計畫名稱：以「衝突圖」輔助科學教學之初探

Enhance science instruction: A study of using "conflict map"

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一、中文摘要

科教研究一再揭露學生在學習科學概念時有迷思概念。本研究首先提出一「衝突圖」之觀點以克服學生之迷思概念。「衝突圖」運用一系列之差異性事件、關鍵性事件、相關之科學概念及官感支援以促進學生之概念轉換（Tsai, in press）。本研究進一步進行一實證研究探討「衝突圖」的使用對於國二學生學電學概念時之概念轉換及認知結構成果之影響。經由準實驗設計法，93 個國二學生被分派為傳統教學組，而 97 個國二學生分派到衝突圖實驗教學組。學生雙層式測驗填答結果顯示衝突圖之教學有助於克服關於電流之迷思概念。而學生的認知結構（經由語意流程圖析法分析）亦顯示衝突圖的使用可幫助學生建構較豐富且整合之知識概念結構。

關鍵詞：衝突圖、概念轉換、迷思概念

Abstract

Research in science education has revealed that students have misconceptions when learning various domains in science. The “conflict map” uses a series of discrepant events, critical events, relevant scientific conceptions and perceptions to promote student conceptual change (Tsai, in press). This study was conducted to examine the effects of using a “conflict map” on 8^{th} graders’ conceptual change and ideational networks about electric circuit. Through a quasi-experimental research design, 93 Taiwanese 8^{th} graders were assigned to a control group, receiving traditional instruction, while 97 8^{th} graders were assigned to an experimental group, which used a “conflict map” as an instructional tool. Research data gathered from two-tier test revealed that the conflict map could help students overcome misconceptions about electric circuit. Student interview data analyzed through a flow map method also showed that the use of conflict map could help student construct richer and more integrated ideational networks about electric circuit.

Keywords

conflict maps, conceptual change, alternative conceptions

Objectives of the study

The main objective of this study was to examine the effects of using a “conflict map” on overcoming junior high school students’ misconceptions about electric circuit. The idea of using “conflict map” is proposed by Tsai (in press). Through a quasi-experimental research design, this study examined the effects of using a conflict map on student conceptual change and ideational networks about electric circuit.

Significance

In the recent two decades, the most important contribution of science educators may have been to explore and assess students’ “misconceptions” or “alternative conceptions,” because many educators believe that students’ prior knowledge could highly influence subsequent learning. A sheer number of studies documenting student misconceptions show that these conceptions are content-dependent and they are resistant to change through conventional teaching strategies (Tsai, 1999). However, knowing students’ misconceptions does not mean that educators have potential methods to promote student conceptual change. This study described an attempt to use a “conflict map” to overcome student misconceptions about electric circuit.

Theoretical underpinnings

The perspective of using conflict map

asserts that students should resolve two conflicts during the process of conceptual change: one exists between new perception and students' misconception (conflict 1), and the other one exists between student misconception and scientific one (conflict 2). Conflict 1 could be resolved through discrepant events, and the resolution of conflict 2 could be achieved through using "critical events or explanations" and relevant perceptions and conceptions that explicate the scientific conception. Figure 1 illustrates a conflict map of conquering students' prevalent misconception that light bulbs would use up electricity or electric current in a series circuit. The discrepant event is designed to show that the current in the circuit is equal anywhere. However, students ask if the current is not being used up, what is lighting the bulbs? The critical event is designed to show and further explain that the decrease of electric potential (shown by voltmeters) makes the bulbs become bright. Ohm's law, the law of energy conservation, the ideas of potential energy (in mechanics), electrons and electric resistance could be considered as other conceptual supports for the target concept. Moreover, the lights of Christmas tree (part of the light bulbs are in series) or the water circuit analogy could be used as other perceptions to explain the scientific concept that will be taught. The use of conflict map as an instructional tool will present the scientific concepts by the following instructional sequence: discrepant perception, target scientific concept, critical event and explanation, relevant concepts (e.g., Ohm's law, potential energy, electrons) and finally supporting perceptions (e.g., water circuit analogy). This sequence is consistent with Posner et al's (1982) well-known conditions of conceptual change; hence, it is expected to promote student conceptual change. The use of conflict maps could help students seek a stable and desirable equilibration between the conceptual schema they have already assembled and the perceptual information arising from the environment. The clarification as well as the connections among relevant misconceptions and scientific ideas are also explored and emphasized.

Methods

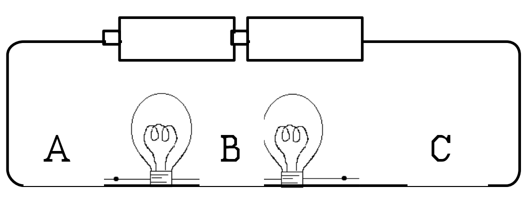
Subjects and research treatment

This study was intended to examine the effects of the conflict map of electric circuit (shown in Figure 1) on student conceptual change and ideational networks. The subjects of this study came from four 8th-grade "fundamental physical science" classes from a junior high school near Taipei City. By using a quasi-experimental research approach, about at the midterm of students' 8th-grade spring semester, two classes were assigned to a traditional teaching group (i.e., control group) and two classes were assigned to a conflict map instruction group (i.e., experimental group). There were 93 students in the traditional group and 97 in the experimental group. These two groups did not show statistical differences in the "fundamental physical science" course score of their 8th-grade fall semester ($p>>.05$). These two groups (four classes) were taught by the same teacher (their original science teacher). The traditional teaching group received textbook-based and almost one-way lecturing instruction. The conflict map treatment group presented the scientific concepts by the instructional sequence described in last section. The instructional time for these two groups were the same (three 50-minute periods). In Taiwan's nation-wide curricula, eighth grade is almost the first time of receiving formal instruction of scientific concepts about electric circuit. This research project was conducted right on the period of scheduled syllabus of teaching electric circuit.

Assessing student conceptual change

Two weeks before conducting the research treatment, the following two-tier test item was administered to all of the subjects to survey student misconceptions.

In the following circuit, the comparisons of the current among A, B, and C points will be:



(a). A>B>C, (b). A=B=C, (c). A<B<C.

The reason for your choice above is:

(i) The light bulbs will use up both current and electric potential (energy).

(ii) The light bulbs will not use up current but use up electric potential (energy).

(iii) The light bulbs will use up current but not electric potential (energy).

A similar two-tier test was administered about one week after the research treatment. Students could have nine possible choices in the two-tier test, and (b)(ii) is the correct answer. Students' responses on the two-tier test were used as a record of their conceptual change.

Exploring student ideational networks about electric circuit

Twelve students from each class (a total of 24 in each group) were randomly selected for an in-depth interview to explore their ideational networks about electric circuit. These students were interviewed about two weeks after the treatment. The researchers showed a simple electric circuit graph (similar to the figure in the first tier of the test) to help students recall what they have known about electric circuit. Through interviewing these students (using a standardized set of questions without providing any directive suggestions), they were asked to freely recall or reconstruct what they had learned about electric circuit. By such an interview-recall method, coupled with a "meta-listening" technique (i.e., asking each subject to listen to a reply of his or her prior elicited recall and possibly to modify his/her original ideas, see Tsai, 1998), every selected student's interview narrative was further analyzed by a "flow map" method (Anderson & Demetrius, 1993). A flow map is constructed by diagramming the respondent's verbalization of thought as it unfolds, and it is a convenient way to display the sequential and complex or cross-linkage thought patterns expressed by the respondent. By employing the flow-map method, this study yielded the following major ideational network outcome variables: size or extent (linear linkages or number of ideas), richness (recurrent or cross linkages), integratedness (proportion of recurrent linkages), and correctness (number of misconceptions). A second independent researcher was asked to analyze sixteen randomly selected narrative data (among 48 narrative data). The inter-coder agreement for sequential statements was .92 and for cross linkages was .89.

Findings

The chi-square test that was conducted to explore the choice pattern in the pretest (two-tier test) between two groups revealed that there was no significant difference between traditional group and conflict map group (chi-square=2.44, $p>>.05$, d.f.=8). In each group, the choices of (a)(i), (a)(iii) and (b)(ii) were each selected by about 25% of the students. These results were reasonable since these three choices are logically consistent cross first tier and second tier. The results of (a)(i) and (a)(iii) further confirmed a well-known student misconception that light bulbs would use up the current. The posttest showed that the choice pattern between these two groups was significantly different (chi-square=15.60, $p<.05$, d.f.=8). 63.9% of the experimental group students answered correctly in the two tier test (i.e., (b)(ii)), while only 39.8% of control group students selected the same choice. Still 15.1% of control group students chose (a)(i) and 9.7% of the control group students chose (a)(iii) as their answer, but few of experimental group students chose such choices after the research treatment (8.2% and 2.1% respectively). It is also interesting to find that about 68% of control group students make a correct choice in the first tier (i.e., b), but many of them (about 28%) did not respond correctly in the second tier; that is, they answered (b)(i) and (b)(iii). These two choices seemed not to be logically consistent cross two tiers and not as many of experimental group students (about 16%) selected such choices. Students in the traditional group may have memorized the correct factual scientific knowledge (i.e., the first tier) but they did not have further understandings about it (i.e., the second tier).

(Please refer to Table1, Figure 2)

The comparisons of students' ideational networks between two groups were analyzed by using their 8th-grade fall semester score in the "fundamental physical science" course as a covariate. The ANCOVA results revealed that experimental group students did not show a larger extent of ideational networks (i.e., number of ideas) than those of control group students. However, the richness and integratedness of ideational networks shown by the experimental group students were better than those of traditional group ($F=4.76$, $p<.05$ and $F=8.45$, $p<.01$ respectively; please refer to Table 2). Experimental group students seemed not to state statistically fewer misconceptions in the flow-map interview than the control group students did; however, the difference almost reached the significance level of 0.05 ($F=2.81$, $p=0.1$). In sum, the use of conflict map as an instructional tool could help junior high school students overcome some specific misconception in electric circuit. Students also construct richer and more integrated knowledge structures as a result of using conflict map.

References

Anderson, O.R., & Demetrius, O.J. (1993). A flow-map method of representing cognitive structure based on respondents' narrative using science content. *Journal of Research in Science Teaching, 30*, 953-969.

Posner, G.J., Strike, K.A., Hewson, P.W., & Gertzog, W.A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education, 66*, 211-277.

Tsai, C.-C. (in press). Enhancing science instruction: The use of "conflict maps." *International Journal of Science Education.*

Tsai, C.-C. (1999). Overcoming junior high school students' misconceptions about microscopic views of phase change: A study of an analogy activity. *Journal of Science Education and Technology, 8*, 83-91.

Tsai, C. (1998). An analysis of Taiwanese eighth graders' science achievement, scientific epistemological beliefs and cognitive structure outcomes after learning basic atomic theory. *International Journal of Science Education, 20*, 413-425.

Table 1: Students' responses on two-tier test

Choice	Pretest [a]		posttest [b]	
	traditional (#, %)	conflict map (#, %)	traditional (#, %)	conflict map (#, %)
(a)(i)	25 (26.9)	21 (21.6)	14 (15.1)	8 (8.2)
(a)(ii)	5 (5.4)	10 (10.3)	3 (3.2)	3 (3.1)
(a)(iii)	22 (23.7)	22 (22.7)	9 (9.7)	2 (2.1)
(b)(i)	6 (6.5)	6 (6.2)	15 (16.1)	8 (8.2)
(b)(ii)	21 (22.6)	23 (23.7)	37 (39.8)	62 (63.9)
(b)(iii)	4 (4.3)	5 (5.2)	11 (11.8)	8 (8.2)
(c)(i)	4 (4.3)	5 (5.2)	1 (1.1)	2 (2.1)
(c)(ii)	3 (3.2)	2 (2.1)	2 (2.2)	2 (2.1)
(c)(iii)	3 (3.2)	3 (3.1)	1 (1.1)	2 (2.1)

Notes:

a. chi-square=2.44, d.f.=8, p>>0.05, n.s.

b. chi-square=15.60, d.f.=8, p<0.05

Table 2: Students' ideational network outcomes between traditional group and conflict map group

	traditional [a] (mean, S.D)	conflict map [a] (mean, S.D)	F [b]	P
Prior science achievement	76.2 (13.3)	73.9 (13.0)	0.38	0.54
Extent	7.46 (2.59)	7.38 (2.45)	0.24	0.62
Richness	6.79 (2.99)	7.75 (3.38)	4.76	0.03*
Integratedness	0.47 (0.05)	0.50 (0.05)	8.45	0.006**
Misconception	0.79 (0.59)	0.58 (0.72)	2.81	0.10

Notes: a. n=24 for each group

b. The F value for variables "extent," "richness," "integratedness," and "misconception" is calculated by using student "prior science achievement" as a covariate (i.e., using ANCOVA method).

* p<0.05, ** p<0.01

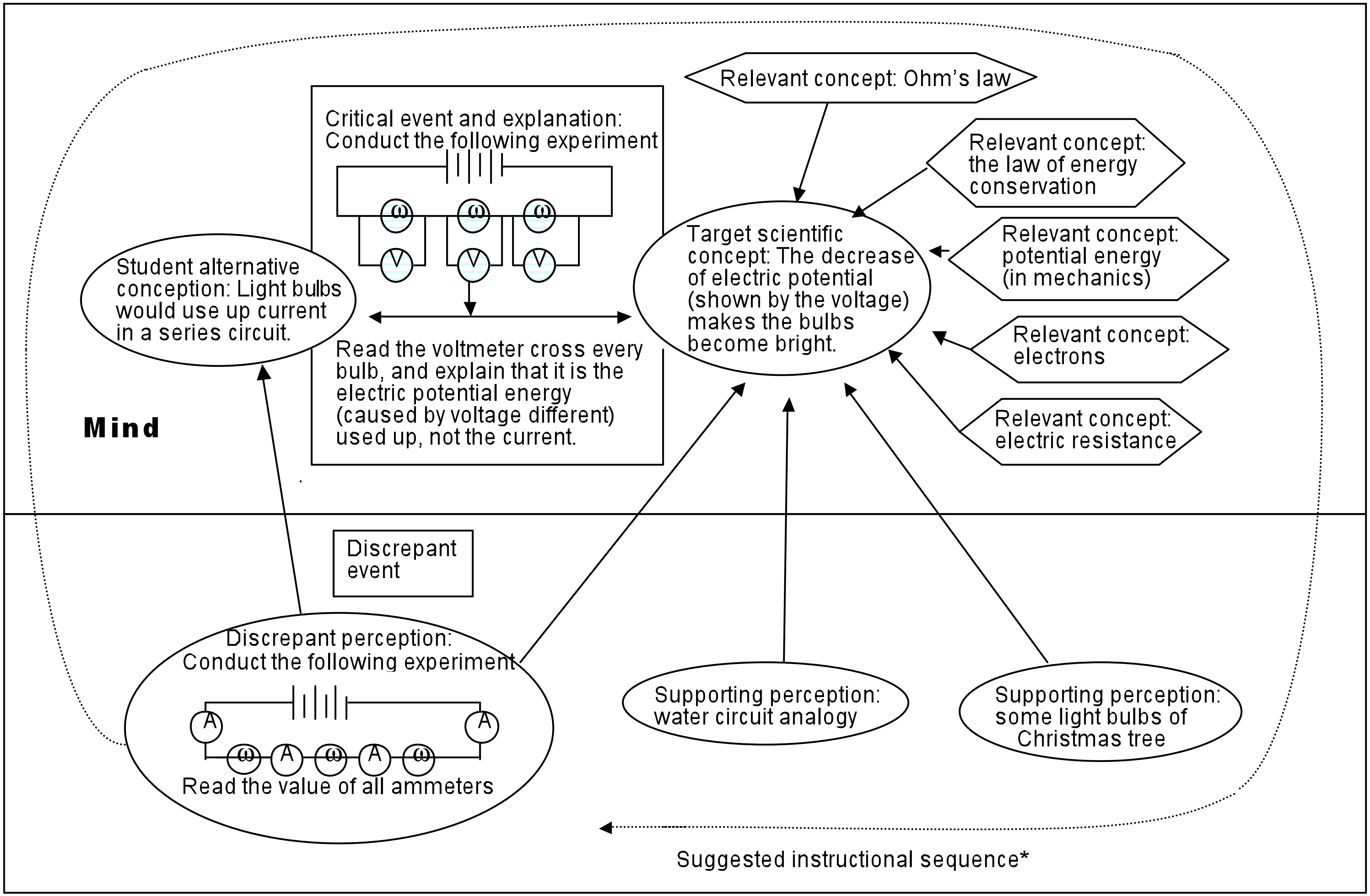


Figure 1: A conflict map about electric circuit

* There is an exception in the teaching sequence that the target scientific concept should be presented earlier than the critical event.

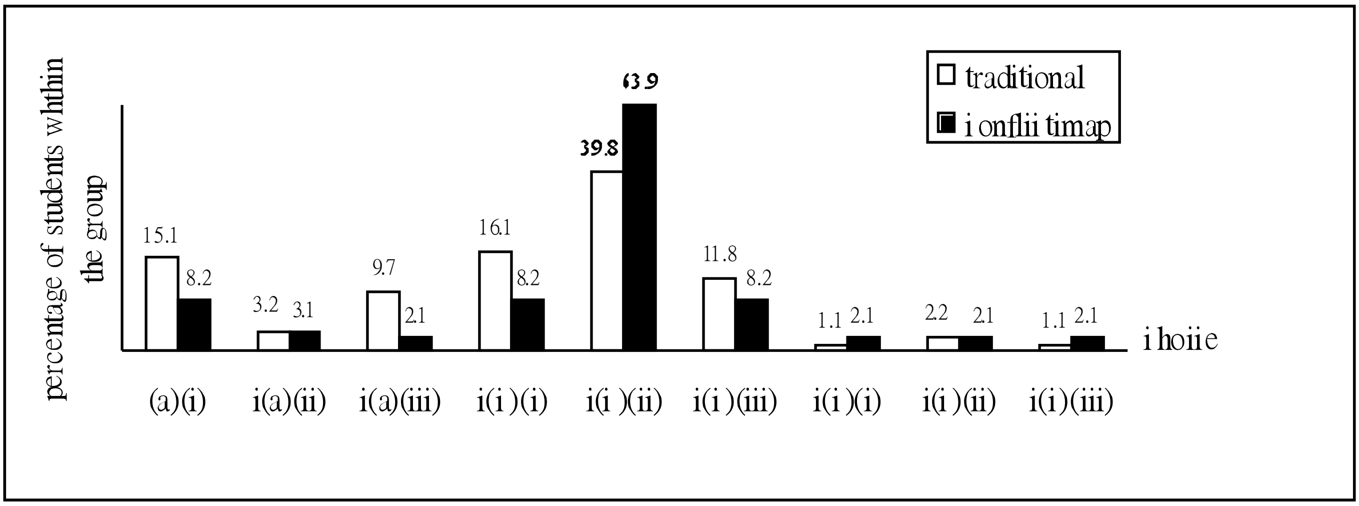


Figure 2: Students' responses on post-two-tier test