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博　士　学　位　论　文

中小学物理教科书的知识建构

Knowledge Building in Physics Textbooks in Primary and Secondary Schools

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Abstract

This dissertation investigates how scientific knowledge is built up step by step in discourse through an analysis of Australian physics textbooks for primary and secondary schools from an integrated perspective of systemic functional linguistics, systemic functional multimodal discourse analysis, Bernstein's knowledge structure theory, and semantic density and semantic gravity in legitimation code theory, aiming to bring some pedagogical implications for school science education.

Systemic functional linguistics has long been interested in the language of science since Halliday's *On the Language of Physical Science*, the analysis of which has developed from canonical science discourses to educational science discourses, aiming to facilitate students' learning. Previous researches into knowledge building in scientific discourses focus on the clause level and then on the semantic level, but few of them specifically focus on the way new knowledge is acquired by discourse, and fewer on the functions of other semiotics, such as images, mathematical symbols. In addition, it is shown that the previous studies into scientific language start from physics but few continue to explore physical data, especially physics textbooks across different levels although physics is the basis of science.

Drawing on the above theories, this dissertation seeks to apply an intergrated approach to investigating the patterns of knowledge construction at different levels of physics textbooks, with an aim to address the following two issues: (a) The ways of knowledge building at each level of school textbooks, that is, the distinctive patterns of linguistic resources in building knowledge and generating meaning across different levels of textbooks; (b) The patterns of semantic waves (that is, the development of semantic density and semantic gravity) at and across each level of textbooks and the relationship between semantic waves and linguistic resources.

The major findings of this dissertation include:

(1) The theory of field in systemic functional linguistics serves as the basis of

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explaining scientific knowledge building in physics textbooks. The adapted entity classifying model and the taxonomic relation system are used as specific tools for the analysis of physics textbooks, which proves useful.

(2) The criteria for distinguishing grammatical metaphors from technicalities prove useful: if a grammatical metaphor occurs with a classifier, in a definition, with a focus, with an elaboration or without introduction, it can be taken as a technicality. In addition, the exploration of semantic density and semantic gravity from the linguistic perspective presents us a more general understanding of knowledge.

(3) There is a distinctive distribution of some genre types at different levels of physics textbooks. Macrogenres, including 'experimental procedure' and 'picture commentary', are favorite types in this study. 'Experimental procedures' are found at all the three levels and 'picture commentaries' characterizes the first level. 'Story' occurs only in the last two levels of textbooks with a decreasing occurrence tendency, which suggests the difference in knowledge building between school science and canonical science. For the same type of macrogenres, there are some variations in schematic structures and sub-stages for different levels of physics textbooks.

(4) The empirical study of entities reveals that all the three levels of physics textbooks tend to use the same five types of entities as top-occurring ones in construing knowledge: concrete everyday entities, generic entities, technical entities, pronouns and metaphoric process entities in the descending order of frequency. The occurrence of each type of entities varies regularly across the three levels of textbooks. Furthermore, the empirical analysis of processes shows that material, relational and mental processes function as the top three ones in all the textbooks. Material processes are predominating ones. The occurrence of each type of processes varies according to a certain tendency across the three levels of textbooks. This similarity and variation of entities and processes across three school physics sub-fields proves that each level of physics textbooks construes a sub-field and that they all belong to the large school physic field.

(5) The analysis of taxonomic relations between technical terms in each school physics sub-field shows: for the higher-level school physics, taxonomic relations

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become more complex with new concepts introduced and causation relations occurring. This analysis reflects the accumulative nature of knowledge building in the three school physics sub-fields.

(6) The analysis reveals that the patterns of both the ideational meanings construed by visual images and the intersemiotic meanings between language and images are getting from simple to complex across three levels of physics textbooks. In addition, the developing patterns of semantic gravity and semantic density at each level of school physics show both some similarities and some great variations.

The significance of this study is three-fold. First, the complementary perspective on knowledge from both systemic functional linguistics and Bernsteinain sociology of education presents a more complete picture about knowledge building in physics textbooks. In addition, an investigation model of semantic density and semantic gravity in legitimation code theory from the linguistic perspective may bridge the gap between systemic functional linguistic and Bernsteinain approaches to knowledge. Second, specific ways are presented for the analysis of field and ideation in scientific discourse: the adapted model of entity classifying, its application procedures, the criteria to distinguish grammatical metaphors from technicalities, and the revised system of taxonomic relations. Third, the quantitative and qualitative analysis of entities, processes, genres and multisemiotics offers a deep insight into ways of knowledge building across three levels of physics textbooks. Furthermore, the developing patterns of semantic gravity and semantic density is explored at each level of school physics from a linguistic perspective, which expands the scope of systemic functional linguistics and Bernstein's sociology of education and in turn of discourse analysis.

Key Words: knowledge building; physics textbooks; systemic functional linguistics; sociology of education

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摘 要

基于系统功能语言学、多模态话语分析以及教育社会学的基本理论，本文选择澳洲中小学的物理教材为研究对象，旨在探究不同层次物理教材建构科学知识的特征。通过对不同层次物理教材的语言以及其它符号进行细致地分析和深入地研究，发现了物理教材建构科学知识的基本方法和语言特点，揭示了其中的基本规律，以期在语言学的视角下，能为中学开展科学理论教学活动带来一些启示。

以韩礼德对《物理的语言》为开端，系统功能语言学一直注重科学语言的研究，其分析对象也由正统的科学话语过渡到了教育话语。前人对科学话语中知识建构的研究聚焦于小句层面，尽管后来也开始从语义层进行研究，但是很少有研究强调新知识是如何通过话语来获得的，也很少有研究强调其它符号（诸如图像、数学符号等）的功能。此外，尽管系统功能语言学对科学语言的研究起源于对物理语言的研究，但是接下来以物理为样本进行的研究几乎没有，尤其以中小学不同阶段物理教程为语料进行的研究更少。同时，鉴于物理在科学中的基础地位，该方面研究很有必要。

本文试图将上面提到的理论相结合，对中小学不同阶段物理教材中的知识建构特征进行分析，旨在回答以下两方面问题：

（a）知识在物理教材每一阶段的建构方式；换言之，知识建构和意义生成在每一物理教材阶段的显著特征又是什么？

（b）在不同层次的物理教材中，语义波（语义密度和语义重力）又具有什么样的特征，以及语义波和语言资源间又是何关系？

本文的研究结论主要包括：

（1） 系统功能语言学的语场理论是阐述物理教材中知识建构的基础。修正的实体分类模型和类别关系系统为物理教材分析提供了具体工具。

（2） 区分语法隐喻和科技术语的标准证明了其有用性。该标准可以表述如下：语法隐喻如果跟分类限定语，或是定义，或是焦点成分，或是详述一起出现，或是直接引入，那么它便是科技术语而不再为语法隐喻。从语言学角度对语义密度和语义重力的研究使我们对知识有了更为全面的理解。

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（3） 语类在三个层次中学物理教材中的分布具有显著特征。元语类是中学物理教材易于采用的类型：实验步骤元语类出现在所有层次，图画评论元语类只出现于第一个层次。故事语类出现在后两个层次中，其数量随着教材层次的上升而有所下降，故事语类的采用表明教育科学同正统科学是有区别的。对于同一类型的元语类，其图示结构和次步骤会因教材层次的不同而有所差异。

（4） 对实体进行的统计分析显示，在知识建构中，所有三个层次的物理教材中出现率最高的五种实体以此是：具体的日常生活实体、泛指实体、科技实体、代词和隐喻过程实体。每一类型实体的出现率会随着教材层次的提高而有规律的增多或是减少。而对过程进行的统计分析显示，在知识建构中，所有三个层次的物理教材中出现率最高的三种过程依次是：物质过程、关系过程和心理过程，其中物质过程在教材中居统治地位。跟实体相同，每一类型过程的出现率也随着教材层次的提高而有规律的增多或是减少。实体与过程在三个中小学物理次语场中运用的相似性和差异性表明，每一层次的中小学物理语场为一个单独的次语场，同时它们都从属于这个较大的中学物理语场的一个小类。

（5） 对每一层次中小学物理语场的科技术语间的类别关系分析显示：随着物理教科书层次的提高，科技术语间的类别关系变得越来越复杂，这是由于新概念的不断引入以及因果关系的出现而引起的。该分析结果再次反映了知识在不同层次的中小学物理教科书中逐步建构的本质。

（6） 该分析还揭示，图像识别的概念意义以及语言和图像之间的相互作用意义也随着教科书层次的提升而变得越来越复杂。每一层次物理教科书中的语义重力和语义密度的展开特征显示出一些相似性，但更多的是差异性。

本研究的意义体现在以下三个方面：（a）以系统功能语言学和伯恩斯坦的教育社会学为理论指导，更为全面的阐释了中小学各个层次物理教科书中的知识建构。此外，语言学角度的语义密度和语义重力的研究模型在一定程度上整合了系统功能语言学和伯恩斯坦对知识的研究。（b）修正的实体分类模型,其具体的运用方法和步骤，区分语法隐喻和科技术语的标准以及修正的类别关系系统为科学话语中的语场和概念分析提供了具体的方法。(c) 对实体、过程、语类和多模态进行的量化研究以及定性分析使我们更加深刻的理解了各个层次中小学物理教科书中的知识建构是如何层层递进的。语言学角度的语义重力和语义密度展开模

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型运用于每个层次的物理教科书分析中，拓展了系统功能语言学和伯恩斯坦教育社会学的理论视野，从而进一步扩充了话语分析研究理论。

关键词： 知识建构 物理教科书 系统功能语言学 教育社会学

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