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Promoting Conceptual Change and Algorithmic Learning in College Students' Understanding of Molecular Density

KEYWORDS: problem-solving, conceptual change, molecular density

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ABSTRACT *This study constructs strategies of problem-solving skills to promote conceptual change, algorithmic learning and investigates its effectiveness on students' understanding of the molecular density concept. The sample consists of 47 college students in a primary electronic engineering department. As a quasi-experimental method, it divides college students into two teaching groups, the experimental group and the control group. The statistic results demonstrated that the experimental group students who had finished the learning strategies had shown better learning performance than those of the control group students. Experimental students also had more accurate answering rates of posttests in contrast to their pretests. The same experimental group students with different learning attitudes indicated more significant conceptual change and algorithmic understanding after completing strategies of problem-solving maps.*

INTRODUCTION

To design and estimate dynamic problem-solving processes becomes the major interest and keen goal for chemistry researchers (Cracolice,Deming & Ehlert, 2008). Several strategies of problem-solving have been proposed (Lazakidou & Retalis, 2010), which aim at helping students develop or improve their execution of numerous steps from chemistry learning process. Applications of strategic skills can clarify and strengthen students' concepts, principles, and laws in molecular density learning, and upgrade their perceptive competence and proficiency in problem-solving processes (Selvaratnam & Canagaratna, 2008). In this globalized world, to face and evaluate rapid changes, there are increasingly measurements for problem-solving as important means to guide students in developing more comprehensive understanding of chemistry concepts by more implemented curriculum (Su, 2013). Most importantly of all, curriculum designers come up with effectiveness and mastery of teaching assessments for the important functions of problem-solving in chemistry programs.

Scholars have developed animations with computer-based technologies to promote students' chemistry learning (Su, 2008; Su & Yeh, 2014) and problem-solving maps (Selvaratnam & Canagaratna, 2008). Eminent researchers (Siburt, Bissell, & Macphail, 2011) point out that students have done all the exercises, but still fail to get high grades on exams. This kind of model exercises will be inefficient for instructors to solve different levels of students' learning. Such a distorted learning can frequently be a serious problem for novice learners, who regard chemistry exams just as a recited task for passing rather than a learning process for built-up concepts. Unlike those students who typically lack of the self-perception for critical thinking, college students with chemistry programs can make conceptual metacognition to fill out gaps between chemistry knowledge and problem-solving abilities.

The primary reason may be attributed to those students who are not able to construct adequate understandings for fundamental chemistry concepts (Su, 2008). Students shall be assigned in operating algorithmic learning to solve conceptual questions. Therefore, it is required for students to prospect for inferential skills of problem-solving maps to solve higher-level algorithmic problems and upgrade their aptitude of chemistry concepts.

Research Purposes

Two frameworks to estimate students' learning performances have been proposed as the purpose of this study in the following way:

(1) To determine students' learning achievements in molecular density to build their individual conceptual understanding and algorithmic proficiency.

(2) To exam students' learning attitude in molecular density learning to analyze their conceptual understanding and algorithmic proficiency.

METHODOLOGY

For more detailed discussions, all 47 participantswere selected from the same class divided into the experimental group and the control group. The major characteristics of two different group students who had completed the 4-hour molecular density course during the academic year would be discussed below.

A quasi-experimental approach was taken in this study for the strategic map of problem-solving in molecular density learning, revised from Selvaratnam and Canagaratna (2008). It was expected that all methods including pretests and posttests, experimental teaching, learning questionnaires, and statistical analyses of students' learning achievements and attitudes, would significantly help students improve their strategies of learning performance. The draft achievement tests were designed by conceptual and algorithmic pair questions taken from Nakhleh (1993), together with the final test design from five chemistry professors to assess the validity of achievement tests.

The Cronbach's α coefficient obtained for the total achievement tests was 0.790. To improve the content validity of attitude questionnaire, two prominent chemistry educators, two scientific philosophers and two educational psychologists were asked to act as advisors and to preview the survey and revise final versions. In terms of constructive validity, 165 copies of pretests were taken into consideration for

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factor analyses. All results of factor analyses would be classified into five dominated aspects of learning attitude: Q1 (toward the problem-solving map courses), Q2 (toward the scientific instructors), Q3 (toward other students), Q4 (toward self-evaluation), and Q5 (toward statistic results). The total mean value is 3.67 (standard deviations, 0.49). The internal consistency of students' attitude scales reached a satisfactory degree. The total scale score could correspond to 0.92 as shown by internal consistency inspection of the Cronbach's α. There were totally 29 items in this questionnaire.

Results and Discussions

Students' pretest data were treated as covariate variables, posttest data as dependent variables, and divided student groups as independent variables. Results obtained by the homogeneity examination of regression slope indicated that there existed no significant differences (p =.108)between two student groups for strategic learning applications both independent and dependent variables. All results of achievement t-tests (see Fig. 1) showed that there were significant differences (t=7.681, p<.001) in students' posttest achievements between the experimental group and control group. It should be noted that Cohen's (1988) experimental effect size, f value was 1.158, indicating larger effect size. Adjusted post-test mean scores indicated that posttest scores of the experimental group (45.83) were superior to those of the control group (31.74), which confirmed the research assumption that experimental strategic problem-solving applications of were better than those of traditional teaching.

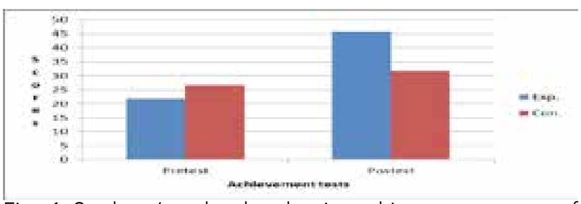

Fig. 1 Students' molecular density achievement t-tests of both pretests and posttests between the

experimental groups and the control groups

According to statistical analyses in Table 1, the experimental group students had more correct answering percentages (%) and numbers (ns) of learning performances in molecular density. To sum up, students' correct conceptual answering percentages (%) and numbers in posttests were superior to those of the pretests 17.5% and 34ns respectively. Students' correct algorithmic answering percentages (%) and numbers in posttests were superior to those of the pretests 7.5% and 9ns respectively. From the statistical analyses of posttest scores' covariance, after pairwise comparisons, and learning achievement tests, the strategic teaching methods proved to have more effective influence on students' learning achievements. After experimental teaching, there were more significant differences between pretests and posttests in molecular density. The reason for the differences lay in the fact that the problem-solving texts with systematic knowledge structure and repeated presentations of problem-solving map, not only showed students' macroscopic learning differences of chemical symbols, but also presented changeable reasons of microscopic conceptions.

-------------Table 1 about here----------------

Table 1 Experimental group students' correct pairwise answering percentages (%) and numbers (ns) between pretests and posttests

Correct pairwise comparisons	Pretest Conceptual	Pretest Algorithmic	Posttest Conceptual	Posttest Algorithmic
Percentages(%)	59.2	44.2	76.7	51.7
ns	58	53	92	62

Table 2 exhibited that major problem-solving effects were indicated by students' five attitude subscales. The blocking variable was tested in a series of ANOVAs with combined samples, since all students had to complete the same learning attitude survey. The effect size was the dominant index to determine different variants in students' learning behavior. All significant effects were tested to determine students' learning dispositions toward molecular density learning. Effect sizes ranging from Q1 to Q4 were between .51 and .64, demonstrated a larger than large level. Scheffe's post hoc comparisons showed students' expressing more "positive" attitudes than those reporting "neutral" and "negative", and more reporting "neutral" expressions as more positive than those reporting "negative" in molecular density learning

Table 2 Summary of learning attitude in ANOVAs post-tests

Experimental Course	Blocking Variable	Analysis of Variance	Attitude Measure Q1	Q2	Q3	Q4	Q5
molecular density	Disposition toward Chemistry(positive, neutral, negative)	F-ratio	7.24	6.94	4.59	4.90	0.93
		p-value	0.002**	0.003**	0.017*	0.012*	0.912
		f	0.64	0.63	0.51	0.53	0.26
		Scheffe	1>3, 2>3	1>3, 2>3	1>3, 2>3	1>2, 1>3	

Note: *p<0.05; **p<0.01

DISCUSSION

As the result revealed significant improvement for the experimental group students in comparison to the control group students in problem-solving performances, it may be attributed to the fact that the relationships between qualitative reasoning and quantitative problem-solving helped to build students' hand-drawn deductive abilities, and construct useful learning performances. Generally speaking, "students' dispositions toward molecular density," proved to have significant effects in the above attitude questionnaire. Several other studies supported that after completing problem-solving of college students would come up with the corresponding results of better learning performances than other applications with no integrated problem-solving maps. Therefore, students felt applications of problem-solving maps in molecular density learning could be helpful for their recognition of chemical concepts and higher-level algorithmic learning. Applications of problem-solving maps could be both multi-functional and practical for students' learning. They had a lot of appeal to students who looked forward to problem-solving detailed strategies of chemistry learning. From this perspective of problem-solving applications, it was not

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enough only to create an environment that fostered students' creativity or promoted individuals' positive beliefs about chemistry learning. The advantages of varied strategic thinking methods might promote individual student's creative performance and support dynamic applications for molecular density learning.

Conclusions

In this orientation, this study would enhance most students' learning performances after they had completed molecular density courses. Based on this problem-solving perspective, it could become a dynamic and effective approach for learning. College students' learning achievements and attitudes were elevated to statistical results.All demonstrations of the experimental results exhibited that problem-solving was helpful for conceptual learning as a significantly positive contribution toward engineering students' learning achievements and attitudes. Within limitations of this study, despite the statistical significance of results, readers would be reminded that the results should not be over generalized beyond the context of this study. Continuing efforts would also be needed to confirm further approaches to fulfill and integrate the academic benefits of this problem-solving study in the future.

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