

Different textbooks in technology education – different opportunities for developing disciplinary literacy

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ABSTRACT

This study aims to investigate textbooks in technology education and what characterizes the content related to how instructional materials in technology for grades 7-9 (ages 13-16) provide students with opportunities to develop disciplinary literacy in the subject of technology - how and to what extent. A delimitation is made to the specific content that covers industrial processes, which according to the curriculum should be taught to students aged 13-16 in the Swedish school. Textbooks constitute an important basis for education, and the study analyses the section that deals with industrial processes in four different technology textbooks commonly used for students aged 13-16. The content of texts has been interpreted in relation to (1) which language development aspects are addressed, (2) which concepts and terms are discussed, and (3) which knowledge students bring with them to upper secondary school through these textbooks. The study investigates the disciplinary specific words, may be unfamiliar to students and how they are explained and described. An important aim is to analyse the opportunities for developing disciplinary literacy provided and whether the examples provided contribute to students' understanding of the subject and to their ability to communicate their understanding of the subject. The preliminary results show differences in what characterizes the content of the books. The preliminary results also show differences regarding the conditions for developing disciplinary literacy.

Key Words: Technology education, Subject literacy, Textbooks, Secondary school, Language development

1. INTRODUCTION

Regarding the subject of technology, students should be able to describe, explain, and reason to demonstrate various aspects such as breadth and depth, how they base their arguments on facts or personal experiences and how they perceive function and usefulness (Skolverket, 2022). Well-functioning textbooks are considered a key factor for students' academic performance (Oates, 2014; SOU, 2021). Each textbook contains pedagogical and didactic ideas, and the design of the texts represents both a selection and an organization of knowledge (Lindensjö & Lundgren, 2000). Students need to read both extensively and varied texts (Stanovich, 2000) and a textbook helps

teachers organize their teaching (Oates, 2014; Lambert, 1999; Juhlin Svensson, 2000). Textbooks are also useful when students prepare for exams (Englund, 2006). Teachers in science and technology subjects appear to use textbooks to a great extent (Bachman, 2005). For teachers who are uncertain about their subject knowledge, the textbook can provide support (Driscoll et al., 1994; Englund, 2006), what is likely the case for many technology teachers in Sweden.

Researchers have found, among other things, that many textbooks lack incentives for reflective thinking (Hoff, 2000). The language of the text is fundamental to how students can understand the text (Reichenbergs, 2000), why it is important that examples demonstrating processes, concepts and terms are not overly complex, the language needs to be precise, but not too complicated (Guzzetti et al., 1995). Certain books have fact boxes and other types of text boxes that, despite looking appealing and interesting, create confusion for the student (Budiansky, 2002). If students can connect their own thoughts to the content in the book, comprehension increases (Ornstein, 1994). Similarly, the tasks in the book need to be perceived as relevant to the students (Kirk et al., 2001), they need to be about something they recognize (Roseman, Kulm & Shuttleworth, 2001). Analogue textbooks often function as reference books for students (Driscoll et al., 1994). However, the number of facts can be a problem (Nelson, 2001) as the number of concepts can be too many (Groves, 1995), making it difficult for students to develop an understanding of them (Nelson, 2001). Overall, the texts, images, tables, etc. in the books can present challenges for students (Bowen & Roth, 2002; Stylianidou, Ormerod & Ogborn, 2002; Peacock & Cleghorn, 2004).

2. AIM AND RESEARCH QUESTIONS OF THE STUDY

Within technology education in Sweden, students should be given the opportunity to "develop knowledge about technological solutions and how the components interact to achieve purpose and function" (Skolverket, 2022). This study aims to investigate analogue textbooks in technology education and what characterizes the content related to how instructional materials in technology for grades 7-9 (ages 13-16) provide students with opportunities to develop disciplinary literacy¹ in the subject of technology - how and to what extent. In this project, we have chosen to focus on the central content of the lower secondary level under the area of Technological Solutions: "Processing raw materials into finished products and handling waste in an industrial process, such as in the manufacturing of food and packaging" (Skolverket, 2022). We refer to this content as industrial processes.

The research questions are as follows: What characterizes the content of analogue technology textbooks regarding industrial processes with a focus on disciplinary literacy?

¹ In this study, we have decided to use the English term "disciplinary literacy" for the Swedish *ämneslitteracitet*.

3. THE THEORETICAL FRAMEWORK FOR THE STUDY

Disciplinary reading involves engaging with the texts one reads within a subject (Shanahan & Shanahan, 2012, 2020). Having insight into the subject's (disciplinary) literacy entails understanding the specific knowledge and skills possessed by those who create, communicate, and use knowledge within that discipline or subject. Within the discipline or subject, there are specific purposes, genres, symbolic artifacts, communication traditions, different quality standards, and language usage (Shanahan & Shanahan, 2012). School textbooks in various subjects are an important part of developing literacy, they provide a picture of the disciplinary literacy (Piper et al., 2018)

To examine the literacy of different technology textbooks, our analysis interprets text structures and linguistic structures. We have interpreted what each book offers students in terms of disciplinary literacy within technology. For our analysis and subsequent discussion, we have also chosen a functional perspective within a didactic analysis of the textbooks (described by Ammert, 2011a), focusing on the content of the book and the perspectives it conveys to the students (Ibid, p. 35), as well as how the content can be received by the students and which knowledge and skills can be stimulated through the book (Ibid, p. 37). We examine the texts, headings, fact boxes, images and tasks of the textbooks, as well as the structure of the text and content. We have been inspired by the analysis model described by Ammert (2011b), through which different types of presentations can be interpreted. According to Ammert (2011b, p. 260), content can be presented and conveyed in different ways, which affects how the reader interprets it. The presentation types described in the analysis model are: stating (reporting, affirmation, facts), explaining (explanation, description, background, consequence), reflecting/analyzing (connection to the reader, experiences or prior knowledge, parallel contexts, concepts and terms, or models).

4. METHODOLOGY

The purpose is to examine the texts, headings, fact boxes, concept summaries, pictures and figures of the technology textbooks, and ultimately discuss how students can comprehend what is written and presented in the books. The aim is to identify patterns in the literacy of each textbook, to see if they differ and what they have in common. We want to study the characteristics that emerge in each book and what they offer to the students who read them. We discuss, among other things, the presentation types offered by each book and what they do not offer. The purpose is to describe how the content is presented in each book and the depth of explanation provided.

Four commonly used technology textbooks for middle school students (ages 13-16) were selected. In each book, we focused on the pages that dealt with industrial processes: Book 1 (20 pages), Book 2 (35 pages), Book 3 (34 pages), and Book 4 (14 pages). Text, headings, fact boxes, concept summaries, pictures and figures serve as analysis units.

Using the model described above, we can analyse and discuss how the main text of the textbook presents the content. A stating presentation type asserts and confirms something without explaining or connecting it to contexts. An explaining type provides explanations, while a reflecting/analysing type sheds light on the content from different perspectives (Ammert, 2011b).

For images and figures, we examine their purposes, whether they are illustrative, and if they clarify the text. Regarding concepts and terms,² we investigate their purposes, quantity, explanation in the running text, explanation alongside the text, and suggested practice. For tasks, we examine if they serve as diagnostics, focus on concepts, assess understanding, require explanation/description, or involve analysis/reflection. The introduction is analysed in terms of goals, what students will learn, and the section's topic. Headings are analysed for language/concepts familiar to students and inclusion of new terms.

5. RESULTS

5.1. Book 1

The chapter begins with a short introduction that introduces the topic and provides a brief historical overview of a technical solution. Early in the chapter, there is a bullet-point summary of what students will learn in this chapter. The narrative voice directly addresses the reader using the pronoun "you"³. The initial headings are formulated in a way that allows students to recognize and understand the concepts and terms used. An example of such a heading is "How baby formula and porridge are made." In sections where different technical solutions are presented, new concepts and terms are explained in the headings themselves, such as the term "evaporation": "Evaporation - heating to remove water."

The main text is explanatory/descriptive in nature, but it also includes comments from conversations with individuals knowledgeable about the production processes. These individuals describe parts of the various processes. The text sections offer varied language and structure. The reader is partially included through the use of the pronoun "we". At the beginning of the chapter, a map of concepts and terms is presented, featuring a total of 21 concepts and terms, some of which are commonly known such as "milk," "grazing cows," and "packaging." The concepts and terms are not emphasized in any way within or in connection to the text, apart from the map of concepts and terms, except for the following four: skim milk, evaporation, spray drying, and roller drying. At the end of the chapter, it is possible to practice eight out of the 21 concepts and terms mentioned in the initial map.

The chapter primarily contains illustrative photographs, which sometimes clarify the text. Most of the photographs can be interpreted by students as they show relatively familiar situations and environments, such as a man feeding a baby with a bottle or cows in a field. Other photographs, such as those depicting historical or factory environments, may require an explanation. There are also photographs of purely illustrative nature.

The chapter concludes with a bullet-point summary followed by a spread called "The Finale," where students can practice a selection of the concepts and terms mentioned at the beginning of

² In the Swedish school context, *ord* (words) and *begrepp* (concepts) are used or only *begrepp* without distinguishing between concepts and terms. We have chosen here to consistently use concepts and terms without distinguishing between what are concepts and what are terms.

³ second person singular pronoun, in Swedish *du*.

the chapter, explain different parts of the technical solutions and problems. There are also instructions for two mini-projects.

5.2. Book 2

The chapter begins with a short introduction to the section on technical systems, with a focus on process industries that use various technical systems, using a paper mill as an example. Early in each section, there is a bullet-point summary of what students will learn in this chapter under the heading "goals." The narrative voice directly addresses the reader using the pronoun "you"⁴ Some headings contain new concepts and terms, such as *process industries* and *bottleneck*, which are explained in the following text section. Other headings provide an explanation for new concepts and terms. When presenting technical systems, all headings follow the same structure, for example, "xxx as a technical system."

The main text is predominantly explanatory/descriptive, but there are sections of a more reflective/analytical nature. These sections, for example, place a question or aspect in a larger perspective, such as the global. The text consists mainly of relatively short main clauses where the reader is directly addressed using "you". The reader is also included through the use of "we" in the text. The sections describing technical systems follow the same disposition and structure.

At the beginning of each section, a number of concepts are presented. A total of 18 concepts and terms are presented. These concepts and terms are highlighted in the text where they are also explained. A smaller selection of concepts and terms is continuously emphasized and practiced, such as "standard time" and "standardization".⁵

The chapter includes illustrative photographs, some of which also clarify the text. These photographs have descriptive captions to clarify the connection to the text. Other photographs are inherently interpretable, such as a photograph of a ball of yarn or a milk carton, but their purpose can mainly be seen as illustrating the theme of the text. The highlighted technical processes are described with a relatively short text, which is also explained through a series of images illustrating the different steps in the processes with a consistent structure.

Students are continuously given the opportunity to practice concepts and terms, describe, explain, or provide examples of what they have just read through one or a few questions on each page the next to the main text. Each section concludes with a number of tasks where students have the opportunity to explain, describe, and reason about what is presented in the chapter. Each section ends with a project (create a model of a process industry or program a robot).

5.3. Book 3

The chapter begins with a box that presents the focus in bullet points. Each section begins, after a short introduction, with a bullet list of what the specific section will cover, along with a list of

⁴ In Swedish: du.

⁵ In Swedish: *normaltid* and *standardisering*.

the highlighted concepts and terms. In the introductory section on early technical processes, most of the headings contain familiar concepts and terms for most students such as "Manufacturing in the Stone Age"/"We become farmers - and specialised"⁶ In later sections, which cover technical processes in today's society, the headings consist of new concepts and terms that are explained in the subsequent text. An example of such a term is "automatic processes". The main text is predominantly explanatory/descriptive. However, the texts in the introductory section on technical processes in a historical perspective are more reflective/analytical, while the concluding and in-depth pages, called "Plus pages," have a more assertive character. The language of the text includes shorter main clauses as well as more elaborated phrases. The text does not directly address the reader, nor does it include the reader. Instead, the impersonal pronoun "one"⁷ or other impersonal formulations are used.

Concepts and terms are presented early in each section, and a total of 28 concepts and terms are highlighted. In addition to these concepts and terms, there is a second level of concepts and terms that are highlighted in connection with the descriptions of the different processes. Those mentioned at the beginning of each section are marked in italics in the text and explained in the running text. Students can practice a number of concepts and terms at the end of each section. These concepts and terms do not always correspond to those highlighted at the beginning of the section. The exercises vary and can, for example, consist of a fill-in-the-blank text, a crossword puzzle, or an exercise where concepts, terms and appropriate descriptions are matched.

Few of the photographs included in the chapter, are purely illustrative in nature. An example of a purely illustrative photograph shows a woman and a man at a conveyor belt in a food industry. The photograph lacks a caption. Most photographs are complemented by a caption, thus providing additional information and clarification of the main text. The captions make the photographs that are not self-explanatory understandable to students. In addition to photographs, there are a few schematic sketches of the different steps in the described processes. The sketches require reading and understanding the text. These schematic sketches include concepts and terms that are not highlighted at the beginning of the section.

Each section concludes with a "Can you?" box, where students have the opportunity to describe, explain, and talk about what has been presented. The content of the chapter is summarized in a concise manner on a page towards the end of the chapter. At the end, there are also "Plus pages" that delve into several aspects of what has been discussed in the chapter. Finally, there is a page with review questions, exercises to describe, analyze, evaluate facts explain concepts and terms as well as practical tasks related to the content.

5.4. Book 4

The chapter begins with four rhetorical reflection questions such as "How were objects made in the past?" and "What are the consequences of today's factory production?"⁸ that also serve as an

⁶ Tillverkning på stenåldern/Vi blir bönder - och specialiserade

⁷ In Swedish "man".

⁸ In Swedish: "Hur tillverkades föremål förr i tiden?" and "Vilka konsekvenser medför dagens fabriksstillverkning?"

introduction to the chapter. After these initial rhetorical questions, the chapter begins directly. The headings are short and alternately formulated with language familiar to the students and alternately so that new concepts and terms constitute the entire heading.

The main text is predominantly explanatory/descriptive, but the section on sustainable development has a more reflective/analytical character. The text consists of longer main clauses and more elaborate phrases. When a process is described and explained, the reader is often addressed directly using "you"⁹ and the reader is included in the steps of the process through formulations with "we." In other sections, the impersonal pronoun "one"¹⁰ is used.

22 concepts and terms are introduced in the text by marking them in bold. In some cases, the explanations of them are supplemented by a sketch of, for example, a sensor or an actuator. Students are given limited opportunities to practice their understanding of concepts and terms using the textbook in the "test yourself" sections following each section.

The purpose of the majority of the photographs in the chapter is to clarify the text. The description of what the photographs depict is provided by an explanatory caption, which in most cases makes them interpretable for the students. However, despite the caption, some of the images might be difficult for students to interpret due to the chosen angle or cropping of the photograph. One photograph, a toothbrush, is purely illustrative. In addition to photographs, there are schematic sketches of the different steps in the processes and various forms of control, such as pneumatic and hydraulic, in the in-depth section called "Learn More."

After each section, there is a box with questions where students can test their understanding of a few of the highlighted concepts and terms, and the meanings of different parts of the processes and how they work. There are also questions for explanation and reasoning. At the end of the chapter, there is a page with questions to ponder and tasks related to programming a robot. Finally, there is a brief summary of the content.

6. DISCUSSION

Disciplinary specific language involves relevant content area specific concepts and terms, and the specific linguistic characteristics that are characteristic of each school subject. For a student to develop disciplinary specific language and thus develop critical thinking, the student must also encounter a language that, on the one hand, allows them to understand and absorb the subject matter and, on the other hand, allows them to encounter a language that enables them to develop their own language.

In the four textbooks the authors have chosen different ways to capture students' interest. An important factor in capturing students' interest early on is that they are initially presented with language that they understand and can relate to without immediately encountering words and concepts whose meaning they do not understand or cannot relate to. The authors have chosen

⁹ In Swedish "du".

¹⁰ In Swedish "man".

different strategies for this. In one book, both the content and illustrations are chosen to be recognizable to many children: the production of food for young children is illustrated with a baby being fed by a man and cows in a meadow. The text is explanatory/narrative with varied language, while moving in environments familiar to many students, and the headings are formulated in a way that allows students to imagine the content of the upcoming text. In another, the chapter begins with early technical processes starting from the Stone Age and ending in mass production in the textile industry of the 20th century. The text in this section has a reflective/analytical character. The headings give an idea of the content of the subsequent text, and many of the descriptions are illustrated through interpretable photographs for the students. In a third book, the students are immediately introduced to an unfamiliar factory environment, while a narrator's voice directly addresses the reader and includes them in the processes being described. The headings here are short and provide limited understanding of the content of the text that follows.

The textbooks are illustrated with carefully selected photographs and sketches. A few photographs are purely illustrative, while the majority aim to clarify the processes being described. The photographs also serve another purpose - to make the textbooks appealing and engaging. In the work on Book 4, it can be assumed that emphasis was placed on making the photographs captivating, although in some cases, it simultaneously complicates the interpretation of the image, as the chosen angle might make it difficult to see what the image is showing even when a descriptive caption is provided.

Concepts and terms constitute an important part of students' development of disciplinary specific language. Highlighting and explaining new disciplinary specific concepts and terms while giving students the opportunity to practice them and place them in a relevant context are important elements. In three of the four textbooks, new concepts and terms are introduced at the beginning of the chapter. Reading and understanding the concepts and the terms is an important part of learning, but it is equally important to actively use them. In three of the books, there are elements where students have the opportunity to work on learning the concepts and terms. Most often, this involves students being able to explain a selection of the concepts and terms that are introduced. Book 3 exhibits the greatest variety of exercises on concepts and terms, while those introduced at the beginning do not always correspond to the concepts and terms that students are expected to practice.

Each chapter or section concludes with a practice/diagnostic section consisting of comprehension questions and tasks where students practice explaining or describing facts. In three of the books, there are also tasks where students are asked to reflect and/or analyze the problems. In all textbooks, students are given the opportunity to try out such processes described, albeit on a smaller scale.

The textbooks demonstrate a wide range of examples and descriptions within the framework of the same theme. Consequently, this leads to significant variations in students' knowledge and understanding of the theme, both in terms of concrete knowledge about processes and the ability to explain and describe industry processes using the concepts and terms found in different teaching materials. One potential consequence of this is that students may progress to high school with highly diverse technology knowledge. At the same time, this places significant demands on

primary school teachers who may need to compensate for aspects that the textbooks may not provide opportunities to practice. It also poses challenges for high school teachers who may encounter new students with substantial differences in their level of knowledge.

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