflection on purpose or strategy; and feel undue pressure and worry about work. Strategic learning approaches are driven by the intention to obtain highest possible grades which leads students to rely on organised studying and an awareness of assessment demands.

These three learning approaches can be measured with Entwistle et al's. [1997] Approaches and Study Skills Inventory for Students (ASSIST). The survey measures deep learning approach with five sub-scales: *Seeking meaning, Relating ideas, Use of evidence, Interest in ideas and Monitoring effectiveness;* surface learning approach with four sub-scales: *Lack of purpose, Unrelated memorising, Fear of failure and Syllabus-boundness;* and strategic learning approach with four sub-scales: *Organised studying, Time management, Achieving and Alertness to assessment demands.*

Secondly, we discuss the construct of "self-efficacy" which refers to students' evaluation of their ability to perform a task [Pintrich and de Groot 1990]. Bandura, [1982] proposed that an individual's perceived self-efficacy has the explanatory power to account for their behaviour mechanism to cope in diverse situations. Brockhus et. al [2014] further suggests that an individual's creative self-efficacy does have an influence on their creative performance. This demonstrates the possible influence of students perceived self-efficacy upon the learning approaches they choose to adopt. Positive correlations have been reported to be significant between self-efficacy to deep learning approaches, [Pintrich and de Groot 1990], [Miller et al. 1996], [Rodriguez 2009], [Stump et al. 2009], [Zare-ee 2010] but not significantly to surface learning approaches [Miller et al. 1996]. Several studies have also demonstrated that high self-efficacy is positively correlated to higher achievement scores [Pintrich and de Groot 1990], [Miller et al. 1996], [Grant and Dweck 2003]. Nonetheless, a study by Christensen et al. [2002] presented contradicting findings when they found that accounting students who received higher grades were more likely to underestimate their own performance.

Thirdly, we discuss the construct of "tolerance for ambiguity". Students' tolerance or intolerance for ambiguity that can be defined as "a tendency to perceive or interpret information marked by vague, incomplete, fragmented, multiple, probable, unstructured, uncertain, inconsistent, contrary, contradictory, or unclear meanings as actual or potential sources of psychological discomfort or threat" [Norton 1975, p. 608]. Students with intolerance for ambiguity are stipulated to react aversively in ambiguous situations due to the difficulty to access risk and make decisions correctly [Furnham and Marks 2013]. Students that are highly tolerant towards ambiguity perceive ambiguous situations as "desirable, challenging and interesting" while reactions of students with low tolerance for ambiguity are "stress, avoidance, delay suppression or denial" [Furnham and Marks 2013, p. 718]. The construct of "tolerance for ambiguity" can be measured with Norton's [1975] Measurement of Ambiguity Tolerance (MAT-50). This survey measures tolerance for ambiguity on eight different scales: *Philosophy, Interpersonal Communication, Public Image, Job-related, Problem solving, Social, Habit and Art forms.*

Finally, we discuss the construct of "mind-set" which can be classified into two distinct categories of growth or fixed mind-set types. Dweck et al., [1995] suggests that these mind-sets which are based on self-implicit theories of intelligence are direct determinants of students' achievement. Several studies that tests Dweck's model has been known to investigate it's correlation to students' self-efficacy (SE) [Miller et al. 1996], [Bråten and Olaussen 1998], [Stump et al. 2009] and more prevalently with mediating constructs such as goal orientations and learning approaches towards students' achievements [Miller et al. 1996], [Ablard 2002], [Grant and Dweck 2003], [Dupeyrat and Mariné 2005], [Mangels et al. 2006]. However, findings regarding these mediating constructs somewhat varies and no clear consensus can be reported.

3. Research approach

In this study, we aimed to analyse the inter-relations of design students' learning approach (LA), self-efficacy (SE), tolerance for ambiguity (TA) and mind-set (MS). A survey was developed based on the assumption that there are relations between these four constructs. Items for the survey were derived from Entwistle et al's. [1997] Approaches and Study Skills Inventory for Students (ASSIST), Norton's [1975] Measurement of Ambiguity Tolerance (MAT-50) and Dweck's [2006] measures of mind-sets. Design students were asked to fill in the survey as part of a longer experiment where students were requested to produce conceptual solutions to a design problem. However, this study reports only the results of the survey.

3.1 Participants

The survey was filled in by 91 industrial design students from two different universities in Malaysia. There were 48 and 43 students from the first and second university respectively. Out of all the students, 56% of them were in the first year of their study while 44% of them were in their final year. 49 of the students were male and the remaining 41 were female. Students' age ranged from 20 to 27 years old.

3.2 Set-up of survey

The survey that was used for this study was divided into four parts. Each part of the survey assessed students' learning approaches, self-efficacy, tolerance for ambiguity and mind-sets respectively. Table 1 illustrates the items and scales of the first part of the survey. To measure students learning approaches, three categories of items were developed with regards to the deep, strategic and surface learning approaches. The three scales have been used in prior studies [Duff 1997], [Speth et al. 2007], [Reid et al. 2012], [Brown et al. 2015] that yielded appropriate validity and was thus kept unchanged. Items for the three categories are a condensed version from the original ASSIST survey which was determined based on a previous study [Hamat et al. 2015]. The previous study had utilized all the original items in the ASSIST survey. However, only items that had high factor loadings in the factor analysis from the previous study was used for this study. Each learning approach category consisted of five items and was measured on a scale of 1 to 5.

Table 2 depicts the items and scales of the second part of the survey that assessed students' level of tolerance for ambiguity. Only three categories were used from Norton's [1975] Measure of Ambiguity Tolerance (MAT-50) and was measured on a scale of 1 to 5. Some of the items were reconstructed from the original version to fit a design learning context while some of the items were re-worded to better fit students' current language style. For example, the item "If I am uncertain about the responsibilities of a job, I get very anxious." was reworded into "If I am uncertain about my responsibilities in a design team, I get very anxious."

Table 1. Scales and items to assess learning approaches and self-efficacy

Learning Approaches (Scale 1: Strongly Disagree to 5: Strongly Agree)		
Deep LA	**Surface LA**	**Strategic LA**
1. When I read, I examine the details carefully to see how they fit in with what's being said.	6. I concentrate on learning just those bits of information I have to know to pass.	11. I don't find it at all difficult to motivate myself.
2. When I am reading, I stop from time to time to reflect on what I am trying to learn from it.	7. I gear my studying closely to just what seems to be required for assignments and exams.	12. I usually plan out my week's work in advance, either on paper or in my head.
3. Often I find myself questioning things I hear in lectures or read in books.	8. Much of what I'm studying makes little sense: it's like unrelated bits and pieces.	13. I generally make good use of my time during the day.
4. Regularly I find myself thinking about ideas from lectures when I'm doing other things.	9. There's not much of the work here that I find interesting or relevant.	14. I'm pretty good at getting down to work whenever I need to.
5. Before tackling a problem or assignment, I first try to work out what lies behind it.	10. I find I have to concentrate on just memorizing a good deal of what I have to learn.	15. I organize my study time carefully to make the best use of it.

Table 2. Scales and items to assess tolerance for ambiguity

Tolerance for ambiguity (Scale 1: Strongly Disagree to 5: Strongly Agree)		
Interpersonal Communication	**Problem Solving**	**Initially: Job-related**
I prefer telling people what I think of them even if it hurts them, rather than keeping it to myself.	I do not like to get started in group projects unless I feel assured that the project will be successful.	I function very poorly whenever there is a serious lack of communication in critique sessions.
It irritates me to have people avoid the answer to my question by asking another question.	Complex problems appeal to me only if I have a clear idea of the total scope of the problem.	When I'm being evaluated in assessments, I feel a great need for clear and explicit evaluations.
I really dislike it when a person does not give straight answers about himself.	In a problem-solving group it is always best to systematically handle the problem.	If I am uncertain about my responsibilities in a design team, I get very anxious.
It really disturbs me when I am unable to follow another person's flow of thought.	In a decision-making situation in which there is not enough information to process the problem, I feel very uncomfortable.	At the end of the semester, I might become frustrated because my design would never be completed (design will never be perfect)
I tend to be very frank with people.	Once I start a task, I don't like to start another task until I finish the first one.	
	Before any important job, I must know how long it will take.	
	I don't like to work on a problem unless there is a possibility of coming out with a clear-cut and unambiguous answer.	
	A problem has little attraction for me if I don't think it has a solution.	
	A group meeting functions best with a definite agenda.	

Table 3. Scale and item to assess self-efficacy

Self-efficacy (Scale 1: Rather badly to 9: Very Well)
Finally, can you please indicate how you scored on your design work, so far?

Table 4. Scales and items to assess mind-set

Mind-set (Scale 1: Strongly Disagree to 5: Strongly Agree)	
Growth Mind-set	**Fixed Mind-set**
You can always significantly change how intelligent you are.	Your intelligence is something very basic about you that you can't change very much.
No matter how much design capability you have, you can always change it quite a bit.	You can learn new things but you can't really change how your design capability is.
If you are given another opportunity, you would like to try a much more challenging task.	If you are given another opportunity, you would like to try to do the same task again.

In the second part of the survey, one item was established to measure students' level of self-efficacy. Table 3 illustrates the item and scale that was used to access students' self-efficacy. This item originated from the original ASSIST survey and was measured on a scale of 1 to 9. Table 4 depicts the third part of the survey that assessed students' mind-set towards design learning on two scales of growth and fixed mind-set. Responses for were indicated on a scale of 1-5.

4. Results

In this section, we first report the reliability of the scales used for the subsequent analyses. From here, we demonstrate the interrelations between the variables on the basis of a correlational analysis. Finally, we tested the differences among two groups of students with an independent T-test. Prior to the independent T-test, students were grouped into low surface and high surface learners according to a hierarchical cluster analysis.

4.1 Reliability of scales

Five scales were used for the analysis of this study. The scales consisted of three types of learning approaches: deep, surface and strategic learning approaches; two types of mind-sets: growth and fixed mind-sets; and tolerance for ambiguity. The scales originally comprised of 15 items for learning approaches, 18 items for tolerance for ambiguity and 6 items for mind-set. The surface learning approach, tolerance for ambiguity and fixed mind-set subscales had high reliabilities of Cronbach's $\alpha = 0.70$, 0.72 and 0.73 respectively. However, the deep and strategic learning approach had relatively low reliability, Cronbach's $\alpha = 0.62$ and 0.65 correspondingly. Additionally, the growth mind-set scale yielded an extremely low reliability of Cronbach's $\alpha = 0.39$. Hence, the growth mind-set scale was excluded and only the fixed mind-set scale was used for subsequent analyses. Table 5 shows the Cronbach's α, number of items and original items of the remaining scales.

Table 5. Reliability of subscales

Scale	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items	Original no of items
Deep Learning Approach	0.62	0.63	2	5
Surface Learning Approach	0.70	0.70	3	5
Strategic Learning Approach	0.65	0.65	2	5
Tolerance for ambiguity	0.72	0.72	16	18
Fixed Mind-set	0.73	0.73	2	3
Growth Mind-set	0.39	0.39	2	3

4.2 Correlations of variables

In the second analysis, students' score in relation to the four theoretical constructs were correlated. The Pearson's correlation are depicted in Table 6. The Pearson's *r* data analysis revealed nine significant correlations. Firstly, a strong positive correlation was found between students' fixed mind-set scores to their adoption of surface learning approaches $r(82) = .53$, $p < 0.01$. Next, moderate correlations were found between students' report of tolerance for ambiguity and surface learning approach $r(85) = -.38$, $p < 0.001$; surface learning approach scores to the strategic learning approach scores $r(85) = .31$, $p < 0.01$ and between students' fixed mind-set scores to their self-efficacy scores $r(74) = .30$, $p < 0.05$. Finally, low correlations were found between students' strategic learning approach and self-efficacy scores $r(77) = .29$, $p < 0.05$; strategic learning approach and fixed mind-set $r(82) = .28$, $p<0.05$; deep learning approach scores to the surface learning approach scores $r(85) = .26$, $p < 0.05$; fixed mind-set and level of tolerance towards ambiguity $r(82) = –.25$, $p < 0.05$; and tolerance for ambiguity to deep learning approach $r(85) = -.23$, $p < 0.05$.

Table 6. Correlations between design learning mind-set, learning approaches, tolerance for ambiguity and self-efficacy

	1	2	3	4	5	6
	Fixed MS	Deep LA	Surface LA	Strategic LA	TA	SE
1. Fixed mind-set	—					
2. Deep LA	.20	—				
3. Surface LA	.53**	.26*	—			
4. Strategic LA	.28*	.13	.31**	—		
5. Tolerance for ambiguity	–.25*	–.23*	–.38***	–.21	—	
6. Self-efficacy	.30*	.09	.22	.29*	–.04	—

*Correlation is significant at p< 0.05.
**Correlation is significant at p< 0.01.
***Correlation is significant at p< 0.001.

Based on the first three correlations which can be described as strong to moderate correlations which were significant at least on a level of p< 0.01, three observations can be made. When students' reported higher surface learning approach scores, they also reported firstly, higher fixed mind-set scores, secondly higher tolerance for ambiguity and thirdly, higher strategic learning approach scores. This suggests that when students view their design capability or intelligence as something that is inbuilt and can't be changed, they would be likely to adopt a surface learning approach and also incline towards a strategic learning approach. The surface and strategic learning approach items of the survey are associated to the need to carefully organize their study time and concentrating on memorizing or learning seemingly unrelated bits and pieces information in order to pass exams. Additionally, these students would have a higher tolerance for ambiguity where they would avoid confrontations during interpersonal communication; accept unclear circumstances in problem solving and decision making situations; and feel unpressured in job-related conditions. Subsequently, we grouped the students into meaningful clusters according to the scores of their learning approaches to further validate these findings. The cluster analysis and independent T-test is reported in the following section 4.3.

4.3 Differences between students with high and low surface learning approaches

Prior to the final analysis, we expected to find differences between the first and final year students. However, no differences could be observed. Subsequently, we tested the differences of fixed-mind-sets, tolerance for ambiguity and self-efficacy scores by comparing groups of students that were clustered according to the learning approach scores that they reported. The SPSS-based hierarchical cluster analysis using the Between-Groups Linkage and Squared Euclidean Distance method was used and students were grouped into low and high surface learners. Subsequently, we compared the two groups of students with an independent T-test. The two clusters comprised of 43 low surface and 36 high surface learners. Table 7 illustrates the results of the independent T-test. Students that were clustered into the high and low surface groups reported higher and lower scores on items related to the surface learning approach respectively. High surface learners reported an average of 76.67% agreement to the surface learning items while the low surface learners reported an average of 51.33% agreement. The mean scores of students' surface learning approach was compared to assess the relevance of the two clusters. Students' surface learning approach scores were significantly different for low surface (M= 7.7, SD= 1.5) and high surface (M= 11.5, SD= 1.5) learners; t(77) = -11.0, p = 0.000.

Table 7. Results of comparison between low surface and high surface students

	Cluster 1: Low Surface N=43	Cluster 2: High Surface N=36
<u>Mind-set</u>		
Fixed Mind-set**	5.2	6.7

Learning Approach		
Deep LA	8.1	8.2
Surface LA***	7.7	11.5
Strategic LA*	6.2	7.1
Individual Dispositon		
Tolerance for ambiguity**	40.3	35.4
Self-efficacy*	5.2	6.0

*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.

Students' strategic learning approach were significantly different for low surface (M= 6.2, SD= 1.5) and high surface (M= 7.1, SD= 1.9) learners; t(77) = -2.4, p = 0.020. This demonstrates that high surface learners would be more likely to adopt strategic learning approaches. With respect to students' deep learning approach, the independent T-test did not reveal any significant difference for low surface (M= 8.1, SD= 1.0) and high surface (M= 8.2, SD= 0.9) learners; t(77) = -0.5, p = 0.642.
Next, we compared the scores of students' fixed mind-set scores. The independent T-test indicated that the fixed mind-set scores were significantly different for low surface (M= 5.2, SD= 1.8) and high surface (M= 6.7, SD= 2.1) learners; t(74) = 3.4, p = 0.001. We then compared the scores of students' tolerance towards ambiguity and their self-efficacy scores. Students' tolerance towards ambiguity were significantly different for low surface (M= 40.3, SD= 6.1) and high surface (M= 35.4, SD= 6.9) learners; t(77) = 3.3, p = 0.001. Students' self-rate on design learning performance were also significantly different for low surface (M= 5.2, SD= 1.4) and high surface (M= 6.0, SD= 1.6) learners; t(69) = -2.3, p = 0.023. Notably, the independent T-test revealed that high surface learners are more tolerant towards ambiguity and would rate their self-efficacy higher. Contrarily, low surface learners are less tolerant of ambiguity but would rate their self-efficacy lower.

5. Summary and discussion

Previous studies have investigated mind-sets and learning approaches from various other fields of education [Bråten and Olaussen 1998], [Dupeyrat and Mariné 2005], [Mangels et al. 2006]. However, investigations specifically in design education have not been examined. Additionally, we had contemplated the different learning requirements of design students that might differ from other fields of education. We thus proceeded to examine the learning approaches and further extended the study by adding the inter-relating dynamics related to design students' individual dispositions.
Previous studies have reported that the deep learning approach is negatively correlated to a fixed mind-set [Dahl et al. 2005], [Stump et al. 2009] and is positively correlated to a growth mind-set [Stump et al. 2009]. However, significant correlations between a fixed mind-set to the surface learning approach were not reported. In comparing the high and low surface learners, this study uncovered that the adoption of high surface learning approaches are related to the fixed mind-set where students' view their own intelligence and design capabilities as unchangeable. Moreover, we found that students who were adopting high surface learning approaches, reported firstly, a higher tolerance of ambiguity and secondly, higher self-efficacy scores.
We first discuss about high surface learners being more susceptible to tolerate ambiguity better. The tolerance for ambiguity scales indicate that the high surface learners would avoid confrontations during interpersonal communication; accept unclear circumstances in problem solving and decision making situations; and feel unpressured in job-related conditions. This suggests that although high surface learners are able tolerate ambiguous situations better, they would also be less analytical as compared to the low surface learners. In an attempt to model the design process, Takeda et al. [1990] indicated the design process as an iterative logical process that is realized by different modes of reasoning. Hence, students' tolerance for ambiguity might prove to be of value in an idea generating phase where creativity

and judgements should be deferred. However, it might prove to be a disadvantageous attribute to adopt in a detail design phase where high analytical reasoning is required.
Secondly, we discuss about high surface learners scoring higher self-efficacy scores. This demonstrates that high surface learners are able to regulate their coping behaviours [Bandura 1982] when dealing with complexities associated to design learning. As design learning is associated to dealing with complex problems that require high reasoning capabilities, high surface learners cope by organizing their time and learning activities towards memorizing information and fulfilling course requirements. This is demonstrated by the significant correlation between students' surface and strategic learning approach scores. Furthermore, high surface learners would also perceive themselves as coping well in their design courses suggesting their unawareness of the complex reasoning processes that is actually required of them. Nonetheless, although the results demonstrate much proof for not adopting a surface learning approach in design, results suggest that high surface learners are more tolerant of ambiguity. This is a necessary attribute for design students as the process of designing in itself is highly associated to complex and wicked problems that require students to deal with ambiguity. However, limitation of this study is that the data had no process data, the data was gathered at a single point in time and the students were not informed to reflect on specific phases of their design process during the data collection sessions. Thus, students adoption of learning approaches throughout or at specific points of the complex design process could not be captured. Future studies should then 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. Additionally, further examination of the effects of students' learning approaches towards the outcomes of their design learning can be pursued. Do learning approaches have an effect on the outcomes of students design projects? The types of outcomes to be measured could come in forms of the students' design process, output or even improvements of either one or both elements.

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Basyarah Hamat, PhD Researcher
TU Delft, Product Innovation and Management
Landbergstraat 15, 2628 CE Delft, Netherlands
Email: b.b.hamat@tudelft.nl