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ABSTRACT

In an effort to investigate the effects of a teaching strategy that helps students to identify concept conflicts through experimentation and guided investigation on students' conceptual changes and learning outcomes, 596 students (393 junior high school, 170 senior high school, and 33 college students) were administered two solution tests (pre-test and post test designed to identify students' conceptions of solutions in chemistry) and a proportional reasoning test. The results suggest that teachers can use cognitive development such as proportional reasoning ability as an indicator when teaching chemistry. In addition, the findings suggest that the use of concept conflict in teaching in the classroom will improve most students' understanding of concepts of solution. (ZWH)

A STUDY OF PROPORTIONAL REASONING AND SELF-REGULATION INSTRUCTION ON STUDENTS' CONCEPTUAL CHANGE IN CONCEPTIONS OF SOLUTION

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ABSTRACT

This study was to investigate the possible students conceptual changes and learning outcomes under the appropriate instruction through a teaching strategy on students' cognitive conflict. An analysis of student responses to the diagnostic pre-test and the post-test, involving conceptions of concentration and saturation of sugar solution, were reported in this paper. The two sugar solution tests and the proportional reasoning test were measured by group demonstration test method which were developed by the first researcher. These three tests were conducted on high school students selected in Taiwan area. It revealed that student conceptions of concentration were related to proportional reasoning, and that a large number of student responses focus on the ideal that sugar weight is the only factor which determined the concentration or saturation of a solution. This paper dealt with one strategy that involving experimentation and guided investigation to change students' misconception and to promote their better understanding of the specific concepts related to conceptions of solution. It was found that the strategy helped students to some extent to change their misconceptions.

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INTRODUCTION

Piaget (1929) was among the first to analyze and evaluate conceptions that children held about scientific ideas. From the constructivist point of views that students must construct some of their own prior knowledge framework from everyday life experiences. Some of the research reports (Lawson & Thompson, 1988; Hwang, 1991) reveled that only the reasoning ability among the variations was significantly related to the number of misconceptions. (ther researches indicated that instructional strategies should do something related to the problems associated with misconceptions, while preconceptions have been founded to inhibit students' acceptance of scientifically correct information. Further, in the area of misconceptions, researchers continue to imply that misconceptions are deeply rooted 'instructor resistant' (Lawson, Abaraham & Renner, 1989), 'resistant to teaching' (Carey, 1986; Hwang, 1993), 'robust and difficult to extinguish' (Vosniado, 1988) or 'incorrect, outdated, or unacceptable in a science-oriented culture' (Crawley & Arditzglow, 1988). For guiding the students from intuitive common sense knowledge to accepted scientific knowledge; and for training the teachers from common sense teaching style to research oriented teaching style, the topics of misconceptions, conceptual change, and teaching strategies designed to bring about conceptual conflict, have become popular in research of science education today (Erickson, 1979; Posner, et al., 1982; Driver & Erickson, 1983; Lawson & Thompson, 1988; Tomnsini, & Halandi, 1988; Renner, et al., 1990; Bar & Travis, 1991; Westbrook & Marek, 1991).

The conceptions of chemical solution are the important parts of curriculum in chemistry teaching. We believe that the study data of the students misconceptions of solution and the conceptual change through the teaching strategy focusing on the cognitive conflict are valuable for improving the chemistry instructions in schools.

PURPOSE OF STUDY

The purposes of this study were as following:

* To diagnose and classify the modes of misconceptions with respect to conceptions of solution and related concepts in chemistry.
* To identify the development patterns related to the acquisition of direct proportional reasoning in high schools.
* To investigate the relationship statistically between students proportional reasonings and their conceptions of solution, concerning the concepts such as weight conservation, concentration, and saturation etc..
* To explore the usefulness of an approach to chemistry instruction, focusing on concept conflict, which specifically considered student misconceptions about solution.

INSTRUMENTS

Three instruments were carried out in the investigation.

(a) The pre-test : the task of conceptions of solution in chemistry(SOLNI2) was presented in two ways: (1) an oral interview mode, using teacher demonstration and student observation format; (2) a written test using administrator demonstration of sugar water solution concerning the concepts of concentration and saturation.

(b) The task of proportional reasoning (PP1) was a group demonstration test consisting of student drawings of water level and answering and justifications of the reasons. According to Piaget cognitive development theory and the interview techniques, the proportional reasoning instrument was also applied to the students to evaluate their cognitive develoment before the pre-test of solution concepts in chemistry.

(c) The post-test: the task of solution concepts (SNTG1), consisting with the same format used as in the pre-test.

All the above instruments, as a kind of group demonstration test, were developed and designed by the first reseacher.

For providing students with ideas or experiences contradictory to the held conceptions of them has been proposed to initiate conceptual conflict and, ultimately, conceptual change, an unit of teaching strategy was designed. This experimental instrutional stragegy was designed to lead students from their existing knowledge to the scientific knowledge. The instruction was administrated between the time period of pre-test and post-tests.

SAMPLING

The subjects ranged in grades from 8 to 11 in junior and senior high school levels. For comparison some of the college students were selected as the samples. A final sample size of 596 subjects which included 393 junior high school students, 170 senior high school students, and 33 college level students was used in the analysis of the data.

PROCEDURES

In this study, the instructional approach involved diagnosing students misconcetions, making them aware of their conceptions, having the students discuss their conceptions, having them do experiment about their conceptions, and bringing students to a more scientific understanding in light of their learning experiences. Special attention was paid in the study of investigating the students reasoning modes in conceptions of solution according to their cognitive development of proportional reasoning.

Clinical interview techniques were considered for diagnostic use to describe some of the students misconceptions and reasonings. All the interviews were recorded on videotapes or tapes and subsequently transcribed. Then the instruments of pre-test and post-test, which were a knid of group demonstration tests, were conducted to the samples. The effectiveness of instruction was measured by conducting a pre-test and post-test designed for each unit concept of chemical solution. In the data analysis, consideration was given both to the overall changes after instruction with strategy of concept conflict in understanding of the students' conceptions of concentration, saturation, and etc., as in figure 1.

(Insert Figure 1 here)

RESULTS

Findings of students thinking modes raised by interview study can be categorized as the followings:

* The solution must be in the liquid phase, solvent must be in a liquid state, and solute must be in a solid state; when sugar dissolves in water, it turns into the liquid state.
* When sugar dissolves in water, it disappears and the weight of solution will be less than the total weight of sugar and water contained in solution.
* A high percentage of students, who were confused by the term concentration, did not possess the abilities of proportional reasoning. Some students thought the quantity of solute is the only factor that determines the concentration of the solution.
* Students could not spontaneously use particulate theory, and even less willingly to use the words "atoms" and "molecule", to describe mixtures or solution concepts.
* Some students who could recognize the diagrams of particle in sugar solution but remained hesitant in useing the words article "atom" or "molecule" to explain the diagram, and thought the particle in solution as the smallest size of sugar cube.
* Students were confused by the terms "saturated" and "unsaturated" in solution.
* From the point of view of thermodynamic theory, students had difficulty in explaining what is the effect of temperature on the concentration or the saturation of a solution.
* Students thought that sugar will be vaporized togather with water when sugar solution was heated, it would cause the weight of sugar reduced in sugar solution.

Results from the statistical analysis of the data from group demonstration tests:

The students conceptions about sugar solution can be analyzed according to the following items by comparing the pre-test and post-test data, and also by the data from proportional reasoning test:

1. Diagnosis of the conceptions of sugar solution

Factor affectting dissolution

* In junior and senior high school, the correct percentages of responses about the effect of temperature to saturation was 38.3 and 54.4 respectively.
* In junior and senior high school, the correct percentages of responses about the factor of solution was 57.1 and 69.8 respectively.

Concentration and Saturation of sugar solution

* In junior and senior high school, the correct percentages of responses about the concept of concentration was 51.8 and 68.0 respectively; about the concept of saturation was 66.7 and 81.1 respectively
* The correlation coefficient, between the concepts of concentration and saturation of sugar solution, were as follows: for junior high school students, r = .06, it was statistically nonsignificant; for senior high school students, r = .30 , it was statistically significant at alpha equal .001 level. The above data means that the concepts of concentration was one of the factors which was attributed to senior high school students thinking modes of saturation phenomenon. For the junior high school students, the concentration concept was nothing related to the conception of saturation.

Temperature on concentration and saturation

* Compared to the senior high school students, most junior high school students could

not consider the effect of temperature on concentration, saturation or solubility.

2. Reasoning patterns of conceptions of sugar solution

* About the saturation concept, whether the junior high school stucents could use the proportional reasoning ability in judging the responses was not the main factor for answering the test correctly. Because the junior high school students explained the answer about the saturation of solution from rote learning only, not by the relative quantity between solute and solvent.

* For senior high school students, the correlations between proportional reasoning and conceptions of solution both in pre-test items and post-test items all were significant statistically (Table 1). But the junior high school students, in the conception of temperature effect on saturation or definition of saturation, do not use proportional reasoning in the problem solving process.

(Insert Table 1 here)

3. Proportional reasoning vs conceptions of solution

* In this sample, the percentages of students with proportional reasoning ability were as follows: (G8: 39%; G9: 44.9%; G10: 50%; G11 85.1%). The percentages of the other students, who were without this kind of ability and applied the addition strategy to solve the proportional problem, were 28.3% for G8; 17.4% for G9; and 13% for G10+G11.

* Students even could not explain the factors about concentration and solubiliiy by proportional reasoning.

* Both in the pre-test and post-test, the students who possessed the proportional reasoning ability would performed much better about the concetps of solution, such as conccentration, saturation etc..

* When an instruction focusing on concept conflict of solution was applied to those formal operational students who had the proportional reasoning ability, they could get higher scores in the post test campared to that of the pretest, .

4. Comparison between pre-test and post-test of solution concepts

* According to students proportional reasoning ability, the chi-square data, between pretest and post-test about the conceptions of solution such as factors which affecting solution, the concentration, saturation and temperature on solubility, were shown in Table 2.

* After instruction, the concept about effect of temperature on saturation ordissolution was found not to be a significant contributing factor to the improved performance for the 8th grade level students.

* All the students even they had the ability of proportionality, did not have the improvement about the conception of temperature on saturation.

(Insert Table 2 here)

* Comparing the results about conceptions of solution in pre-test and post-test, it revealed that the percentage of correct responses would be higher for students who possessed the ability of proportional reasoning (Table 3).

(Insert Table 3 here)

CONCLUSIONS

The study findings suggest that the cognitive development such as proportional reasoning ability can be used as an indicator in chemistry teaching. The other findings from the analysis of variations indicated that the improved performance on the post-test by the students, as a whole, could be attributed, in part, to the application of instruction concerning the design of teaching with concept conflict in the classroom. The study findings suggest that use of concept conflict in teaching in the classroom will improve most students learning in conceptions of solution, i.e. the experimental instructional method could cause a significantly better acquisition of solution concepts and elimination some of specific misconception. Therefore, misconceptions may be seen as the key to successful instruction if they are explicitly considered by the teachers. Efforts in instruction strategies need to take this aspect into consideration.

Table 1 The Correlation of Pre-test and Post-test of Conception of Solution based on Porportional Reasoning

SUBJECTS	CONCEPT OF SOLUTION	CORRELATION COEFFICIENT
JUNIOR HIGH:	PRETEST	
	condition of solution (F1)	.34***
	concentration of solution (CON1)	.47***
	saturation of sugar solution (SA1)	.38***
	temperature on concentration (TC1)	.19***
	temperature on saturation (TST1)	0.08
	POSTTEST	
	temperature on saturation (TS3)	.14*
	condition of solution (F2)	-0.01
	concentration of solution (CON2)	.25***
	saturation of sugar solution (SA2)	0.04
SENIOR HIGH:	PRETEST	
	condition of solution (F1)	.29***
	concentration of solution (CON1)	.29***
	saturation of sugar solution (SA1)	.39***
	temperature on saturation (TS1)	.26***
	temperature on concentration (TC1)	.28***
	temperature on saturation (TST1)	.26***
	POSTTEST	
	temperature on saturation (TS2)	.39***
	temperature on saturation (TS3)	.34***
	condition of solution (F2)	.29***
	concentration of solution (CON2)	.37***
	saturation of sugar solution (SA2)	.32***

*P<.05 **P<.01 ***P<.001

Table 2 The Chi-square of Pre-test and Post-test of Solution Concepts Based on Proportional Reasoning

Subject	Variation	Proportional Reasoning=R	Proportional Reasoning= NR	Proportional Reasoning= R+NR
Junior High School.	factors		0.14	1.57
	concentration	11.69***	25.45***	68.84***
	saturation	2.90	15.91***	33.49***
	temp .n saturation	1.68	1.74	1.95
Senior High School:	factors	4.21*	3.59	1.52
	concentration	12.29**	9.66**	2.07**
	saturation	31.87***	23.85***	8.39**
	temp on saturation	1.05	1.33	2.93

* p<.05 **p<.01 ***p<.001

Table 3 Percents of Correct Response about Solution Concept Classified by Proportional Reasoning

SCHOOL LEVELS	CONCEPTIONS OF SOLUTION		PROPORTIONAL REASONING A	T	R	TR	Total	CHI-SQUA
JUNIOR	F1(N=382) FACTORS	n %	47 21.6	39 17.9	121 55.5	11 5.0	218 57.1	44.57***
	CON1(N=392) CONCENTRATION %	n 13.3	27 16.7	34 64.5	131 5.4	11 51.8	203	101.70***
	SA1(N=390) SATURATION	n %	46 17.7	56 21.5	141 54.2	17 6.5	260 66.7	67.10***
	TS1(N=107) TEMP & SAT	n %	3 7.3	12 29.3	24 58.5	2 4.9	41 38.3	4.79
	TC1(N=390) TEMP & CON	n %	67 22.6	76 25.7	136 45.9	17 5.7	296 75.9	17.17***
	TST1(N=391) TEMP & SAT	n %	55 24.7	59 26.5	97 43.5	12 5.4	223 57.0	2.51
	TS2(N=246) TEMP & SAT	n %	49 22.3	63 28.6	100 45.5	8 3.6	220 89.4	16.84***
	TS3(N=254) TEMP & SAT	n %	25 16.4	50 32.9	73 48.0	4 2.6	152 59.8	10.50*
	F2(N=255) FACTOR	n %	50 20.3	81 32.9	105 42.7	10 4.1	246 96.5	7.91*
	CON2(N=249) CONCENTRATION	n %	23 15.2	33 21.9	88 58.3	7 4.6	151 60.6	48.27***
	SA2(N=256) SATURATION	n %	43 19.0	72 31.9	102 45.1	9 4.0	226 88.3	16.20***
SENIOR	F1(N=149) FACTORS	n %	9 8.7	12 11.5	78 75.0	5 4.8	104 69.8	11.45**
	CON1(N=150) CONCENTRATION %	n 9.8	10 11.8	12 74.5	76 3.9	4 68.0	102	10.07*
	SA1(N=151) SATURATION	n %	8 6.5	14 11.3	94 75.8	8 6.5	124 81.1	34.98***
	TS1(N=149) TEMP & SAT	n %	9 11.1	7 8.6	61 75.3	4 4.9	81 54.4	4.76
	TC1(N=151) TEMP & CONC	n %	17 13.0	15 11.5	91 69.5	8 6.1	131 86.8	1.73
	TST1(N=149) TEMP & SAT	n %	9 11.1	7 8.6	61 75.3	4 4.9	81 54.4	4.76
	TS2(N=150) TEMP & SAT	n %	18 12.5	16 11.1	103 71.5	7 4.9	144 96.0	12.10**
	TS3(N=148) TEMP & SAT	n %	1 1.6	2 3.1	56 87.5	5 7.8	64 43.2	25.00***
	F2(N=147) FACTOR	n %	18 13.1	17 12.4	93 67.9	9 6.6	137 93.2	16.70**
	CON2(N=148) CONCENTRATION	n %	13 10.5	12 9.7	89 71.8	9 7.3	124 83.8	13.01*
	SA2(N=155) SATURATION	n %	15 11.4	14 10.6	95 72.0	7 5.3	132 85.2	6.14

Pretest variables: F1, CON1, SA1, TS1, TC1, TST1

Posttest variables: TS2, TS3, F2, CON2, SA2

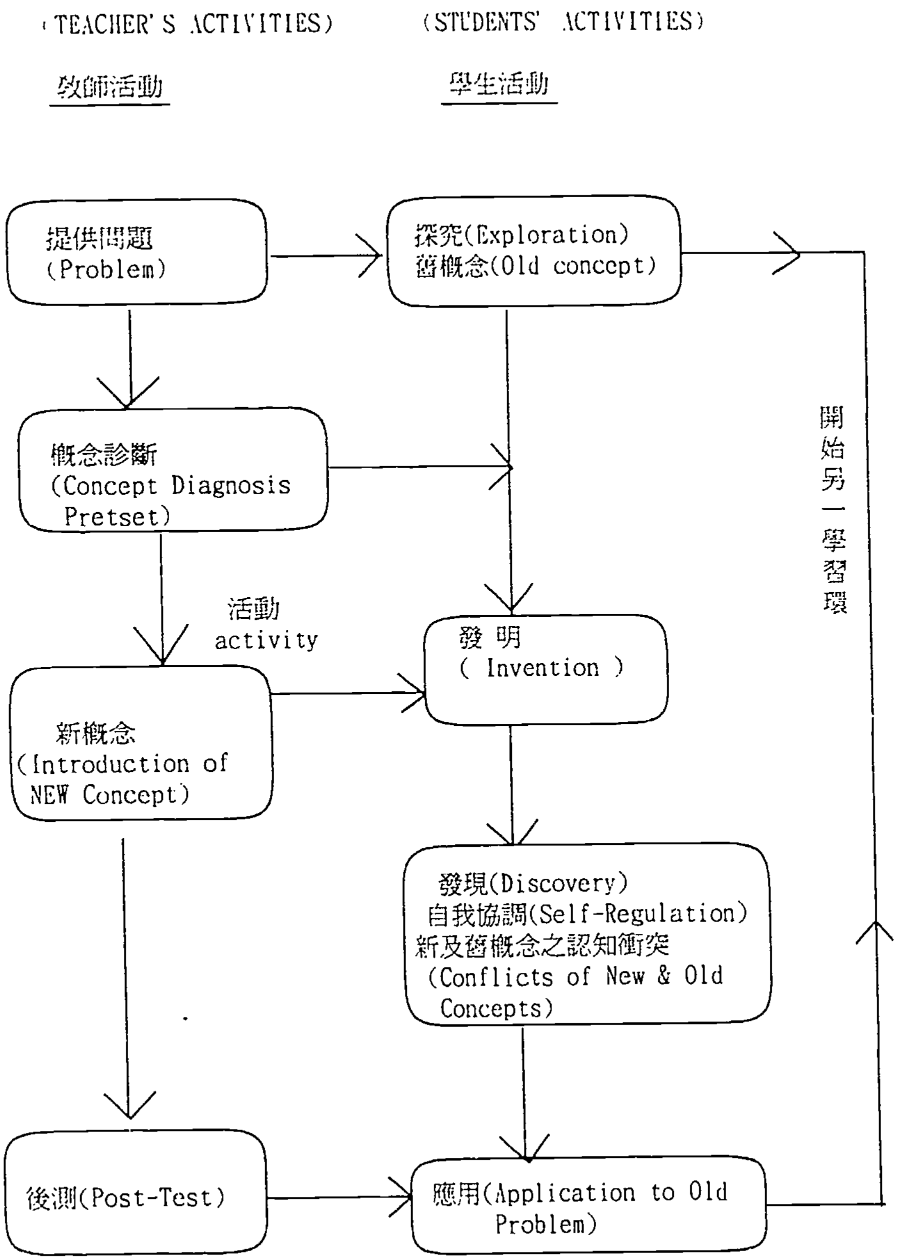

Figure 1 The teaching model of the conception of heat and temperature through the cognitive conflict strategy
（圖一 溫度及熱量概念之認知衝突教學模式）

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