The relationships between conceptions of and approaches to learning computer science among college computer science students

Jui-Chi Wu[a*], Cheng-Yen Hou[a], Yi-Ching Su[b] & Jyh-Chong Liang[a]
[a] *Graduate Institute of Applied Science and Technology, National Taiwan University of Science and Technology, Taiwan*
[b] *Asia-Pacific Institute of Creativity, Taiwan*
*remywu567@gmail.com

Abstract: Previous researches have established a link between students' conceptions of learning and approaches to learning. College computer science education involves more specific training and academic preparation for the students. However, until recently, only a few quantitative studies have been conducted to assess college computer science majors' conceptions of and approaches to learning computer science. Therefore, this study was conducted to assess these students' conceptions of and approaches to learning computer science, and then to explore the relationships between Conceptions of Learning Computer Science Survey (COLCS) and Approaches to Learning Computer Science Survey (ALCS). The participants in this study included 421 computer science students in Taiwan. Results showed that the students with deep motivation and strategies expressed higher-level of conceptions of learning computer science, and did not attempt to have 'testing' conception of learning computer science especially for the students with deep motivation. In addition, the regression analyses revealed that the computer science students' conceptions of learning were viewed as predictors to explain their approaches to learning.

Keywords: Conceptions of learning, approaches to learning, computer science.

1. Introduction

Nowadays, the current computer science curricula have played an important role in enhancing and motivating students' learning computer science (Jukic, & Matic, 2011). The conceptions of learning generally refer to the learners' views about their learning experiences and their preferred ways during learning process (Lee, Johanson, & Tsai, 2008; Liang, Lee, & Tsai, 2010). Saljo (1979) is the first person who started a series of relevant research firstly identified college students' conceptions of learning by interview as five categories: (1) increase of knowledge, (2) memorizing, (3) acquisition of facts or procedures that can be retained and /or utilized in practice, (4) abstraction of meaning, and (5) interpretative process aimed at the understanding of reality. In Lee et al.'s study (2008), by developing a questionnaire of assessing Taiwan high school students' conceptions of learning science, which could be divided into six factors: 'Memorizing,' 'Testing,' 'Calculating and practicing,' 'Increase of knowledge,' 'Applying' and 'Understanding and seeing in a new way.' Tsai, et al. (2012) utilized the structural equation model and revealed that high school students' conceptions of learning science could divided into two levels, that is lower level (i.e. learning science as memorizing, preparing for tests, calculating and practicing) and higher level of learning science (learning science as increase of knowledge, applying, and attaining understanding).

The approaches to learning refer to the students or learners' ways or methods to learn or process their academic task (Biggs, 1987). Researchers have clarified two major different approaches, the surface and deep learning approaches (Chin & Brown, 2000). Accordingly, the surface learning approach is then characterized as (1) surface motivation and (2) surface strategy. In contrast, the deep learning approach is then defined as (3) deep motivation and (4) deep strategy (Chiou, & Liang, 2012). Through the literature reviews, most of the studies have shown that students with more constructivist or higher-level of conceptions of learning were inclined to employ deeper strategies, motives, or approaches to learning (Chiou, & Liang, 2012; Lee, et al., 2008).

In this study, we attempted to investigate how computer science students conceptualize learning and how they learn is an essential issue for computer science educators. Through gathering questionnaire data from a group of college computer science major students in Taiwan, this study was conducted to assess these students' conceptions of and approaches to learning computer science, and then explore the relationships between these two. This study was undertaken to investigate the following research questions:

(1) Through exploratory factor analyses, could the developed questionnaires in this study, Conceptions of Learning Computer Science Survey and Approaches to Learning Computer Science Survey, be adequate tools to probe the computer science students' conceptions of and approaches to learning computer science?
(2) What are the relationships between computer science students' conceptions of and approaches to learning computer science?
(3) Through regression analysis, could computer science students' conceptions of learning be used to make significant predictions about their approaches to learning computer science?

2. Method

Participants

The participants in this study included 421 college students in Taiwan. They were from 16 universities from the north, middle, and south parts of Taiwan. There were 258 male and 162 female students (one with missing data regarding gender), and they all majored in computer science-related departments such as the Department of Computer Science. The age of the students was from 18 to 27, and the average age was 19.92.

Measures

In order to evaluate the computer science students' conceptions of and approaches to learning computer science, two surveys were developed and administered in this study. First, to explore the students' conceptions of learning computer science, this study modified the instrument, Conceptions of Learning Science (COLS) developed by Tsai (2004) and Lee et al. (2008), named Conceptions of Learning Computer Science Survey (COLCS). The current study utilized modified survey, COLCS, also employ a similar multiple factors framework to explore the students' conceptions of learning computer science. Particularly, different from other conceptions of learning surveys, COLCS, added one more factor, named 'Learning computer science as Programming' to reflect the unique feature of computer science domain. The items of this new factor were confirmed by three experts in computer science or computer science education fields. All of the items mentioned above were presented in 1-7 Likert scale, ranging from '1 - Strongly disagree' to '7 - Strongly agree.' The survey included the following eight factors:

(1) Memorizing: Learning computer science is conceptualized as mainly through the students' memorization of definitions, formulae, laws, concepts and the special terms of computer science.
(2) Testing: Learning computer science is regarded as passing the examinations or getting higher scores in the computer science tests.
(3) Calculating and practicing: Learning computer science means calculating, practicing the class tutorial problems, and manipulating the program, formulae and numbers.
(4) Programming: Learning computer science is considered as familiarizing the skills of computer programming.
(5) Increasing one's knowledge: Learning computer science is viewed as an increase of the students' computer science knowledge.
(6) Application: Learning computer science means that the applications of the received computer science knowledge in the real life.
(7) Understanding: Learning computer science is conceptualized as achieving a true understanding of relevant knowledge.
(8) Seeing in a new way: Learning computer science is viewed as providing a new perspective for life.

The second survey implemented in this study, the Approaches to Learning Computer Science Survey (ALCS) was modified from Kember et al.'s study (2004) and Liang et al.'s study (2010). All of the items mentioned above in the ALCS were presented in 1-7 Likert scale, ranging from '1 - Strongly disagree' to '7 - Strongly agree.' The survey included the following four factors, with a sample item for each factor:

(1) Surface motive: Learning computer science is driven by extrinsic motivations, such as learning computer science in order to meet teacher's or parents' expectations or getting higher course grades.
(2) Surface strategy: Computer science is learned by using rote-like strategies, such as remembering the specific terms or parts for just passing the class examinations.
(3) Deep motive: Learning computer science is fostered by the students' intrinsic motivation, such as learning computer science driven by their own interest and curiosity.
(4) Deep strategy: Computer science is learned via using more meaningful strategies, such as trying to attain coherent understandings or making connections to prior knowledge.

Data analysis

This study used principle component analysis to clarify the factor structure of COLCS and ALCS surveys respectively. Then the alpha coefficient for each factor of the survey was calculated to ensure the reliability of each factor. The Pearson correlation was utilized to explore the relationships between the students' factors of COLCS and ALCS. Moreover, a stepwise regression model was built by using all the factors of COLCS as predictors, and each factor of ALCS was regarded as the outcome variable.

3. Results and Discussion

Factor analysis

COLCS and ALCS were not originally developed for the college students who majored in computer science, this study, hence, utilized exploratory factor analysis to examine the factor structure and the reliability of the factors in these two new surveys.

The factor analysis of the COLCS, shown in Table 1, revealed that the computer science students' responses on the survey were grouped into seven factors(26 items), that is 'Memorizing,' 'Testing,' 'Calculating and practicing,' 'Programming,' 'Increasing one's knowledge,' 'Application and Understanding,' and 'Seeing in a new way.' Different from previous studies (e.g. Lee et al., 2008; Liang, & Tsai, 2010), the 'Application' factor and 'Understanding' factor were combined into one factor as 'Application and understanding' in the current study. These factors accounted for 75.29 % of the variance. The reliability coefficients (Cronbach's alpha value) for each factor were around 0.80 - 0.92, and the overall alpha was 0.89, suggesting that the internal consistency of COLCS survey with these seven factors was sufficient for statistical analysis.

To validate the factors of the ALCS survey as shown in Table 2 revealed that the students' responses on the survey were grouped into four factors (17 items), that is 'Surface motive,' 'Surface strategy,' 'Deep motive,' and 'Deep strategy.' These factors accounted for 69.65% of the variance. The reliability coefficients (Cronbach's alpha value) for each factor were around 0.76 - 0.90 and the overall alpha were 0.84. Thus, the ALCS survey, with four factors, was deemed to be sufficiently reliable for assessing college students' approaches to learning computer science.

Table 1: Rotated factor loadings and Cronbach's alpha values for the seven factors of the COLCS

	Factor 1: M	Factor 2: T	Factor 3: CP	Factor 4: P	Factor 5: IK	Factor 6: AU	Factor 7: S
Factor 1: Memorizing (M), α = 0.80, mean=3.88, S.D.=1.10							
M 1	0.80						
M 2	0.83						
M 3	0.75						
Factor 2: Testing (T), α = 0.86, mean=3.52, S.D.=1.12							
T 1		0.69					
T 2		0.81					
T 3		0.82					
T 4		0.84					
Factor 3: Calculating and practicing (CP), α = 0.84, mean=4.07, S.D.=1.17							
CP 1			0.77				
CP 2			0.84				
CP 3			0.77				
Factor 4: Programming (P), α = 0.88, mean=4.79, S.D.=1.10							
P 1				0.71			
P 2				0.81			
P 3				0.89			
P 4				0.87			
Factor 5: Increasing one's knowledge (IK), α = 0.84, mean=5.35, S.D.=0.97							
IK 1					0.85		
IK 2					0.78		
IK 3					0.55		
Factor 6: Application and understanding (AU), α = 0.87, mean=5.25, S.D.=0.86							
AU 1						0.69	
AU 2						0.75	
AU 3						0.53	
AU 4						0.64	
Factor 7: Seeing in a new way (S), α = 0.92, mean=5.28, S.D.=0.94							
S 1							0.71
S 2							0.83
S 3							0.87
S 4							0.80
S 5							0.79

Overall alpha: 0.89; Total variance explained: 75.29%.

Students' scores on the factors

The students' mean scores on each factor of the COLCS is shown in Table 1, all the students' mean scores on each factor were all larger than 4 points on a seven-point scale, except for both of the 'Memorizing' (an average of 3.88 per item) and 'Testing' (an average of 3.52 per item) factors, which were lower than the theoretical mean of the seven-point Likert scale (i.e., 4). The students attained the highest scores on the 'IK' factor (an average of 5.35 per item), and followed by the factor 'Seeing in a new way' (an average of 5.28 per item). These results imply that the computer science students tended to show stronger agreement with these higher-level conceptions and they attempted to take learning computer science as increasing their own knowledge and seeing the new perspectives for life. Moreover, in the ALCS, all the students' mean scores on each factor, as shown in Table 2, were all larger than 4 points on a seven-point scale, except for the 'Surface strategy' factor. The students attained the highest average score on the 'Deep Strategy' factor (an average of 5.11 per item), followed very closely by the factor 'Surface Motive' (an average of 5.10 per item), and they attained the lowest score on the 'Surface Strategy' factor (an average of 3.86 per item). These results indicate that the computer science students possessed deep strategies and surface motivation of learning computer science at the same time.

Table 2: Rotated factor loadings and Cronbach's alpha values for the four subscales of the ALCS

	Factor 1: Surface Motive	Factor 2: Surface Strategy	Factor 3: Deep Motive	Factor 4: Deep Strategy
Factor 1: Surface Motive, $\alpha = 0.81$, mean=5.10, S.D.=1.11				
Surface Motive 1	0.82			
Surface Motive 2	0.85			
Surface Motive 3	0.76			
Factor 2: Surface Strategy, $\alpha = 0.76$, mean=3.86, S.D.=1.06				
Surface Strategy 1		0.67		
Surface Strategy 2		0.62		
Surface Strategy 3		0.84		
Surface Strategy 4		0.84		
Factor 3: Deep Motive, $\alpha = 0.90$, mean=4.81, S.D.=0.91				
Deep Motive 1			0.74	
Deep Motive 2			0.82	
Deep Motive 3			0.84	
Deep Motive 4			0.86	
Deep Motive 5			0.66	
Deep Motive 6			0.58	
Factor 4: Deep Strategy, $\alpha = 0.89$, mean=5.11, S.D.=0.91				
Deep Strategy 1				0.78
Deep Strategy 2				0.75
Deep Strategy 3				0.85
Deep Strategy 4				0.79

Overall alpha: 0.84. Total variance explained: 69.65%

Correlation between COLCS and ALCS

The Pearson's correlation was used to reveal the relationships between the factors of these two surveys. The results are presented in Table 3. It was found that the students with surface motivation tended to express all the conceptions of learning computer science, except for the ‘Testing’ factor. The students with surface strategies tended to have lower-level conceptions of learning computer science such as ‘Memorizing,’ ‘Testing’ and ‘Calculating and practicing.’ On the other hand, the students with deep motivation tended not to possess the ‘Testing’ conception while learning computer science, and tended to have higher-level learning conceptions such as ‘Programming,’ ‘Increasing one's knowledge,’ ‘Application and understanding’ and ‘Seeing in a new way.’ In addition, the students’ deep strategies were quite positively related to higher-level conceptions of learning computer science such as ‘Programming,’ ‘Increasing one's knowledge,’ ‘Application and understanding’ and ‘Seeing in a new way.’

In general, the results showed that the students’ surface motivation was associated with most of the conceptions of learning computer science. However, the students with surface strategies likely only had lower-level of conceptions of learning computer science. More importantly, the students with deep motivation and strategies expressed higher-level of conceptions of learning computer science, and did not attempt to have ‘testing’ conception of learning computer science especially for the students with deep motivation.

Table 3: The correlations between students’ responses to COLCS and ALCS

	Surface Motive	Surface Strategy	Deep Motive	Deep Strategy
Memorizing	0.21*	0.45*	0.01	-0.01
Testing	0.12	0.55*	-0.17*	-0.15
Calculating and practicing	0.23*	0.44*	0.06	0.03
Programming	0.48*	0.13	0.37*	0.39*
Increasing one’s knowledge	0.46*	-0.04	0.44*	0.47*
Application and understanding	0.51*	-0.06	0.55*	0.61*
Seeing in a new way	0.43*	-0.09	0.48*	0.53*

Notes: *p<.001

Stepwise regression analysis for predicting students’ ALCS by the COLCS factors

This study conducted a series of stepwise multiple regression analyses to predict students’ approaches to learning computer science. The students’ conceptions of learning computer science were used as predictors, and their approaches were as the outcomes for the analyses. The results are shown in Table 4. As a result, both of the students’ conceptions of learning computer science such as ‘Applications and understanding’ and ‘Programming’ were significantly positive predictors of their three of the approaches to learning computer science, including ‘Surface Motive,’ ‘Deep Motive,’ and ‘Deep Strategy.’ The students’ ‘Memorizing’ conception of learning computer science was a significantly positive predictor of their surface approaches to learning computer science, including both ‘Surface Motive’ and ‘Surface Strategy’. In addition, the students’ ‘Increasing one’s knowledge’ of the learning conceptions could make significant prediction for their ‘Surface Motive’ of learning computer science.

In sum, the results show that both of the students’ higher-level conceptions of learning computer science (i.e., ‘Applications and understanding’ and ‘Programming’) played important roles not only in their surface motivation, but also in their deep approaches to learning computer science. On the other hand, ‘Memorizing,’ a lower- level of conception of learning made significant contributions to their surface approaches to learning computer science.

Table 4: Stepwise regression model of predicting the students' ALCS (n=421)

Approaches to learning computer science		B	S.E.	β	T	R^2
Surface Motive						
	Application and understanding	0.34	0.07	0.26	4.73*	0.38
	Programming	0.30	0.04	0.29	6.74*	
	Increasing one's knowledge	0.21	0.06	0.18	3.41*	
	Memorizing	0.13	0.04	0.13	3.37*	
	Constant	0.28	0.31		0.90	
Surface Strategy						
	Testing	0.34	0.05	0.36	7.32*	0.36
	Memorizing	0.19	0.04	0.20	4.26*	
	Calculating and practicing	0.15	0.04	0.17	3.61*	
	Constant	1.31	0.18		7.31*	
Deep Motive						
	Application and understanding	0.50	0.05	0.48	10.59*	0.32
	Programming	0.13	0.04	0.16	3.60*	
	Constant	1.54	0.24		6.49*	
Deep Strategy						
	Application and understanding	0.57	0.05	0.54	12.74*	0.39
	Programming	0.13	0.04	0.15	3.63*	
	Constant	1.51	0.22		6.75*	

Notes: *p<.001

Selected References

[1] Durndell, A., & Thomson, K. (1997). Gender and computing: a decade of change? Computers & Education, 28, 1-9.

[2] Reberts, F. S. (2011). The challenges of multidisciplinary education in computer science. Journal of Computer Science and Technology, 26, 636-642.

[3] Peterson, E. R., Brown, G. T. L., & Lrving, S.E. (2010). Secondary school students' conceptions of learning and their relationship to achievement. Learning and Individual Differences, 20, 167-176.

[4] Kizilgunes, B., Tekkaya, C., & Sungur, S. (2009). Modeling the relations among students' epistemological beliefs, motivations, learning approach, and achievement. The Journal of Educational Research, 102, 243-255.