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The Relationships of Taiwanese College Students' Conceptions, Approaches, and Self-efficacy to Learning Civil Engineering in a Flipped Classroom

Meilun SHIH[a], Yi-Nan HUANG[b], Jyh-Chong LIANG[c*], Min-Hsien LEE[c] & Silvia Wen-Yu LEE[d]

[a]Center for General Education, National Taiwan University, Taiwan
[b]Department of Civil Engineering, National Taiwan University, Taiwan
[c]Program of Learning Sciences, National Taiwan Normal University, Taiwan
[d]Graduate Institute of Science Education, National Changhua University of Education, Taiwan
*aljc@ntnu.edu.tw

Abstract: This study examined the relationships among Taiwanese college students' conceptions of learning engineering, approaches to learning engineering, and self-efficacy of learning engineering. Three questionnaires: the Conceptions of Learning Engineering questionnaire (COLE), the Approaches to Learning Engineering questionnaire (ALE), and Self-efficacy of learning engineering (SELE) were used to gathered data from 111 college students majoring in Engineering in Taiwan. The analysis of correlational, stepwise regression, and multiple regression analysis results support that students with lower-level conceptions (LC) of learning engineering tend to display surface motive and surface approaches to learning engineering. Testing was the only significant COLE predictors explaining the surface motive, surface strategy of the ALE. While students' higher-level COLE (collaboration and engineering learning) positively related to their SELE, their SELE also foster students higher-level COLE. In addition, students' "Engineering" conception could significantly and positively predict their SELE, no matter they possess higher-level or lower level of COLE.

Keywords: conceptions of learning, approaches to learning, self-efficacy, civil engineering, flipped classroom

1. Introduction

Conceptions of learning refer to students' natural understanding or interpretation of the learning phenomena (Marton, 1981). Students' conceptions of learning are significant factors of the quality of their learning outcomes (Ellis, 2004; Duarte, 2007). Numerous studies have also revealed that students' approaches to or strategies of learning are correlated with their conceptions of learning, and that students with deep learning approaches usually have better outcomes (Kember et al. 2004; Cano, 2005). Moreover, as indicated in previous studies, learners' self-efficacy can positively predict their learning outcomes and is context dependent like learning strategy (Ellis et al. 2006; Ellis et al. 2008). In order to provide appropriate teaching and learning experiences for learners, it is important to understand the relationships among students' learning conceptions, learning approaches, and self-efficacy in different domains.

2. Literature Review

2.1. Conceptions of Learning

Learners conceive learning in different ways. Research on learning has shown that learners' conceptions or beliefs of learning have profound impacts on their learning process, and thus their quality of learning outcomes (Purdie & Hattie, 2002). Although overall similarities in the conceptions of learning had been found across previous studies, variations within different educational contexts may still occur. Most of researchers agreed that there is a hierarchical distinction from constructivist (actively constructing meanings) to reproductive (passively receiving knowledge) among these categories. Conceptions at the upper levels reflect a constructivist view of learning (e.g., understanding), while those at the lower levels reflect a reproduced view of learning (e.g., memorization) (Purdie & Hattie, 2002; Burnett et al. 2004).

2.2. Approaches to Learning

According to Marton and Booth (1997), learning can be elaborated from three aspects: what conceptions learners refer to the experience, what learners think they learn through the experience, and how they approach the experience. Earlier studies by Marton and Säljö (1976) and Biggs (1994) classified learning approaches into deep approaches and surface approaches. As described by Biggs and Tang (2007), a deep approach refers to the situation in which learners show an intrinsic motivation to learn, are active in their learning, and are willing to participate in various learning activities. In contrast, a surface approach refers to the situation in which learners are passive in their learning, view learning as externally imposed tasks, and only perform learning activities to fulfill course requirements or to memorize facts. Although similarities in the meanings of deep and surface approaches may exist across different domains, learners' learning strategies may be context dependent. As such, further investigation of learning approaches in different contexts is quite important.

2.3. Self-Efficacy of Learning

Self-efficacy is defined as one's belief in one's capability to organize or execute the actions required to complete a specific task or given goal (Cordova, Sinatra, Jones, Taasoobshiraz, & Lombardi, 2014). It related to how people fee, think, motivate themselves to achieve the desired outcome (Bandura, 1986). When individuals recognize familiar activities, they usually possess high self-efficacy. Conversely, when they identify new activities, their perceived self-efficacy is low. Therefore, students' learning experiences play an important role in explaining their self-efficacy of learning (Bandura, 1997). A variety of studies have proved that the judgment of self-efficacy on performance prediction is situation- or discipline-specific (Tsai, Ho, Liang, & Lin, 2011; Liu, Hsieh, Cho, & Schallet, 2006). That is, how students judge their own capability to master academic tasks can positively predict their learning outcomes.

3. Methodology

3.1. Participants

The participants in this study included 111 college students from a university in northern in Taiwan. There were 86 male and 25 female students, and they were all majoring in engineering. The age distribution of the participating students was from 19 to 24, with an average of 19.91.

3.2. Instruments

Three questionnaires were employed in this study: conceptions of learning engineering (COLE), approaches to learning engineering (ALE), and self-efficacy of learning engineering (SELE). The

COLE and ALE questionnaire were developed by Shih, Huang, and Liang (2017) with an overall alpha value of 0.88 for COLE and 0.78 (pre-test) and 0.83 (post-test) for ALE. The SELE was modified from Tsai, Ho, Liang, and Lin's (2011) self-efficacy questionnaire for learning science. The overall alpha value of the original SELE was 0.94, indicating sufficient internal consistency of the questionnaire items.

3.3. Data Analysis

The relationships among the students' COLE, ALE, and SELE were explored through correlational and stepwise regression analysis. Moreover, a series of t-tests and multiple regressions were conducted to examine whether any significant difference existed in the two participating students group: one with higher-level COLE (HC) and the other with lower-level COLE (LC).

4. Results and Discussion

4.1. Relationships between students' COLE, ALE, and SELE

The Pearson's correlation coefficients were calculated with students' responses to the COLE, ALE, and SELE, and the results are presented in Table 3. In general, these results support that students with lower-level conceptions of learning engineering tend to display surface motive and surface approaches to learning engineering. For example, students who hold memorizing conception to learning engineering tend to use surface motive "fear of failure" ($r=0.19$, $p<0.1$). Students' testing conception to learning engineering was positively correlated with their surface strategy "minimizing the scope" ($r=0.19$, $p<0.1$) and "rote learning" ($r=0.32$, $p<0.01$), but negatively correlated with their deep motive ($r=-0.32$, $p<0.01$). In addition, when students' higher level of COLE "Engineering" ($r=0.26$, $p<0.01$) and "Collaboration" ($r=0.27$, $p<0.01$) were positively correlated with their SELE, their SELE was also positively related to their deep motive ($r=0.56$, $p<0.001$), deep strategy ($r=0.53$, $p<0.001$), and surface motive ($r=0.39$, $p<0.001$) factors of the ALE.

Table 1: The correlations among the factors among the COLE, ALE and SELE.

	Memorizing	Testing	CP	IU	A	S	E	Co	SELE
DM	0.01	-0.32**	-0.05	0.21*	0.08	0.11	0.11	0.34***	0.56***
DS	0.03	-0.07	0.10	-0.01	-0.03	-0.01	0.01	0.07	0.53***
SM (Fear of failure)	0.19†	0.06	0.16	0.09	-0.07	0.13	0.07	-0.06	0.13
SM (Qualification)	-0.04	-0.05	-0.11	0.05	0.11	0.06	-0.02	0.16	0.39***
SS (Minimizing the scope)	0.03	0.19†	0.06	-0.03	0.04	-0.05	-0.09	-0.15	0.06
SS	0.14	0.32**	0.14	-0.06	-0.11	0.03	-0.12	-0.24*	0.12

(Rote learning)									
SELE	-0.02	-0.13	0.00	0.09	0.00	0.08	0.26**	0.27**	------

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$; $^{\dagger}p < 0.1$; CP: Calculating and practicing, IU: Increase one's knowledge and Understanding; A: Application; S: Seeing in a new way; E: Engineering; Co: Collaboration. DM: Deep Motive, DS: Deep Strategy, SM: Surface Motive, SS: Surface Strategy

Furthermore, the stepwise multiple regression method was used to make predictions about the students' approaches to learning engineering, and the results are illustrated in Table 2.

<u>Table 2: Stepwise regression model of predicting students' learning approaches to and self-efficacy of learning engineering.</u>

Approaches		B	S.E.	β	T	Adjusted R^2
DM						
	Collaboration	0.28	0.10	0.26	2.71**	0.15
	Testing	-0.24	0.10	-0.24	-2.47*	
	Constant	2.96	0.51		5.77***	
DS	--	--	--	--	--	--
SM (Fear of failure)						
	Testing	0.23	0.11	0.19	1.98†	0.03
	Constant	2.87	0.34		8.57***	
SM (Qualification)	--	--	--	--	--	--
SS (Minimizing the scope)						
	Testing	0.24	0.12	0.19	1.95†	0.03
	Constant	2.37	0.27		8.92***	
SS (Rote learning)						
	Testing	0.35	0.10	0.32	3.37**	0.09
	Constant	2.37	0.22		10.58***	
SELE						
	Collaboration	0.19	0.10	0.20	1.92†	0.08

	Engineering	0.19	0.11	0.18	1.78†	
	Constant	1.95	0.44		4.40***	

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$; $^{\dagger}p < 0.1$; DM: Deep Motive, DS: Deep Strategy, SM: Surface Motive, SS: Surface Strategy; SELE: Self-Efficacy of Learning Engineering.

The regression analysis revealed that collaboration (t=2.71, p <0.01) was the only significant predictor explaining the deep motive of the ALE, while testing (t=-2.47, p <0.05) negatively related to deep motive of the ALE. Totally, these two factors accounted for 15% of variance. This shows that students with constructivist conceptions of collaboration are more likely to hold deep motive to learning engineering, but students who have the testing conception of learning engineering are more likely to hold less deep motive of ALE. Moreover, this result revealed that testing was the only significant predictors explaining the surface motive (t=1.98, p<0.1), surface strategy of minimizing the scope (t=1.95, p<0.1) and rote learning (t=3.37, p<0.01) of the ALE. However, the strength of the predictive effects existing between testing–surface motive (3% of variance) and testing–surface strategy (3%-9% of variance) were not high. In addition, collaboration (t=1.92, p <0.1) and engineering (t=1.78, p <0.1) played a positive role in students' SELE. That is, enhancing students' conceptions of learning engineering to a more sophisticated level such as collaboration and engineering would be an important indication of holding more self-efficacy of learning engineering.

4.2. Differences between HC and LC groups

To compare the differences in the ALE and SELE of the two groups of students, one with higher-level COLE and the other with lower-level COLE, a series of t-tests were used. Table 3 shows the results of the comparison of the ALE scales and SELE identified by the t-tests. The results indicated that the students in HC group showed less orientation toward using surface strategy "minimizing the scope" (t=-1.72, p<0.1) and "rote learning" (t=2.91, p<0.01). There is no significant difference of students' COLE on their SELE.

Table 3: The scores of the post test on the subscales of ALE and SELE for the lower and higher conception group students.

	DM	DS	SM (Fear of failure)	SM (Qualification)	SS (Minimizing the scope)	SS (Rote learning)	SELE
Higher COLS	3.62 (0.74)	3.60 (0.65)	3.39 (0.87)	3.61 (0.78)	2.72 (0.75)	2.88 (0.77)	3.47 (0.54)
Lower COLS	3.50 (0.56)	3.62 (0.58)	3.62 (0.69)	3.40 (0.63)	2.99 (0.84)	3.27 (0.58)	3.34 (0.57)
t-test	0.96	-0.18	-1.53	1.53	-1.72†	-2.91**	1.11

$^{**}p < 0.01$; $^{\dagger}p < 0.1$; ALS: Approaches to Learning Engineering; SELE: Self-Efficacy of Learning Engineering; DM: Deep Motive, DS: Deep Strategy, SM: Surface Motive, SS: Surface Strategy

Multiple regression analysis was conducted to the HC group students and LC group students. While students' higher-level conception "Collaboration" could positively predict their "Deep strategy" (β=0.27, *p*<0.1), their lower-level conceptions "Memorizing" and "Calculating and practicing" could negatively predict their "surface strategy" (β=–0.54, *p*<0.1; β=–0.36, *p*<0.1). "Testing" is the only significant factor could negatively predict students' "deep motive" (β=–0.72, *p*<0.01), but positively predict their "surface strategy" (β=0.52, *p*<0.05). For LC group students, students' "surface motive-fear of failure" could be positively predict by their "Memorizing" conception (β=0.43, *p*<0.05), but negatively predict by their "collaboration" conception (β=–0.41, *p*<0.05). For LC students, "Collaboration" is the only significant predictor for their "deep motive" (β=0.30, *p*<0.05).

In general, as showed in Table 4 and Table 5, students' "Engineering" conception could significantly and positively predict their SELE of both HC (β=0.31, *p*<0.05) and LC (β=0.29, *p*<0.1) groups. For LC groups, students' "Collaboration" (β=0.32, *p*<0.05) was another positive predictor for their SELE. However, "Seeing in a new way" could negatively predict LC students' SELE (β=–0.58, *p*<0.05).

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