

中学科学教科书中的知识表征——概念意义分形视角

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# 厦门大学

## 博士学位论文

### 中学科学教科书中的知识表征 ——概念意义分形视角

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

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## Abstract

From the perspective of the ideational fractals in systemic functional linguistics, this dissertation 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 study 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 which only manifest expansion. The other category includes those which manifest projection. In respect of knowledge representation, the favored structures in the former category tend to those manifesting the logico-semantic relations of hypotactic enhancement and paratactic extension, and the favored structures in the latter category tend to be those which are formed without tactic switches and manifest mental projection. On the whole, when deployed for knowledge representation, the favored intricate clause complexes tend to 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.

**Key Words:** knowledge representation; ideational fractals; middle school science textbooks

## 摘要

本文以系统功能语言学的概念意义分形为视角,研究中学科学教科书中的知识表征。该研究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。

本研究认为,科学教科书中的概念意义分形——即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、以及图像与题注、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、知识以及语类的阐释。这些理论为在统一视角内研究所选科学教科书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,科学教科书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,科学教科书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,本研究详细考察了三套美国中学科学教科书中的相关繁式小句复合体、图文组合体以及语类复合体,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的。主要发现如下:

首先,中学科学教科书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，当中学科学教科书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，中学科学教科书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。

再则，在知识表征方面，中学科学教科书中的语类复合也很重要。就本文所考察的报告、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。

本研究期望在五方面有所意义：1) 能够为语言教育者、科学教育者和教科书作者提供启示；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科书中知识表征资源、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。

**关键词：**知识表征；概念意义分形；中学科学教科书



## Table of contents

<b>Abstract</b> .....	I
<b>摘要</b> .....	IV
<b>Table of contents</b> .....	VII
<b>目录</b> .....	X
<b>List of abbreviations</b> .....	XIV
<b>List of figures and tables</b> .....	XV
<b>Chapter 1 Introduction</b> .....	1
<b>1.1 A brief introduction to ideational fractals</b> .....	1
<b>1.2 Background of the study</b> .....	3
<b>1.3 Objectives of the study</b> .....	7
<b>1.4 Methodology and data collection</b> .....	10
<b>1.5 Terminology</b> .....	13
1.5.1 Discourse and text .....	14
1.5.2 Science and SD.....	15
<b>1.6 Organization of the dissertation</b> .....	18
<b>Chapter 2 Literature review</b> .....	21
<b>2.1 Linguistic studies on SD</b> .....	21
2.1.1 Lexicogrammatical studies in SFL .....	21
2.1.2 Genre studies in SFL.....	26
2.1.3 Studies in ESP.....	29
2.1.4 Studies in other linguistic fields.....	33
2.1.5 Assessments of the previous studies .....	35
<b>2.2 Multimodal studies on SD</b> .....	36
2.2.1 MSSD concerned with meaning-making .....	37

2.2.2 MSSD concerned with image-text relations.....	41
2.2.3 MSSD concerned with characterizing visual images.....	43
2.2.4 MSSD with other concerns.....	44
2. 2.5 Assessments of the previous studies.....	45
<b>2.3 Interpretations of knowledge.....</b>	<b>46</b>
2.3.1 Interpretations in philosophy and psychology .....	46
2.3.2 Interpretations in SFL .....	48
2.3.3 Interpretations in Bernsteinian sociology of education.....	51
2.3.4 Assessment of the interpretations.....	55
<b>2.4 Summary .....</b>	<b>56</b>
<b>Chapter 3 Theoretical framework .....</b>	<b>58</b>
<b>3.1 The framework for analyzing knowledge representation.....</b>	<b>59</b>
<b>3.2 SFL's multidimensional interpretation of language .....</b>	<b>62</b>
3.2.1 The dimension of metafunction .....	63
3.2.2 The dimension of stratification .....	65
3.2.3 The dimension of instantiation .....	68
<b>3.3 SFL's exposition of ideational fractals.....</b>	<b>70</b>
3.3.1 Grammatical manifestation of ideational fractals .....	72
3.3.2 Rhetorical manifestation of ideational fractals .....	75
<b>3.4 Semiotic integration and inter-semiotic ideational fractals.....</b>	<b>76</b>
3.4.1 Semiotic integration in SFL .....	76
3.4.2 Inter-semiotic manifestation of ideational fractals.....	79
<b>3.5 Martin's systemic functional exposition of genre.....</b>	<b>83</b>
<b>3.6 Summary.....</b>	<b>85</b>
<b>Chapter 4 Clause complexing in knowledge representation.....</b>	<b>87</b>
<b>4.1 The symbolic representation of ICCs.....</b>	<b>87</b>
<b>4.2 The structuring of OEMICCs .....</b>	<b>90</b>
4.2.1 Homogeneous OEMICCs .....	95
4.2.2 Heterogeneous OEMICCs with a single nesting layer .....	101
4.2.3 Heterogeneous OEMICCs with double nesting layers .....	113

4.2.4 The favored structuring patterns.....	117
<b>4.3 The structuring of PMICCs.....</b>	<b>119</b>
4.3.1 Projection only in the main clause nexus.....	122
4.3.2 Projection in the nested sub-complex(es).....	126
4.3.3 Projection in homogeneous PMICC .....	131
4.3.4 The favored structuring patterns.....	132
<b>4.4 Summary .....</b>	<b>133</b>
<b>Chapter 5 Image-language integrating in</b>	
<b>knowledge representation .....</b>	<b>137</b>
<b>5.1 Identification of the visual and verbal resources .....</b>	<b>137</b>
5.1.1 The visual images in the textbook data.....	137
5.1.2 The verbal resources related to the images.....	143
<b>5.2 The integration of images with captions .....</b>	<b>147</b>
5.2.1 Integration through elaboration .....	148
5.2.2 Integration through extension .....	157
5.2.3 Integration through enhancement .....	162
5.2.4 A comparative analysis.....	166
<b>5.3 The integration of images with labels and glosses .....</b>	<b>168</b>
5.3.1 The integration of images with labels .....	169
5.3.2 The integration of images with glosses .....	173
<b>5.4 Summary .....</b>	<b>178</b>
<b>Chapter 6 Genre complexing in knowledge representation.....</b>	<b>180</b>
<b>6.1 An account of the genres involved.....</b>	<b>180</b>
<b>6.2 Genre complexing via extension .....</b>	<b>182</b>
6.2.1 Extension between reporting genres .....	182
6.2.2 Extension between explaining genres .....	187
<b>6.3 Genre complexing via elaboration .....</b>	<b>193</b>
6.3.1 Generic elaboration via specification.....	194
6.3.2 Generic elaboration via reformulation.....	200
<b>6.4 Genre complexing via enhancement .....</b>	<b>205</b>

6.4.1 Enhancement between a report and an explanation .....	205
6.4.2 Enhancement between a report and an exposition .....	213
<b>6.5 Summary .....</b>	<b>217</b>
<b>Chapter 7 Conclusion.....</b>	<b>219</b>
7.1 Major findings of the current study.....	219
7.2 Significance of the study .....	223
7.3 Limitations and suggestions for future research.....	225
<b>Appendix 1.....</b>	<b>227</b>
<b>Appendix 2.....</b>	<b>228</b>
<b>Appendix 3.....</b>	<b>231</b>
<b>References.....</b>	<b>234</b>
<b>Acknowledgements.....</b>	<b>256</b>

厦门大学博硕

# 目 录

英文摘要.....	I
中文摘要.....	IV
英文目录.....	VII
中文目录.....	X
缩写说明.....	XIV
图表说明.....	XV
<b>第一章 绪论</b> .....	1
1.1 概念意义分形简介.....	1
1.2 研究背景.....	3
1.3 研究目的.....	7
1.4 研究方法与语料收集.....	10
1.5 术语.....	13
1.5.1 话语与篇章.....	14
1.5.2 科学与科学话语.....	15
1.5 论文结构.....	18
<b>第二章 文献综述</b> .....	21
2.1 科学话语的语言学研究.....	21
2.1.1 系统功能语言学领域的词汇语法研究.....	21
2.1.2 系统功能语言学领域的语类研究.....	26
2.1.3 专门用途英语领域的研究.....	29
2.1.4 其他语言学领域的研究.....	33
2.1.5 既往研究的评述.....	35
2.2 科学话语的多模态研究.....	36
2.2.1 关注意义创造的多模态科学话语研究.....	37

2.2.2 关注图文关系的多模态科学话语研究.....	41
2.2.3 描述视觉图像的多模态科学话语研究.....	43
2.2.4 其他多模态科学话语研究.....	44
2.2.5 既往研究的评述.....	45
<b>2.3 知识的释解.....</b>	<b>46</b>
2.3.1 哲学和心理学中的释解.....	46
2.3.2 系统功能语言学中的释解.....	48
2.3.3 伯恩斯坦社会教育学中的释解.....	51
2.3.4 既往释解的评述.....	55
<b>2.4 小结.....</b>	<b>56</b>
<b>第三章 理论框架.....</b>	<b>58</b>
3.1 知识表征的分析框架.....	59
3.2 系统功能语言学对语言的多维释解.....	62
3.2.1 元功能维度.....	63
3.2.2 层次化维度.....	65
3.2.3 实例化维度.....	68
3.3 系统功能语言学对概念意义分形的阐释.....	70
3.3.1 概念意义分形的语法展现.....	72
3.3.2 概念意义分形的修辞展现.....	75
3.4 符号整合与符际概念意义分形.....	76
3.4.1 系统功能语言学中的符号整合.....	76
3.4.2 概念意义分形的符际展现.....	79
3.5 马丁对语类的系统功能阐释.....	83
3.6 小结.....	85
<b>第四章 知识表征中的小句复合.....</b>	<b>87</b>
4.1 繁式小句复合体的符号表示.....	87
4.2 仅展示扩展关系的繁式小句复合体的组构.....	90
4.2.1 仅展示扩展关系的均质繁式小句复合体.....	95
4.2.2 带有单层嵌套的仅展示扩展关系的异质繁式小句复合体.....	101
4.2.3 带有双层嵌套的仅展示扩展关系的异质繁式小句复合体.....	113

4.2.4 优选组构模式.....	117
<b>4.3 展示投射关系的繁式小句复合体的组构.....</b>	<b>119</b>
4.3.1 投射仅在主小句链中.....	122
4.3.2 投射在嵌套的次级小句链中.....	126
4.3.3 投射在均质繁式小句复合体中.....	131
4.3.4 优选组构模式.....	132
<b>4.4 小结.....</b>	<b>133</b>
<b>第五章 知识表征中的图文整合.....</b>	<b>137</b>
<b>5.1 图像和语言资源的认定.....</b>	<b>137</b>
5.1.1 教科书语料中的图像.....	137
5.1.2 与图像关联的语言资源.....	143
<b>5.2 图像与题注的整合.....</b>	<b>147</b>
5.2.1 通过详述整合.....	148
5.2.2 通过延伸整合.....	157
5.2.3 通过增强整合.....	162
5.2.4 比较分析.....	166
<b>5.3 图像与标注和注释的整合.....</b>	<b>168</b>
5.3.1 图像与标注的整合.....	169
5.3.2 图像与注释的整合.....	173
<b>5.4 小结.....</b>	<b>178</b>
<b>第六章 知识表征中的语类复合.....</b>	<b>180</b>
<b>6.1 所涉语类介绍.....</b>	<b>180</b>
<b>6.2 语类之间的延伸复合.....</b>	<b>182</b>
6.2.1 报告语类之间的延伸.....	182
6.2.2 解释语类之间的延伸.....	187
<b>6.3 语类之间的详述复合.....</b>	<b>193</b>
6.3.1 细化式语类详述.....	194
6.3.2 重释式语类详述.....	200
<b>6.4 语类之间的增强复合.....</b>	<b>205</b>
6.4.1 报告与解释之间的增强.....	205
6.4.2 报告与论证之间的增强.....	213

6.5 小结.....	217
<b>第七章 结论.....</b>	<b>219</b>
7.1 本研究的主要发现.....	219
7.2 本研究的意义.....	223
7.3 本研究的局限性与未来研究方向.....	225
<b>附录 1.....</b>	<b>227</b>
<b>附录 2.....</b>	<b>228</b>
<b>附录 3.....</b>	<b>231</b>
<b>参考文献.....</b>	<b>234</b>
<b>致谢.....</b>	<b>256</b>

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