A kind of or a part of? Analyzing Students' Comprehension of the Statements of the Hyponymy-Meronymy in the Science Textbooks

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ABSTRACT

The purpose of this study was to analyze the students' semantic comprehension of the hyponymy-meronymy of the science statements in science textbooks. The statements in science textbooks usually involve the process of concepts classification when organizing the science concepts. Hyponymy means "*a kind of*" relation, while meronymy means the "*a part of*" relation. A text of 'Matter and Atom' was extracted from the science textbooks of the secondary school. 368 8th to 11th grade students were asked to answer the instrument which called 'Semantic Test of Matter and Atom' after reading the treatment text. The results showed a few students confused with the relation of hyponymy or meronymy. Senior students comprehended the relations of concepts more clearly than junior students did. However, students showed the diversity of their semantic comprehension when the statements were restated with the opposite semantic relations (hyponymy ↔meronymy) and with different forms (e.g. X is a part/kind of Y and A part/kind of Y is X). The result indicated not only the semantic relations but also the statement forms could affect students' semantic comprehension in the hyponymy and the meronymy of science concepts in science textbooks.

KEY WORDS: hyponymy, meronymy, science textbooks

INTRODUCTION

The main function of science textbooks is to explain the events or phenomena of nature scientifically for science leaning. However, the explanations are actually the process of classifying science concepts. This means the process implies the classification relations of concepts. For instance, *the blood is made up of the plasmas and the blood cells, and the blood cells include the red corpuscles, the thrombocytes and the leukocytes*. The first sentence shows the 'meronymy' which means concept A is part of concept B (shown as A⊙B). The

blood cells are a part of the blood is correct semantically since the blood cells are the components of blood. Second sentence is the 'hyponymy' that concept A is a kind of concept B (shown as A⊕B). Because the red corpuscles could be regarded as a kind of the blood cells instead of a part of the components of blood cells.

Hyponymy and Meronymy implicate the different semantic relations, and not be shown explicitly in science textbooks. Students should recognize the relations of concepts by themselves. However, they might misunderstand these relations. For example, they might treat the blood cells as a sort of the blood, while the red corpuscles are only a part of the blood cells. This might cause the inaccurate concept frameworks and intervene students for further science learning.

The issues of the hyponymy and the meronymy of concepts have been extensively utilized in computer programs, logic, psychology and so forth. It is also important for science education for promoting students' comprehension of the science concepts. Therefore, this study aimed to explore how students comprehended the hyponymy and the meronymy of science concepts in the science textbooks.

RESEARCH QUESTIONS

1. How did students recognize the hyponymy and the meronymy of concepts in science textbooks?
2. What were the comprehension differences between senior students and junior students for the hyponymy and the meronymy?
3. What was the students' semantic comprehension with the different semantic relations and the statement forms?

THEORETIC BACKGROUND

In natural language, hyponymy is defined as the kind of relation and is presented as *'x is a kind/type/sort of y' or 'x is a Φ kind of y(Φ means properties)'* to refer accurately the different hyponymic relations between X and Y. Chaffin et al.(1984) defined six types of hyponymy according the properties of concepts. They were perception(horse⊕animal), function(car⊕vehicle), geography(Russia⊕country), activity(chess⊕game), state(fear⊕emotion) and action (fry⊕cook). Moreover, Miller(1998) argued the taxonomic and functional properties of concepts should be concerned in the hyponymic relation. Further, Cruse(2002) suggested some conclusions for the hyponymy and argued that hyponymy should be treated as a prototype category, and taxonyms should be the central role in this relation.

On the other hand, meronymy is the "*a part of*" relation. The term refers to the relation between whole and part. Cruse(1986) distinguished two subtypes of meronymy: *necessary*

meronyms (ear⊙body) and *optional meronyms* (handle⊙door) to show some objects were the direct parts of the whole, while some were attached parts. Iris et al.(1988) considered the transitivity and distinguished more different subtypes ： *segment-whole*(day⊙month, slice⊙bread) was transitive, while the *functional component-whole* (car⊙engine, handle⊙door) and *member-collection* (lion⊙pride, crew⊙captain) were not necessarily transitive. Additionally, Winston et al.(1987) considered the *function*, *homoeomeria* and *separability* to interpret the types of meronymy relations which shown as Table 1.

Table 1. The types of meronymy relation(Winston et al, 1987)

Relation	Examples	Fun.	Homo.	Sepa.
component-integral object	pedal ⊙ bicycle	+	-	+
member-collection	member ⊙ committee	-	-	+
portion-mass	slice ⊙ pie	-	+	+
stuff-object	flour ⊙ cake	-	-	-
feature-activity	swallowing ⊙ eating	+	-	-
place-area	oasis ⊙ desert	-	+	-

METHOD

This study was to diagnose the students' comprehension in the classification of concepts. The research method and the details were as follows:

Research procedures

In this study, participants who came from the senior and junior high schools were asked to read the text and answer the test. The text which included 11 clauses was extracted from the topic of 'M*atter and Atom*' in the science textbook of the junior high school. The text was as followings.

(1)The hydrogen is made up of the hydrogen molecules, (2)and the hydrogen molecules are composed of two hydrogen atoms. (3)The hydrogen only includes the hydrogen atoms, (4)so it is an element. At the same reason, (5)the oxygen is also an element. (6)The water could product the hydrogen and the oxygen by the electrolysis. (7)Each water molecule is composed of two hydrogen atoms and one oxygen atom. (8)Therefore, the water is made up of two atoms with the fixed proportion, (9)and it could be regarded as the compound. (10)The mixture is mixed by two or more than two pure matters with the unfixed proportion. (11) For example, the air is mixed by many kinds of the pure matters, such as the nitrogen, the oxygen, the argon, the carbon dioxide and so forth.

Subjects and instruments

The study involved 184 junior students and 184 senior students from four high schools in Taipei city. The grades of subjects were from 8th grade to 11th grade. They had learned the treatment text in their science class before this study.

The Semantics Test of Matter and Atom(STMA) included 12 items which divided into the 'meronymy' and the 'hyponymy'. The items were the two-tiers form that the first tier was the true-false questions, while the second was the open-ending questions for their reasons.

Table 2. The items of the STMA.

Meronymy	Hyponymy
1. A part of the hydrogen molecule is the hydrogen atom	7. The nitrogen gas is a kind of the air
2. The hydrogen atom is a part of the hydrogen molecule	8. A kind of the elements is the hydrogen gas
3. The oxygen gas is a part of the air	9. A kind of the air is the oxygen gas
4. The pure matter is a part of the mixture	10. A kind of the compounds is the water
5. A part of the elements is the hydrogen atom	11. The pure matter is a kind of the mixture
6. A part of the water molecule is the hydrogen atom	12. The hydrogen atom is a kind of the elements

Analysis of the text and the items

The connections of the text and the items were presented in Figure1. The concepts in the text were divided into six "bottom-up" levels with the different colors. The line, dash line and curve indicated the hyponymy, the meronymy, and the indefinite relation respectively. The digit in brackets meant the clauses code, and the symbol of # was the item code.

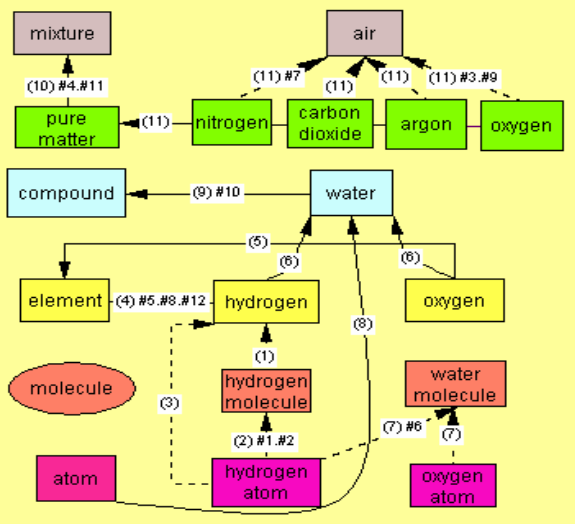

Figure 1. The connections of text and items

FINDINGS

The recognition of students for the hyponymy and the meronymy

Students agreed highly on item 2, 3, 6, 10, 11 and 12, especially for items 3 with 93% agreement. In item 10, 84% students thought the statement was correct, however, 14% students suggested the opposite perspective because the statement was inadequate to interpret

the meaning. Item 1 also appeared the similar question that students argued the statement of item 2 was more suitable than that of item 1 for representing the meronymy.

In contrast, the agreement in item 5 and 7 were diverse. Three-fifth students thought the relation in item 5 is meronymy, but 30% didn't think so. Moreover, 4% suggested hydrogen atom should be the prototype of element. Additionally, 43% students argued item 7 was correct and differed from "oxygen gas is a-part-of air".

The recognition differences between the grades

The results, as Table 3, revealed the discrepancies are more different in the hyponymy than in the meronymy, especially in item 7, 10 and 11. The semantic comprehension of the junior students was not as well as that of the senior students. For instance, 57% junior students suggested that The nitrogen gas is a kind of the air, and 20% argued The pure matter is a kind of the mixture. Additionally, the result in Item 10 showed that senior students seemed to accept the hyponymic relation with the different statements which translated 'water is a kind of compound' into 'A kind of the compounds is the water' more than junior students.

Table 3. T test of the different grades

Meronymy					Hyponymy				
No.	Mean(S/J*)	T value	Df	Sig.	No.	Mean(S/J*)	T value	df	Sig.
I1	.66/.64	.36	364	.717	I7	.27/.57	-6.04	365	.000*
I2	.93/.89	1.59	363	.112	I8	.65/.66	-.22	364	.826
I3	.93/.93	-.03	366	.977	I9	.66/.75	-1.83	363	.068
I4	.79/.74	.96	363	.340	I10	.88/.80	2.03	363	.043*
I5	.61/.57	.92	361	.361	I11	.11/.20	-2.42	364	.016*
I6	.91/.89	.48	364	.629	I12	.87/.92	-1.46	363	.145

*S/J=senior/junior

Students' comprehension in the hyponymy and the meronymy

Some pair-items in STMA involved the three types: 1)same relation with the different forms of statement(SRDS), 2) different relations with the same statement(DRSS), and 3) different relations with the different forms of statement(DRDS). The results were shown as the Table 4 to Table 6.

In item 1 and 2 described the SRDS which 'A part of the hydrogen molecule is the hydrogen atom' and 'The hydrogen atom is a part of the hydrogen molecule'. 221 students(60%) agreed both of them were correct, however, 111 students(30%) thought the statement of item2 was more proper than that of item1 to interpret the meronymy. Item 4 and 11 explored the DRSS. Most students suggested the relation between pure matter and mixture was hyponymy, Moreover, 43 students agreed both of them were correct because of the reason that the mixture is a set idea which the pure matter is a component of it. However,

72 students argued the relation was neither the hyponymy nor the meronymy after reading the text.

Table 4. SRDS CrossTab

I1*I2		I2		sum
		F	T	
I1	F	15	111	126
	T	18	221	239
sum		33	332	365

Table 5. DRSS CrossTab

I4*I11		I11		sum
		F	T	
I4	F	72	13	85
	T	235	43	278
sum		307	56	363

Table 6. DRDS CrossTab

I5*I12		I12		sum
		F	T	
I5	F	24	125	149
	T	14	197	211
sum		38	322	360

Item 5 and 12 showed the DRDS. Most students could understand the semantic relations. 322(89%) students thought the relation was hyponymy. However, 197 students argued both of item 5 and 12 were correct. One possible reason for this was students regarded the 'part' as the board sense which involved not only the meronymy but also the hyponymy instead of the narrow sense which meant meronymy. This seemed to indicate that the word of 'part' was diverse semantically for students.

CONCLUSION

The purpose of this study was to probe the students' semantic comprehension in the hyponymy and the meronymy of concepts after reading the treatment text. The treatment text only included 121 words totally, however, the statements implied the complicate classification of concepts which shown as Figure 1. According to the results, most students could make sense to the concepts relations and senior students seemed to comprehend the hyponymy and the meronymy better than junior students did. However, some students seemed to confound with the relation switch which transferred the meronymy into the hyponymy(e.g. transferred item 3 into item 7), and the statement switch which exchanged the location of 'Subject' and 'Predicate' (e.g. transferred item 2 into item 1). In other words, the relation switch and the statement switch could affect their comprehension of concepts classification in science textbooks. Furthermore, students could recognize that the polysemy of 'part' which indicated not only the meronymy but also the hyponymy.

n conclusion, the statements interpreted the concept classification in the science textbooks seem simple to read, they, however, usually involve the unintelligible semantic relation of science concepts. This means the hyponymy and the meronymy of concepts derived from the text are usually abstract and complicate to understand. Therefore, it is necessary to pay more attention on the statements which interpreted and explained the hyponymy and the meronymy of science concepts in the science textbooks for improving students' semantic comprehension in science learning.

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