



*Knowledge Representation in Middle School Science Textbooks:
From the Perspective of Ideational Fractals*

中学科学教材中的知识表征： 概念意义分形视角



赵文超 / 著



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内 容 简 介

本书研究英文中学科学教材中的知识表征,是韩氏社会符号学领域研究教育语篇的一部学术专著。该书以系统功能语言学中的概念意义分形思想为基础,以三套美国中学科学教材为研究对象,综合运用定量和定性分析方法,从小句复合、图文整合和语类复合三个方面,全面、系统考察和探讨了概念意义分形在有关意义整合过程中的表现模式和特征。

全书共分7章,主要内容包括既往研究述评、理论框架阐述及研究主题讨论。其中主题讨论涉及繁式小句整合体的组构、图像与其题注、标注和注释的协作,以及报告、解释和论证三种语类之间的组合,分析紧密结合实例,力求解释有理有据。

本书的研究发现对英语教学、科学教学、英文读写素养培养,以及相关英文教材选编都具有一定的启示和借鉴意义。

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前 言

本书以系统功能语言学的概念意义分形为视角,研究中学科学教材中的知识表征。该书旨在揭示中学科学知识的表征是如何分别通过多个限定性占级小句的复合、图像与其题注、标注及注释的整合,以及报告、解释和论证三种语类之间的复合得以实现的。

本书认为,科学教材中的概念意义分形——逻辑语义投射和扩展——不仅展现在词汇语法结构所形成的语义环境之中,而且还体现在语类复合、图像与题注,以及标注和注释等语言资源的整合中。支撑这一认识的理论包括:系统功能语言学对语言的多维释解,系统功能语言学对概念意义分形、符号整合、知识及语类的阐释。这些理论为在统一视角内研究所选科学教材中的知识表征提供了有力保证。

文献考察显示,针对学术性和教育性科学话语的词汇语法研究、多模态研究和语类研究已经取得了令人瞩目的成果,但问题和不足之处依然存在。尤其值得注意的是,科学教材中具有多个链接的繁式小句复合体的组构模式依然缺乏系统的研究,科学教材中有关子语类如何组织形成宏语类仍缺乏实证研究。此外,多模态科学话语研究由于语料数量和解释模型的局限性,对符际意义整合的研究也缺乏较具普适性的成果。鉴于此,本书详细考察了三套美国中学科学教材中的相关繁式小句复合体、图文组合体及语类复合体,研究了它们如何通过投射和扩展两类逻辑语义关系实现语义的整合或知识的表征。主要发现有下面三个方面。

首先,中学科学教材中由多个限定性占级小句构成的繁式小句复合体可以根据它们所展示的序列和逻辑语义关系分成两大类。其中一类仅展示扩展关系,另一类展示投射关系。在知识表征方面,前一类中的优选结构多为那些展示从属增强和并列延伸关系的繁式小句复合体,而后一类中的优选结构多为那些展示心理投射但不展示序列关系变化的繁式小句复合体。总体来看,当表征知识时,优选的繁式小句复合体多为那些展示单个嵌套层并带有单个次级复合体的繁式小句复合体,而且它们的组构多倾向于通过从属增强和并列延伸关系来完成,而很少通过从属延伸和并列详述关系来完成。此外,研究还发现,物理科学中繁式小句复

合体展示扩展和投射关系的频率最高,而生命科学中繁式小句复合体展示扩展和投射关系的频率最低。

其次,当中学科学教材中的知识表征需要符际协作时,所使用的主要视觉资源为写实性图像。在所考察的三门科学科目中,物理和地球科学较喜欢用叙事性图像,而生命科学则较喜欢用分析性和分类性图像。在符际整合方面,图像和题注之间高频展现的四种逻辑语义关系依次为增补、阐说、澄清和例释。相比之下,散离和增强则很少用于图像与题注的整合。在生命和地球科学中,图像与题注之间的整合最喜用延伸关系,而在物理科学中则最喜用阐说关系。此外,研究还发现,中学科学教材中的图像与其标注的整合倾向于借助详述关系,而图像与其注释的整合则倾向于通过增补、阐说和澄清来完成。

最后,在知识表征方面,中学科学教材中的语类复合也很重要。就本书所考察的报告、解释和论证三种语类来说,当语类复合以详述和延伸模式进行时,所涉及的一般是同类语类,而当语类复合以增强方式进行时,所涉及的语类却归属不同类别。对于详述型语类复合体,详述的方式一般是细化和重释;对于延伸型语类复合体,当所涉语类均为报告时,它们可以是同一子类也可以是不同子类,当所涉语类均为解释时,起始语类与后续语类的选择通常具有一定的限制。对于增强型语类复合体,被增强的语类通常是报告,而行使增强的语类则一般是解释或论证语类中的阐述。

本书期望体现出五个方面的意义:①能够为语言教育者、科学教育者和教材作者提供启示;②能促进科学学习者对科学知识的理解并提高他们的科学素养;③能深化人们对科学教材中知识表征资源、机制和模式的识解;④能丰富人们对科学及其具体分支科目的学科特性的认识;⑤能增进人们对系统功能语言学对语言和其他符号系统的理论阐释的认识。

赵文超

2016年7月15日

Preface

From the perspective of the ideational fractals in systemic functional linguistics, this book attempts to investigate the knowledge representation in middle school science textbooks. The investigation purports to reveal how knowledge representation in the textbooks is accomplished respectively through the complexing of multiple finite ranking clauses, the integrating of visual images with their captions, labels, and glosses, and the complexing of school science genres from the reporting, explaining, and arguing genre families.

The investigation is based on the recognition that the ideational fractals in science textbooks, i.e. the logico-semantic types of projection and expansion, are not only manifested in the semantic environments created by lexicogrammatical structures, but are also manifested in the semantic environments created through the complexing of genres and the integrating of visual images with such verbal resources as captions, labels and glosses. The recognition is derived from the multidimensional interpretation of language in systemic functional linguistics and the exposition of ideational fractals, semiotic integration, knowledge, and genre in systemic functional linguistics. These theoretical bases guarantee that knowledge representation in the selected science textbooks can be approached from a unitary perspective.

The literature review shows that problems and inadequacies still exist though many lexicogrammatical, multimodal, and genre studies have been devoted to various academic and pedagogic scientific discourses. Notably, how the intricate clause complexes with more than one nexus in school science textbooks are structured remains an issue short of systematic investigation, and how elementary genres in school science textbooks are organized for the formation of macro-genres is still devoid of empirical research. In addition, multimodal scientific discourses still call for studies based on abundant data and models of more explanatory power so that the

inter-semiotic semantic integration therein can be explored with more generalizable results. Against this background, this book scrutinizes the concerned intricate clause complexes, image-language integrations, and genre complexes in three sets of American middle school science textbooks, investigating how they fulfill semantic integration or knowledge representation through the logico-semantic relations of projection and expansion. The major findings are as follows.

Firstly, the intricate clause complexes formed by multiple finite ranking clauses in middle school science textbooks can be categorized into two broad categories according to the tactic and logico-semantic relations and the nesting layers manifested in their structuring patterns. One category comprises those that only manifest expansion. The other category includes those that manifest projection. In respect of knowledge representation, the favored structures in the former category tend to be those manifesting the logico-semantic relations of hypotactic enhancement and paratactic extension, and the favored structures in the latter category tend to be those that are formed without tactic switches and manifest mental projection. On the whole, when deployed for knowledge representation, the favored intricate clause complexes tend to be those structured with a single nesting layer and with a single sub-complex, and the structuring of those intricate clause complexes tend to have the most recourse to hypotactic enhancement and paratactic extension but have the least recourse to hypotactic extension and paratactic elaboration. In addition, it is discovered that intricate clause complexes in Physical Science tend to manifest expansion and projection with the highest frequency whereas intricate clause complexes in Life Science tend to manifest the two types of logico-semantic relations with the lowest frequency.

Secondly, when knowledge representation in middle school science textbooks demands inter-semiotic synergy, the visual resources used tend to be dominated by realistic images. Among the three science subjects examined, Physical Science and Earth Science favor narrative images, whereas Life Science favors analytical and classificational images. In respect of inter-semiotic integration, the top four frequently manifested image-caption logico-semantic relations are, in order, augmentation, exposition, clarification and exemplification, while divergence and enhancement are much less frequently used for image-caption integrating. While Life Science and Earth

Science most prefer extension to be employed for image-caption integrating, the same purpose in Physical Science most prefers to be fulfilled through exposition. Moreover, it is discovered that visual images in middle school science textbooks tend to integrate with their verbal labels through elaborative relations, and integrate with their verbal glosses through the relation of augmentation, exposition, and clarification.

Thirdly, genre complexing is also significant for knowledge representation in middle school science textbooks. As far as the reporting, explaining, and arguing genres are concerned, it is discovered that the elaborating and extending modes of genre complexing are generally carried out between genres from the same family, whereas the enhancing modes of genre complexing often involve two genres from two different families. For elaborating genre complexes, the elaboration generally turns out in the manners of specification and reformulation. For extending genre complexes, if the elementary genres are reporting ones, they can be typologically identical or different. If the elementary genres are explaining ones, there is usually restriction on which one functions as the initiating genre and which one functions as the continuing genre. For enhancing genre complexes, it is found that the genre enhanced is usually a reporting genre while the enhancing genre is usually an explaining genre or the arguing genre of exposition.

The investigation is expected to be significant in five aspects: 1) to provide implications for language educators, science educators, and textbook writers; 2) to promote science learners' comprehension of scientific knowledge and boost their development of scientific literacy; 3) to deepen our understanding of the knowledge-representing resources, mechanisms, and patterns in school science textbooks; 4) to enrich our knowledge about the disciplinary natures of science and specific science subjects; 5) to improve our understanding of the Hallidayan systemic functional theorization on language and other semiotic systems.

Zhao Wenchao

July 15, 2016

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Chapter 1

Introduction

In modern schooling contexts, pedagogic discourse, verbalized or visualized, is a crucial channel through which students acquire disciplinary knowledge. Textbooks, as one major type of pedagogic discourse, have been investigated in the linguistic field from different perspectives. However, how knowledge is represented in them remains an issue calling for answers. Intended to be one additional contribution to the solution of the issue, the study in this book looks into the pedagogic scientific discourse in middle school science textbooks (henceforth MSSTs), proposing that knowledge representation therein is a semantic enterprise accomplished synergistically through the work of lexicogrammatical structures, visual representations, and genres. Specifically, the current study purports to bring out how knowledge in three sets of American MSSTs is represented through clause complexing, image-language integrating, and genre complexing. As the first step of the study, the present chapter is designed to make explicit the background, the objectives, the methodology, and the data collection of the research, followed by a specification of the term 'scientific discourse' (henceforth SD) and the organization of the entire book. However, since the entire study is carried out from the perspective of ideational fractals, a term which is not very familiar to researchers in the linguistic field, the present chapter will first provide a brief introduction to the term.

1.1 A Brief Introduction to Ideational Fractals

In this book, the term of ideational fractals is derived from systemic functional linguistics (henceforth SFL). Within the term, the notion of fractal originates from mathematician Mandelbrot's work on self-similarity in material systems (see

Matthiessen et al., 2010). Etymologically, the word, coined by Mandelbrot, comes from the Latin adjective *fractus*, which has the same root as *fraction* and *fragment* and means *irregular* or *fragmented* (see Mandelbrot, 1977: 4). The mathematician used the word to describe many of the seemingly complex forms found in nature, for example, the forms of coastlines, snowflakes, and clouds. To Mandelbrot (1977), many fractal forms are of the feature of self-similarity, where self-similarity is taken as a scale-invariant property, meaning that “the object or phenomenon under consideration is found to remain (locally) identical to itself after application of a dilatation or contraction” (Nottale, 1993: 40).

As a theoretical term, ‘fractal’ in SFL is used to refer to “a general semantic pattern that is manifested throughout the semantic and lexicogrammatical systems in different environments” (Matthiessen et al., 2010: 100). This means that SFL has borrowed the notion of ‘fractal’ from Mandelbrot’s work on self-similarity in material systems for the purpose of characterizing self-similarity in semiotic systems. According to Matthiessen et al. (2010), fractals in the social semiotic system of language operate within all metafunctions.

Within the interpersonal metafunction, fractals manifest themselves mainly in the semantic environments occupied by the resources in the system of MODAL ASSESSEMENT (cf. Matthiessen et al., 2010: 100). Generally, these resources are the modal adjuncts (including mood adjuncts and comment adjuncts) operating in such grammatical domains as clauses and nominal groups (see Halliday & Matthiessen, 2004: 608-612). Within the textual metafunction, the fractals discerned are textual ones. Their manifestation is done by virtue of the systems of THEME and INFORMATION, in environments such as whole texts, rhetorical paragraphs, the clause nexus, the clause, the nominal group and the verbal group (cf. Matthiessen et al., 2010: 100).

Of particular relevance to the current study are the fractals identified in the ideational metafunction. These fractals are referred to in this book as ideational fractals. According to Matthiessen et al. (2010), these fractals are actually the logico-semantic types of projection and expansion, and their manifestation environments include those of whole texts and rhetorical paragraphs within texts, the tactic environment of a clause nexus, the transitivity environment of a clause, and the modification environment of a nominal group. Being ideational fractals, “expansion and projection are also manifested

as logico-semantic relations that link clauses together to form clause complexes” (Halliday & Matthiessen, 2004: 367). The current study approaches knowledge representation in science textbooks from the perspective of ideational fractals, arguing that ideational fractals are not only manifested in such semantic environments as created by clauses and clause complexes, but are also discernible in the semantic environments created by image-language integrating and genre complexing. Specifically, this study holds that the ideational fractals manifested in clause complexes, i.e. the logico-semantic relations, also obtain in the semantic environments created by image-language integrating and genre complexing.

1.2 Background of the Study

The current book investigates knowledge representation in MSSTs. Such an investigation is motivated for both academic and practical reasons. Academically, the investigation is intended to add to people’s understanding of the knowledge-representing resources, fashions, and patterns in MSSTs. Practically, the investigation is intended to provide implications for language educators, science educators, and science textbook writers. These motivations are derived from a consideration of the nature of learning science and a critical review of the previous studies on SD.

As is observable in modern schooling contexts, science is an indispensable component of middle school curriculum. It is not only a crucial resort for developing school students’ scientific literacy, but also one of the critical channels for expanding their knowledge about the world. In respect of science education, there is an increasing awareness that students’ learning of science is in essence acquisition of a specialized language (cf. Christie, 1989; Halliday, 1993a; Wellington & Osborne, 2001; Schleppegrell, 2004). For this reason, Norris and Phillips (2003) insist that knowledge and understanding of scientific language is critical to students’ development of scientific literacy in both its “fundamental” sense (i.e. ability to read and write science text) and “derived” sense (i.e. knowledgeability about science).

In SFL, knowledge is recognized as the same thing as meaning and language is treated as a primary semiotic resource for knowledge-representing or meaning-making (cf.