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Vygotsky and Science Education

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Introduction

It is through others, we become ourselves. **(Vygotsky, 1997, p. 105)**

Lev Semenovich Vygotsky (1896–1934) was widely acclaimed as a scientific genius from Russia, so much so that after his death his brain, along with those of Vladimir Lenin (1870–1924) and Ivan Pavlov (1849–1936), was studied by Russian scientists researching the neuroanatomical basis of exceptional talent. More recently, in the West, Stephen Toulmin (1978) referred to Vygotsky as the "Mozart of Psychology" because his work was prodigious and novel, and has immense contemporary relevance, despite his very early death from tuberculosis (TB) at the age of 37.

1.1 Vygotsky and Science Education

This book introduces Vygotsky and his work, emphasising implications for science education. It aims to provide a reference/handbook for university teachers in education and, more specifically, in science education. Researchers in science education can use this text as an introduction to Vygotsky's substantial contribution

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to theory and practice in the field. A unique contribution in this book is to infuse my experiences of working from a Vygotskian perspective as a school science teacher, a university teacher of both science and science education, and a researcher in science education. My key motivation for writing the book came from highly positive student and colleague responses to the Vygotskian-inspired methodology I used both with students and colleagues. I was also encouraged to write the book by members of the Vygotsky family, when attending Vygotsky summer school immersion programmes in Russia, as a member of the International Vygotsky Society.

I hope that you enjoy reading about science learning, teaching and research from a Vygotskian perspective, which promotes social, as opposed to individual, learning of science. His concepts and research findings have led to some bold ideas in practice, such as:

- Emancipating learners, by harnessing their interests and creating learning environments from them: they lead the learning.
- Engaging learners, by introducing them to some of the greatest and most beautiful achievements in science, be it stories, trips, videos, podcasts, etc. Vygotsky motivated his students to learn by showing, reading, or experiencing in other ways, some of the greatest products of the human soul in art, literature, science, music and other areas of interest that generate strong emotion and lead to the desire to learn more.
- Teaching them a little beyond their current knowledge, with support: whatever they can do today with help, tomorrow they can do it by themselves.

Vygotskian theory is becoming increasingly relevant and important in science learning and teaching in the twenty-first century. Vygotsky's focus on learning as a social process, as opposed to a purely individual one, resonates with current practice in science and science education, for example, co-operation and collaboration. Twenty-first-century learning seeks for students to develop skills relating to different ways of working from those of the twentieth century, to help students develop a global perspective through which people collaborate across geographical and social borders to address major issues, such as climate change and antibiotic resistance.

One of the key aspects of Vygotsky's legacy to science education is his cultural-historical theory (CHT), which proposes that the *social setting* is fundamental to learning in childhood and adulthood and determines the quality of learning that takes place. Learning occurs as an individual engages in social settings, from babyhood to adult learning. Other Vygotskian concepts and practices which are key to science learning include the zone of proximal development (ZPD), concept development, and the importance of imagination and play in learning and in 'doing' science. Vygotsky rejected the objective approach to learning used by many psychologists who established their ideas on what may be considered as an 'average' child, based on specific measurements. Vygotsky maintained that the environment for learning should be attuned to learners in ways that encourage them to learn more for the sake of learning, as opposed to learning only for external motivation (exams, careers, etc.).

The book aims to develop a framework of Vygotskian theory for research and practice in science education, accessible to students, teachers, and researchers in science education for early years, school, college and university, and adult science learning and teaching. Thus, play and imagination are explored in depth in the chapter on science in early childhood learning (Chap. 5); the ZPD is considered in depth in the primary school science chapter (Chap. 6); and concept development in the secondary-level chapter (Chap. 7). Chapters on informal science learning (Chap. 8); higher education science learning and teaching (Chap. 9); and science teacher education (Chap. 10) draw on cultural-historical activity theory (CHAT) the ZPD, imagination and play in science learning, and concept development.

Formal science education currently focuses on curricula and assessment, guided by global competition in terms of international projects such as the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Studies (TIMSS). These projects produce rankings of science learning in different countries. Science education could be focused more on solving problems relating to global issues, which might result in earlier and better change.

1.2 Structure of This Book

This book has an introduction (Part I), two main content sections (Parts II and III), and ends with an epilogue (Part IV).

Part I: Introduction

Chapter 1: Introduction – provides an overview of this book, which introduces some Vygotskian ideas that are considered useful in the learning and teaching of science at all levels, in both formal and informal contexts. The chapter summarises each of the subsequent chapters and suggests ways to navigate the book (see Table 1.1 below).

Part II: Vygotsky and His Legacy to Science Education

There are three chapters:

Chapter 2: Vygotsky: Life and Legacy – presents a short biography of Vygotsky, including the social and cultural influences on his work. I learned a great deal about Vygotsky's theory and practice by reading and writing about his short life. This chapter includes reference to philosophers, psychologists, scientists, playwrights, poets and novelists whose work influenced Vygotsky's ideas, research and practice.

Chapter 3: Key Vygotskian Concepts for Science Education – introduces key Vygotskian concepts and practices that are relevant to science education, although some concepts are attributed to Vygotsky, but not developed purely by him. This chapter includes concepts such as: ZPD; concept development, CHT; and Vygotsky's early ideas for the development of CHAT, together with his colleague A. N. Leontiev (1981) and later to be more fully developed by Yrjö *Engeström, about 50 years after Vygotsky's death* (Engeström, 1987). CHAT helps us to understand and analyse the relationship between human minds (what we think and feel) and activity (what we

Table 1.1 Useful cross-referencing for specific science education contexts

Science education contexts	Cross references	
	Key chapter	Some additional cross-references from other chapters
Science Education Researchers	Chap. 4	Cross-reference sections: 2.3; 2.4; 3.2; 3.3; 3.4; 3.5; 5.6; 6.5; 6.6; Table 7.1; 7.3; 7.7; 8.2; 9.7; 10.4.
Early Years Science Education	Chap. 5	Cross-reference sections: 3.2; 3.4.
Primary School Science Education	Chap. 6	Cross-reference sections: 3.2; Figure 3.1; 5.3; 5.5; 5.6.
Secondary-Level Science Education	Chap. 7	Cross-reference sections: 3.2; 3.3.
Informal Science Education	Chap. 8	Cross-reference sections: 3.4; Figure 3.2.
Science in Higher Education	Chap. 9	Cross-reference sections: 3.2; 7.3; 7.5; 7.6; 7.7.
Science Teacher Education	Chap. 10	Cross-reference sections: 3.2; 7.5; 7.6; 7.7.

do). CHAT has attracted a growing interest among academics worldwide since the 1990s. The concept of social constructivism was *not* developed by Vygotsky; it has been attributed erroneously to him, probably due to his CHT of learning, which emphasises social, as opposed to individual learning.

Chapter 4: Vygotsky and Science Education Research – describes Vygotsky's own methodologies and how aspects of his work have more recently been applied in science education research.

Part III: Application of Vygotskian Theory in Science Education Contexts

There are six chapters that highlight Vygotskian ideas and practices in science education in various settings, ranging from early years science learning and teaching to higher education science.

Chapter 5: Vygotsky and Science Learning in the Early Years – describes theory and practice of science learning in pre-school and early primary school. It also introduces some of Vygotsky and other scholars' research on child development.

Chapter 6: Vygotsky and Primary School Science – illustrates ways in which Vygotskian theory and practice have been applied to science learning for children between 4 and 12 years of age. There is a focus on the ZPD.

Chapter 7: Vygotsky and Secondary-Level School Science – focuses on scientific concept development. Much of the traditional learning of science concepts (SCs) has been committing definitions and formulae to memory, which does not always lead to true understanding. This chapter describes some of the Vygotskian approaches which have been shown to improve students' understanding and use of true scientific concepts.

Chapter 8: Vygotsky and Informal Science Learning – introduces a dialectical interrelationship between informal and formal science learning, in which the former

provides students with many opportunities to *talk about* science with their fellow students, scientists and science teachers, thus helping students to make sense of their learning.

Chapter 9: Vygotsky and Science in Higher Education – illustrates ways that social constructivist approaches, some based on Vygotskian theory, have been used to help students to develop scientific *habits of mind*, which are required for becoming good scientists (Gauld, 1982).

Chapter 10: Vygotsky and Science Teacher Education – includes initial teacher education (ITE), continuing professional development (CPD) for teachers, and informal science education contexts.

Part IV: Epilogue

The epilogue, presented as Chap. 11, presents a skeleton framework for the application of Vygotskian principles and practice in science education. It also considers the potential influence that Vygotsky's work may have on improving ways of 'doing' science. This is timely, as there are currently many issues in science that require more attention to bridging the gap between the scientific institutions and the world that surrounds them.

1.3 Navigating the Book Chapters

This book provides a comprehensive, yet concise, overview of Vygotsky's legacy to science education in many different learning, teaching and research contexts. In Table 1.1 below, I have indicated cross-references to different chapter sections for each context. There is some repetition of Vygotskian concepts throughout the chapters, but this has been kept to a minimum via Table 1.1, which should save readers a lot of time in trying to find useful cross-references between the various chapters.

My first introduction to Vygotsky was while completing my master's thesis on scientific concept development. More experience of Vygotsky began when I started lecturing in learning theories to pre-service teachers, in-service teachers, and master's and doctoral students. I became hooked on Vygotsky's life and legacy to science and science education. I use Vygotskian concepts and practices in my own teaching, learning and research. The positive responses from students ignited my motivation to start this book.

The book is written as a guide for readers who wish to learn more about Vygotsky, and how his inspirational work relates to many different science education contexts, most especially in twenty-first-century learning and teaching. Also, Vygotskian scholars reading this book might be interested in the different ways in which his work has been appropriated in science education.

I hope that you, the reader, will gain some useful ideas, and perhaps inspiration, for learning, teaching and 'doing' science!

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Part II
Vygotsky and His Legacy to Science Education

Chapter 2
Vygotsky – Life and Legacy

2.1 Introduction

Lev Semenovich Vygotsky (1896–1934) was widely acclaimed as a scientific genius from Russia, whose work is now highly influential globally in all aspects of education. His focus on social (as opposed to individual) learning has provided a basis for successful collaboration to promote better learning. Vygotsky's work is key to recent developments in science education that have embraced social constructivist approaches to learning and teaching science.

This chapter introduces Vygotsky's short life in its social and historical context and includes a section on those scholars who influenced his work. The more I learned about Vygotsky's life the more I improved my understanding of his teaching and research, which led me to adapt my own work to incorporate Vygotskian approaches in my learning, teaching and research in science education in the twenty-first century. Most of the chapter summarises my intensive reading on Vygotsky, and my discussions with Vygotsky's family members, Russian scholars who were taught by some of Vygotsky's students, and international colleagues with whom I have worked for many years.

The chapter concludes with an introduction to some twenty-first-century scientific research that demonstrates the importance of social constructivism in academic learning and indicates how Vygotsky's work has contributed to the basis for current science learning and teaching.

2.2 Vygotsky in Context

Vygotsky was born in the city of Orsha, Byelorussia (now Belarus) on November 5th, 1896. His family were Jewish, and Orsha was in a designated area, the Pale of Settlement, within which Russian Jews were required to live and work. The Pale

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was situated in the western region of Russia, in an area covering approximately one million square kilometres between the Baltic and the Black Sea. Vygotsky's short life was heavily influenced by the prevailing conditions in Russia (including political, economic, social and famine), which are highlighted throughout the chapter.

2.2.1 Childhood and Schooling (1986–1917)

Shortly after his birth, Vygotsky's family moved southwards to Gomel, a bigger city than Orsha within the Pale. His father accepted a post as department chief of the United Bank of Gomel. His mother was a teacher, who remained at home after the birth of their eight children. She taught her children languages, poetry and philosophy and often took them to the theatre.

Vygotsky was the second child and the oldest son. His intellect was prodigious from an early stage. He was educated at home by a private tutor, Solomon Ashpiz, from the age of 11 to 15. Ashpiz was a mathematician, also Jewish, and had spent time in Siberia for revolutionary activities when he was younger. He was known as a very kind and gentle person yet would only teach what would now be called 'gifted' children. Ashpiz' teaching method used a technique based on Socratic dialogue. He would ask a question and listen with his eyes closed as Vygotsky answered. Ashpiz would then open his eyes and ask the young Vygotsky to repeat certain sections of the answer until he got them correct. This method was successful: by late adolescence Vygotsky had mastered the fundamentals of a classical education, several languages, and Jewish history and culture.

By the age of 15, Vygotsky earned the nickname 'little professor'. He went to a private Jewish boys' secondary school when he was 15 and excelled in mathematics, history, philosophy, literature and drama. He was a key member, and subsequently the leader of a 'history circle' – a group of interested young friends and siblings who were trying to develop a philosophy of history. Vygotsky was enthusiastic about Hegel's views on history, particularly in terms of the dialectical formula of thesis, antithesis and synthesis. The 'history circle' applied this analysis to historical events. And so began for him the importance of history in development which later manifested itself in his CHT of the development of higher psychological functions (HPFs).

At the end of his schooling, Vygotsky achieved gold-level standard, which entitled him to attend university. Unfortunately, that year only 3% of Jewish applicants were allowed university places. Furthermore, instead of the best students (of which Vygotsky would have been one) being selected, a ballot was held to choose successful applicants. Vygotsky's friend Semion Dobkin writes of Vygotsky's upset when he heard this news, assuming that his name would not be drawn from the hat. Dobkin set a wager that if Vygotsky got into university, he would have to buy a volume of Bunin's poetry for him. Dobkin won: Vygotsky attended Moscow University and Dobkin got his book (Levitin, 1982).