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Textbooks are a major tool in the teaching and learning process. This paper presents the results of an analysis of the Finnish and Thai 6th grade science textbooks: electric circuit lesson. Textual and pictorial information from the textbooks were analyzed under four main categories: 1) introduction of the concepts, 2) type of knowledge, 3) representations, and 4) contexts. The analysis revealed that the Thai textbook emphasized procedural knowledge, while conceptual knowledge was emphasized mostly in Finnish textbook. Physics concepts are introduced typically through describing the relation between the new and earlier introduced concepts. Both textbooks employed rather traditional contexts, such as technical applications, technology in society, and the ideal context.

Keywords: electric circuit, science textbook, primary level, content analysis

INTRODUCTION

Textbooks play a vital role in science teaching and learning (e.g. Strangman et al., 2003; Abd-El-Khalick, Waters & An-Phong, 2008). According to the latest Finnish follow up of assessment in the natural sciences, altogether 79% of the teachers indicate that they use a science textbook every lesson or almost every lesson (Kärnä, Hakonen & Kuusela, 2012). From PISA (OECD, 2007) school questionnaire data, 76.2% of Thai headmasters and 74.7% of Finnish headmasters claim that there is only little or not all shortage of science textbooks. Therefore, textbooks seem to be important in both countries.

Ideas supporting constructivism are well documented by research on comprehension of written text and it has been concluded that reading is a process of active construction of meanings (e.g., Spiro, 1980; Bransford, 2000). Bransford, Brown, and Cocking (2000) argue that when students are reading a textbook their previous knowledge interacts with the information, text and pictures, available in order to influence comprehension and recall. In addition, Chiappetta and Fillman (2007) summarize that at all levels of education science, textbooks are often used as the primary organizer of the subject matter that students are expected to master and provide detailed explanations of topics to be taught. Hence, textbooks play an important role in offering credible information. The students are supposed to learn through processing this information.

When a teacher uses a textbook, he or she does not only follow the text, but typically uses the other pedagogical approaches found the textbook, such as textual and pictorial representations. Mohammad and Kumari (2007) analyzed teachers' experiences and practices related to the use of science textbooks in public schools in rural Pakistan. They found that the teachers had difficulties in recognizing mistakes in the textbooks and in with the reflective use of textbooks. Consequently, the textbook authors have a responsibility to ensure clarity of the language they used, the provision of adequate information, and they eliminating misprinting errors. In addition, authors and editors should ensure that the textbook support adequate methodological guidance and have some input to the planning of lessons. According to Swanepoel (2010) the quality of science textbooks is related to the

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State of the literature

- There is a long tradition on the content analysis of textbooks.
- Several comparative studies in this field have been made. However, the comparison of the different type of textbooks is challenging because the structure, content and the terminology used in the textbooks varies.

Contribution of this paper to the literature

- A framework for comparing science textbooks through the use of four main categories: *1) conceptual and procedural knowledge introduced, 2) representations and 3) pictures used in the textbook and, moreover, 4) contexts where the knowledge has been introduced.*
- A comparison of primary science textbook sections in the context of electric circuit in Finland and in Thailand.
- An outcome of the comparison is: The Thai textbook emphasised procedural knowledge, while conceptual knowledge was emphasised mostly in the Finnish textbook. Physics concepts are introduced typically through describing the relation between the new and earlier introduced concepts. Both textbooks employed rather traditional contexts, such as technical applications, technology in society, and the ideal context.

support, the textbook offers to the teaching. She reviewed in her thesis several studies and concluded that a textbook should also support teachers in their conceptual change; moreover, the subject matter knowledge should be compactly presented in the textbook a manner that orientates any teacher using it. Research on textbook has focused on textbook comparison, the effect of textbooks on the development of teaching and learning or designing a curriculum, implementation of educational policy or national level curriculum. A textbook author is required to consider several aspects during the writing process: what knowledge should be introduced and how it should be introduced. What kinds of representations – such as figures – are used? At least in developed countries, textbook should emphasize motivation and interest toward science as well. Further, publishing companies need to sell these books. Therefore, textbooks have to follow local "canons" for textbooks and not be too innovative.

In science education, textbooks play a vital role in conveying concepts (subject matter), natural laws and theories to students. The quality of understanding or understanding the meaning of a concept is related to the capacity to use and apply the concepts in familiar and new situations (Gott and Duggan 1995, pp. 25-26). Therefore, when introducing a concept in a textbook it is essential to make clear how the concept is related to other concepts, physical laws and principles. Mintzes and Wandersee (1989) emphasized the relations between concepts and the role of examples when introducing concepts through a concept map. When examples and/or non-examples in the concept's domain are given, the concept should be constructed through a classification activity (Joyce & Weil, 1980, pp. 25-60).

In addition to the learning of conceptual knowledge, textbooks support the learning of procedural knowledge or processes (McCormick, 1997). Casteel & Isom (1994) stated: "The literacy processes produce comprehension and the communication of ideas, and these are manifested through reading, writing, listening, speaking, and thinking. These processes in turn support the development of science process skills necessary for gaining the knowledge and understanding of the physical world" (pp. 540). Therefore, one way for students to attain the required procedural knowledge and develop process skills is reading a textbook.

All representations in the textbook – such as text, pictures, diagrams, charts, models, tables, and graphs– are used for communicating ideas and concepts (Roth & McGinn, 1998, pp. 35). There is plenty of research on representations in several fields such as mathematics, physics and biology. The representations in textbook have been categorized from different perspectives. For example, Carolan, Prain, and Bruce (2008) suggested the diverse representations use in teaching and learning science be divided into two groups: one of them can be further categorized as specific to the domain of science (such as 3D models, tables, graphs, diagrams, science journals, multimodal reports, and appropriate vocabulary and measurement for specific topics).

Research has identified several factors that interrelate with the development of a positive attitude towards the learning of science, like the perceived relevance of science from the point of view of everyday life, further studies or occupation, interestingness of the content or a context where certain science content or topics are met (Simon, 2000; Osborne, Simon, and Collins, 2003). According to text-based learning research a situational interest or positive attitude is the result of certain text characteristics or the context where the text has been presented (Hidi & Baird, 1986; Krapp, 2002). Consequently, the context where the textual or pictorial information is presented or how the relevance of topic is demonstrated could have an influence on the development of a student's attitude. Especially, context-based approaches have had an influence on textbooks in terms of stimulating young people's interest in science and helping them see how it relates to their everyday lives (Bennett, Hogarth and Lubben, 2003). Because students' interest is so important to future involvement

in the subject, it is useful to know how textbooks emphasize the different contexts.

In what follows we summarize the above aspects as essential features of textbooks. The last four items are used as main categories in the content analysis of Finnish (Cantell et al., 2008) and Thai (Institute for the Promotion of Teaching Science and Technology, 2009) science textbooks. A science textbook:

- *is written according to national level curricula or some education policy*
- *allows the use of different teaching methods, educational technology and learning tools*
- *emphasizes conceptual and procedural knowledge in a form students are able to learn,*
- *supports meaning making while introducing new knowledge*
- *uses different representations while introducing the knowledge*
- *supports the development of a positive attitude to science through demonstrating the relevance of science and the use of appropriate contexts when introducing new knowledge*

Research questions

In this paper we will focus to Finnish and Thai science textbooks. The study is part of a comparative study where science education is compared in high and low performing countries, measured with the PISA Scientific Literacy Assessment scale (OECD, 2007). In order to analyze Finnish and Thai primary textbooks, the chapters to be analyzed have to be selected carefully. For our study, we selected chapters focusing on electric circuit in primary textbooks. Electric circuit is introduced in the national core curriculum of both countries and is a common topic for teaching worldwide; furthermore, this topic can be taught in terms of the conceptual and practical levels, especially as it definitely relates to students' everyday phenomena and society as well. Duit and Rhöneck (2001, pp. 1) suggested that: "Electricity is one of the basic areas of physics which is important at all levels of physics teaching. At the primary level young children have already gained experience with simple electric circuits."

The research questions are:

How science concepts are introduced in Finnish and Thai primary science textbooks?

To what extent do Finnish and Thai science textbook emphasize the learning of conceptual and procedural knowledge?

What kinds of representations do textbooks use to clarify science concepts?

In which contexts are the concepts introduced?

METHODOLOGY

In Finland, science textbooks are produced by private publishing companies. In an author group, there are science education researchers, teacher educators, and schoolteachers. The Finnish textbook was chosen because of its widespread use in schools. In Thailand, the selected book is published by the Ministry of Education and authored by a committee of consultants from various education professional groups. The analyzed book is used in most of public schools in Thailand. Altogether 6 pages in Finnish and 12 pages in Thai textbook were selected for analysis.

The study can be characterized as qualitative content analysis. According to Neuendorf (2002, pp. 10) "Content analysis is an in-depth analysis using quantitative or qualitative techniques of messages using a scientific method and is not limited as to the types of variables that may be measured or the context in which the messages are created or presented." Weber (1990) stated that content analysis refers to a method of transforming the symbolic content of a document, such as words or images, from a qualitative, unsystematic form into a quantitative, systematic form. We used non-parametric tests in comparing the textbooks.

We followed the steps described below in our analysis:

- *We translated the electricity chapters in the textbooks into English and then read several times in order to select the text corpus for the analysis.*
- *We identified the main and sub categories and writing of the definitions for categories based on the literature review and the content of the textbooks. Therefore, the analysis can be characterized as deductive*
- *We made a list of all physics terms introduced in the selected chapters in order to determine the concepts introduced in each chapter. Concepts, mentioned not in the curriculum, like a chair, were not included in the analysis.*
- *We classified the sentences, phrases, and pictures covering the selected concepts according to main and sub categories (see appendix A and B). There were typically several concepts in each sentence.*

Sub categories were defined inductively in phase 2 of the research process. After the preliminary reading (phase 2), the following main categories were defined:

Introduction of concepts: The way the concepts are introduced to the students.

Type of knowledge: Text and figures emphasizing the learning of procedural knowledge or conceptual knowledge.

Representations: All the textual and pictorial information in the analyzed chapters and indicates which type of the figures, pictures or drawings are used to introducing the concepts to the students.

Table 1. Definitions of the categories and examples of the original expressions

Category	Definition of the category	Examples of original expressions
Analogy	A concept is introduced by a metaphor or an analogy. A comparison between the new concept and already known concepts that have some particular things in common is done.	*"Flash of lightning and the glow of a **light bulb** are similar phenomena."* *"The wall **socket** has two poles which are equivalent to the poles in a battery."*
Example	A textbook supports concept formation through giving examples or through supporting classification.	*"Button **batteries**, are used in watches, cameras and calculators."* *"The **voltage** between the poles is 230 volts."*
Relation	A concept is related to other concepts, physical laws and principles.	*"One pole of a **battery** is called the **plus pole** (+)."*
Introduced earlier	The concept is introduced earlier, for example in a previous chapter.	*"The unit of **voltage** is volt (1V)"*
Just used	The concept is just used without any definition.	*"They can be recharged with a battery charger that is connected to a **socket**."*

Contexts: Concepts in the textbook are presented in different contexts.

Analysis framework

In what follows, we define in more detail the main categories and subcategories of the textbook analysis.

Introduction of concepts

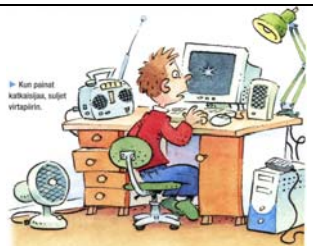
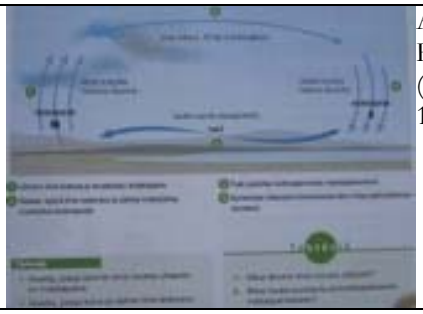
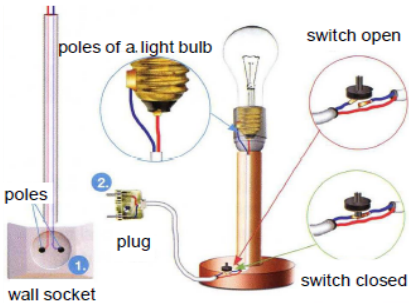
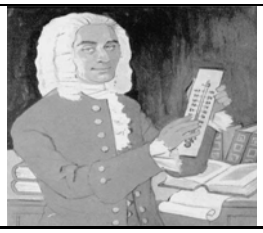
Many authors in the philosophy of science have suggested that the concepts of physics should be seen rather as structures or networks than logically or semantically defined entities (Thagard, 1992; Nersessian, 1995). Therefore, when introducing a concept in a textbook it is essential how the concept is related to other concepts, physical laws and principles. Classification is a natural process in science: physical phenomena can be classified into motion, electric, thermal, and sound phenomena. Respectively, the attributes of materials can be classified into mechanical, electrical, optical, and acoustic attributes. Consequently, a science textbook could support concept formation through giving examples and supporting classification. Furthermore, textbooks also use metaphors and analogies to help students to develop a meaning to a new concept especially when the concept is abstract and outside their previous experience. Metaphors and analogies are comparisons between new concept and already known concepts that have some particular things in common. Links between the new concept and known concept are constructed with shared and unshared attributes and this is called mapping. Metaphors and analogies typically include phrases like, "It's just like ..."; "It's the same as ..." and "… could be compared …" (Duit, 1991; James & Scharmann, 2007).

As a summary, a concept could be introduced in a textbook through an example or examples, through describing relation between a new concept and already existing concepts, or through a metaphor or an analogy. If the concept has already been introduced in a previous chapter, then the concept is typically just used. Sometimes the concept is just used without any definition (Table 1).

Type of Knowledge

Any information such as texts and pictures are presented in the textbook to emphasize the students' learning (cognitive domain) and developing interest (affective domain). In what situations, do textual and pictorial information emphasize learning of conceptual or procedural knowledge for students? We have two categories here: Conceptual and procedural knowledge (Anderson and Krathwohl, 2001). Conceptual knowledge is static knowledge and it includes facts, concepts, and principles that could be applied in a certain domain (de Jong & Ferguson-Hessler, 1996). Anderson and Krathwohl (2001) categorized it into 3 sub domains: knowledge of classifications and categories; knowledge of principles and generalizations; and knowledge of theories, models, and structures. Procedural knowledge is knowledge of how to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods (Spivey, 2007). It is the knowledge required to perform a task: knowledge that can be applied directly and is most often represented as production rules (Tobias & Duffy, 2009). It helps the problem solver make transitions from one problem state to another (de Jong & Ferguson-Hessler, 1996). Anderson and Krathwohl (2001) categorized it into 3 sub domains: knowledge of subject-specific skills and algorithms; knowledge of subject-specific techniques and methods; and knowledge of criteria for determining when to use appropriate procedures.

Table 2. Definition of categories of pictorial representations

Types of figure	Examples of representation
The *realistic* are visual images that represent reality according to human optical perception such as photographs.	 A Figure from the Finnish Textbook (Cantell et al., 2008, pp. 49)
The *conventional* are visual representations that represent reality in a coded way. They are usually graphs, maps, flow-charts, molecular structures and diagrams.	The Figure in Thai textbook (Institute for the Promotion of Teaching Science and Technology, 2009, pp. 21)
The *hybrids* are usually conventional representations with added on realistic features.	The Figure in Thai textbook (Institute for the Promotion of Teaching Science and Technology, 2009, pp. 115)
The *line drawings* are the visual images that consist of distinct straight and curved lines. Line drawings may tend towards realism, or it may be a caricature, cartoon, or ideograph.	 A Figure from the Finnish Textbook (Cantell et al., 2008, pp. 50)
The *manipulated* are the visual pictures that have been manipulated using computer programs. This type of figure is divided into 2 kinds:	 A Figure from the Finnish Textbook (Cantell et al., 2008, pp. 52)
The *narrative* are visual representations that represent 'unfolding actions and events, processes of change and transitory spatial arrangements'	 A Figure from the Finnish Textbook (Cantell et al., 2008, pp. 11)
The *classificational* are visual representations that exhibit taxonomies.	The Figure in Thai textbook (Institute for the Promotion of Teaching Science and Technology, 2009, pp. 83)
The *analytical* are visual representations that focus on the relationships between the 'objects' of representation in terms of a part-whole structure.	 A Figure from the Finnish Textbook (Cantell et al., 2008, pp. 49)
The *metaphorical* are the visual representations that 'connote or symbolize meanings and values over and above what they literally represent'.	 "Celsius and thermometer" (Alexopoulos, B. et al. (1989). *Science for primary school.* Athens, Greece: OEDB, pp. 55 cited in Dimopoulos et al, 2003).

The PISA 2006 science framework (OECD, 2006) combines conceptual and procedural type of knowledge and defines three broad competencies in terms of an individual's scientific knowledge and use of that knowledge to identify scientific issues; explain scientific phenomena and; draw evidence-based conclusions. These broad science competencies could also be understood as categories for procedural knowledge and are useful for planning science teaching and textbooks in addition to the planning of science items for international measurements.

Representations

A concept could be introduced through a text or through a picture. Therefore, all textual and pictorial information in the analyzed chapters were classified based on the type of representation in two main categories: textual representation, which includes all kind of texts and pictorial representation. Pictorial representations aim to assist students in terms of conceptual explanations. They can expand the meaning making potential of the texts. In addition, Gardner (1993 cited in Zambo, 2006) suggested that picture books are unique learning tools because they provide both words and images and these multiple modes of input tap varied learning styles. In order to analyze the pictorial representations in the science textbooks, their classifications were divided into two dimensions: type and function following Dimopoulos et al (2003). The line drawings and manipulated pictures were added to the original categories because they occur in the analyzed textbooks and all representations are presented in Table 2.

Contexts

A context is a situation or a background where a concept is met. For example, when a student looks at the picture he/she could link his/her own ideas with the science content. For example, a picture where a student is pushing a remote control recalls an experience of turning on or putting off a television. This picture in the context of a closed circuit is supporting the meaning making for the closed circuit and, consequently, helps students to apply that concept in their everyday lives. For this reason, particular context and students' interest go together with the same direction of interest enhancement. In addition to Hoffman (2002)"While the interestingness in physics instruction depends on situational conditions, such as the particular context in which a topic of physics is presented and particular activities students are allowed to engage in the social climate is characterized by conditions of teacher-to student and student-to-student interactions" (pp. 448).

Juuti et al (2004) surveyed student interest using the following six categories: ideal context, science and technology in society (STS) context, technical

Table 3. Physics concepts related to electric circuits in Finnish and Thai textbooks

Common concepts	Concepts only in Thai textbook	Concepts only in Finnish Textbook
Battery	Alternating current	Accumulators
Circuit diagram	Direct current	Ampere
Closed circuit	Electric bell	Break
Conductor	Motor	Charger
Electric circuit		Chemical energy
Electric current		Electric charges
Electric devices		Flashlight
Electricity		Fuse
Energy		Light
Filament		Plug
In parallel		Socket
In series		Thermal
Lamp		Volt
Light bulb		
Minus pole		
Open circuit		
Plus pole		
Poles		
Resistors		
Short-circuit		
Switch		
Voltage		
Wire		
Total= 23	**Total = 4**	**Total= 13**

applications context, human being context, investigation context, technology, design, and constructing context. They found that topics in one context were often more interesting than those in other contexts. Further, there are gender differences between contexts. In addition to these contexts, the historical situation could be a context. We will apply the following context classification in the analysis:

- *Ideal context: the concept is introduced through an intangible situation—or a circumstance.*
- *Science and technology in society (STS) context: the concept is introduced through the relationships between the use of a concept or an application related to the concept and society.*
- *Technical applications context: the concept is used in a situation of technical application use.*
- *Human being context: the concept is introduced relating to our physical state or an activity a human being is conducting.*
- *Historical context: the concept is introduced through explaining how and/or who take the concept into use.*
- *Investigation context: the concept is introduced by an investigating method such as observation in the classroom, hands on activities, doing and experiment.*
- *Design and constructing context: the concept is introduced for designing and constructing something in any situation.*

RESULTS

The results of the analysis are presented according to the research questions. The first question focuses on the physics concepts related to electric circuit in grade 6 have been introduced. Table 3 presents the common and dissimilar concepts in two textbooks.

Concepts were introduced through different representations and contexts. Altogether, 36 concepts were presented 354 times in Finnish and 27 concepts were presented 228 times in the Thai textbook. Table 4 presents most frequently seen concepts in the Finnish and Thai textbooks. The percentage indicates frequency of a concept among all concepts in the textbook.

Table 4. The frequency of the 5 most used concepts in the Finnish and Thai textbooks

	Finland		Thailand	
The most frequently seen 5 concepts in both textbooks	*f*	*f* (% of all concepts)	*f*	*f* (%)
Battery	60	10.3	42	7.2
Electric circuit	8	1.4	16	2.7
Electric current	31	5.3	14	2.4
Lamp	31	5.3	41	7.0
Wire	19	3.3	15	2.6
Total (N of all concepts =582)	149	25.6	128	22.0

Table 5. Comparison how concepts were introduced of the Finnish and Thai textbooks

	Finland		Thailand	
Introduction of the concepts	*f*	*f* (%)	*f*	*f* (%)
Analogy	8	2.3	0	0
Example	37	10.5	49	21.5
Introduced earlier	22	6.2	16	7.0
Just used	26	7.3	27	11.8
Relation	261	73.7	136	59.6
Total (N=582)	354	100	228	100

$\chi^2 = 23.8$

Table 6. Emphasizing type of knowledge from the Finnish and Thai textbooks when students read through pictorial and textual information in the textbooks

	Finland		Thailand	
Type of knowledge	*f*	*f* (%)	*f*	*f* (%)
Conceptual	315	89.0	171	75.0
Procedural	39	11.0	57	25.0
Total (N = 582)	354	100	228	100

$\chi^2 = 19.7$

"Battery" was used most frequently, then lamp, and electric current in both textbooks. The Thai textbook introduced electric circuit more often than the Finnish textbook (twice more frequently, vice versa electric current was introduced twice more frequently in the Finnish textbook than in the Thai textbook. Both countries introduced the concept of wire with almost similar frequencies.

Introduction of the concepts

The frequencies of the ways of introducing the concepts are described in Table 5. The Finnish and Thai frequency distributions differ statistically.

Type of knowledge

Table 6 summarizes the analysis of the type of knowledge that the textbooks emphasis. The analyses revealed that learning of procedural knowledge was emphasized more often in the Thai than in Finn textbook, The most frequently used concept in both countries was a "battery" but in Thailand it was more often used to emphasize couplings or other procedures than in the Finnish textbook, $\chi^2(28, N=102) = 7.1$ ($p<0.001$). In the Thai textbook also a lamp was used in situations where procedural knowledge was emphasized, $\chi^2(14, N=72) = 4.2$ ($p<0.001$) more often than the Finn textbook.

Representations

Table 7 presents number of representations used in the Finnish and Thai textbooks. The Finnish and Thai frequency distributions differ statistically significantly. We also took examined the representations of 'battery and lamp' in the Finnish and Thai textbooks. The most frequently used representations for the battery in Finland and in Thailand was the textual form ($N_{FIN}=55$; $N_{THAI}=33$). In Finland 5 realistic pictures and in Thailand 7 realistic pictures and 2 line drawings were used. The distributions used for a lamp were very similar.

In addition, the electric current was represented as texts in both textbooks but more frequently in the Finnish textbook. Manipulated figure was used to demonstrate this concept once in the Finnish textbook and none in the Thai textbook.

Contexts

Finally, we analyzed which context was used for introducing the concepts in the Finnish and Thai textbooks. The results are described in Table 8.

It is notable that the Finnish and Thai distribution differed significantly. The order of the most three common contexts was the same in the textbooks. Further, in Finnish book, there were no concepts in human beings or investigation context while in Thai book there were no concepts in the historical context.

Table 7. Comparison of how the concepts are introduced via representations in the Finn and Thai textbooks

	Finland		Thailand	
Representations	*f*	*f* (%)	*f*	*f* (%)
Analytical	6	1.7	0	0
Hybrid	0	0	1	.4
Line drawing	5	1.4	18	7.9
Manipulated figure	8	2.3	0	0
Realistic figure	14	4.0	36	15.8
Realistic line drawing	6	1.7	0	0
Textual information	314	88.7	173	75.9
Total (N = 582)	354	100	228	100

$\chi^2 = 55.2$

Table 8. Comparison of how the concepts are introduced via contexts in the Finn and Thai textbooks

	Finland		Thailand	
Contexts	*f*	*f (%)*	*f*	*f (%)*
Historical	3	.8	0	0
Human beings	0	0	3	1.3
Ideal	61	17.2	17	7.5
Investigation	0	0	14	6.1
Science, technology, and society (STS)	73	20.6	62	27.2
Technical applications	217	61.3	132	57.9
Total (N = 582)	354	100	228	100

$\chi^2 = 41.1$

DISCUSSION

The main finding of the research was that in the Finnish and Thai textbooks the content of the book chapters focusing on the 'electric circuit' could be considered to be rather similar. There were altogether 23 common concepts introduced in the textbooks. In the case of representations, textual representations were used more then realistic figures or realistic line drawings. In the Thai textbook, there were more realistic figures and line drawings but less text than the Finnish textbooks. This means that the Thai textbook was more of the picture book type, while the Finnish textbook emphasized more concepts. The most frequently used contexts were technical applications, and science, technology, and society (STS).

The Thai textbook introduced concepts through procedures more often than the Finnish textbook. Especially battery, bulb, and other concepts related to electric circuits were introduced in Thai textbook through explaining how to make the coupling. The descriptions certainly help the students to perform the task as it is: knowledge that can be applied directly and is represented most often as production rules (Tobias & Duffy, 2009). This approach fit well with the current trends in science teaching such as the inquiry method, laboratory, collaborative learning, and hands-on activities. Park, Park, and Lee (2009) highlighted the procedural knowledge emphasis for students' learning by investigating in what ways the inquiry oriented questions or tasks in earth science textbooks reflect the unique characteristics of earth science inquiry methodology in the U.S. and South Korea. The results showed that the U.S. textbooks included a small number of inquiry activities and did not introduce features of earth science methodology; in contrast, the South Korean textbooks introduced a large number of activities. However, these teaching methods rather support students' procedural learning than understanding the meanings of concepts.

The results of representations analysis showed that the main formats of representations are texts and realistic figures. Realistic figures always presented along with textual description or the important concepts introduced. Prain & Waldrip (2006) explored the use of multi-modal representations of concepts in electricity lesson in primary science. They found that teachers tend to use a diversity of modes (such as verbal, graphic and visual, written, and 3D modes) as resources to promote interest in topics. Consequently, both textbooks support teachers in multimodal representation use. Colorful figures were used to to draw students' attention and arouse situational interest. Further, well-designed figures can reduce the need for detail textual information; therefore, well-designed figures may reduce the cognitive load (Yousoof, Sapiyan, and Kamaluddin, 2007; Leavitt, n.d.). Moreover, Plass *et al.* (2009) showed that any choice of representations in visual learning materials must take into account not only the function of the representation, but also the prior knowledge of the learners who will be using the materials. Therefore, it is important to introduce concepts several times to support the reorganization of prior knowledge. The cognitive load associated with depictive, descriptive and symbolic representations depend on the learner's prior knowledge.

An important aspect in the PISA 2006 and 2009 science framework (OECD, 2006, 2009) are the situations (personal, social and global) and contexts – such as STS – where the science concepts are met. Contexts in the analyzed textbooks seemed to be rather traditional taking into account what is known about students' interest, especially from the gender perspective (Juuti et al, 2004). After analyzing the data from a large national survey, they recommended textbook authors and teachers should introduce concepts in the context of the human being. They did not report gender differences within this context. The emphasis of technical applications in textbook is problematic from the gender perspective. The technical application context was most disliked by girls. In general, boys are more interested to know how technical applications work than girls (Aikenhead, 1994, pp. 52-53, Hoffmann, 2002). In addition, there was an example in Thai text book of how technological context can be combined with human being context. For example, *"if we touch the wire without an insulator, electric current will leak and run through our body. We will be dead for this reason."* (Thai textbook, pp. 114). STS context were used in a similar way in both textbooks. Summarizing, there are challenges, which we have to face in the future to find more versatile contexts to introduce electricity concepts.

Both textbooks illustrated the concepts (subject matter) mostly in the context of technical applications with the aim to relate the concept to the students' lives. From this point of view, students are prone to be interested and understand a lesson well when that lesson incorporates their experiences. If students are more interested and motivated by the experiences they are having in their lessons, this increased engagement might result in improved learning (Bennett, 2005). Furthermore, the concepts from the textbooks attempted to link students not only with their own lives but also other with new situations they might encounter. This means that students can apply the idea of each concept to other situations or new situations as well. Yager and Akcay (2008) did action research on STS (Science – Technology – Society), they found that students can use the information and skills from their own lives in new situations, generating ideas for use of science concepts in new situations, and conversing about science at home.

Another minor observation is that in the Finnish textbook, a total of 8 realistic figures were somehow manipulated. For example, some lines were added or phenomena in the figure were magnified. Manipulation of the figures was made easier by the availability of powerful software, such as Photoshop. Manipulation can be understood as a form of hybrid representation. These manipulated figures are designed so that they emphasize the phenomenon in a clear and attractive manner as possible. The aim of manipulation is to make the phenomena easier to perceive. We recommend that in picture captions should indicate whether a figure was manipulated.

Besides, based on our findings, some perspectives on science education of both countries were reflected. The Finnish textbook introduced more concepts and also described more often relations between concepts than the Thai textbook; from this point, it could be one reason why Finnish students received higher scores than Thai students in the PISA scientific literacy assessment. On the contrary, the concepts in Thai textbook were more often presented in a procedural pattern. The main reason for this could be based on the principle that activities organization is provides the means for all learners to draw from authentic experience; drill in practical work for complete mastery; enable learners to think critically and acquire the reading habit and continuous thirst for knowledge (Thai National Education Act B.E. 2542 (1999). Therefore, this viewpoint can reflect one aspect of the Thai textbook, why the concepts were mostly introduced by procedural form and why Thai students achieved rather low scores for scientific literacy in terms of scientific knowledge (or concepts) in the PISA assessment. In summary, we believe that some results from this study can be an indicator for further development in science education.

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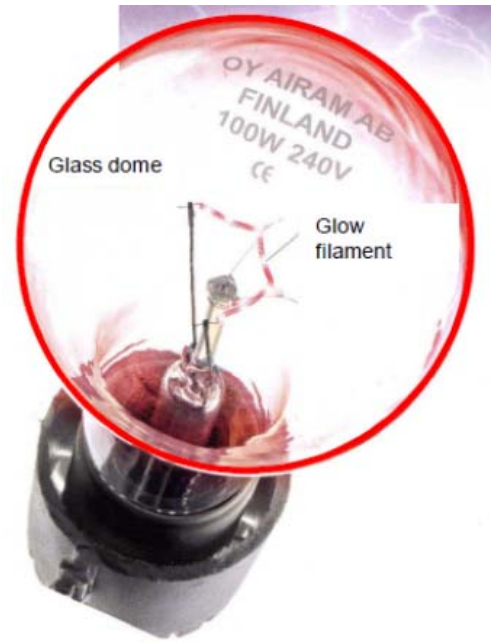
Appendix A. Example of Finnish textbook analysis table

Information in the textbook	Concept based on Physics terminology	Type of knowledge	How the concepts are introduced	Representation	Use of concept in context
Flash of lightning and the glow of a **light bulb** are similar phenomena. What causes them?	Light bulb	Conceptual	Text	Analogy	STS
Electric current makes the glow **filament** glow	Electric current	Conceptual	Text	Relation	Ideal
	filament		Text	Just used	Tech.app.
The turning on of the **light bulb** in a flashlight can be compared to a flash of lightning. The condition for lightning to occur is that between the bottom of the thundercloud and the surface of the earth there are different types of **electric charges**	Light bulb	Conceptual	Text	Analogy	Tech.app.
	Electric charges		Text	Just used	STS
When a **light bulb** is connected with two **wires** to a **battery**, an **electric current** runs through the glow **filament** of the light bulb and the light bulb lights up.	Light bulb	Conceptual	Relation	Text	Tech.app.
	Wire		Relation	Text	Tech.app.
	Battery		Relation	Text	Tech.app.
	Electric current		Relation	Text	Ideal
			Relation	Text	Tech.app.
The unit of **voltage** is **volt** (1V) and the unit of **electric current** is **ampere** (1 A). The unit of the **voltage**, **volt**, is named after an Italian Alessandro Volta. He built the first **batteries** as early as 1800.	Voltage	Conceptual	Introd. earlier	Text	Ideal
	Volt		Relation	Text	Ideal
	Electric current		Introd. earlier	Text	Ideal
	Ampere		Relation	Text	Ideal
	Voltage		Introd. earlier	Text	Historical
	Volt		Relation	Text	Historical
	Battery		Just used	Text	Historical
See Figure 1a below.	Electric current	Conceptual	Example	Manipulated fig.	Tech.app.
	Light bulb		Relation	Manipulated fig.	Tech.app.
	Filament			Manipulated fig.	Tech.app.
	Electric current			Text	Tech.app.
	Light bulb			Text	Tech.app.
	Filament			Text	Tech.app.
See Figure 1b below.	Battery	Conceptual	Example	Realistic	Tech.app.
	Plus pole		Example	Realistic	Tech.app.
	Minus pole		Example	Realistic	Tech.app.
	Battery		Relation	Text	Tech.app.
	Pole		Relation	Text	Tech.app.
There is **voltage** between the **poles** of a **battery** and between the **poles** of an **accumulator**	Voltage	Conceptual	Relation	Text	Ideal
	Pole		Relation	Text	Tech.app.
	Battery		Relation	Text	Tech.app.
	Accumulator		Relation	Text	Tech.app.
Small accumulators are the same size as normal batteries. **They** can be recharged with a battery charger that is connected to a **socket**. So the **accumulator** can be used for a long time as long as you remember to charge it occasionally.	Accumulators	Conceptual	Analogy	Text	Tech.app.
	Accumulators		Relation	Text	Tech.app.
	Socket		Just used	Text	Tech.app.
	Accumulators		Relation	Text	STS
See Figure 1c below.	Lamp		Relation	Analytical	Tech.app.
	Switch		Relation	Analytical	Tech.app.
	Wire		Relation	Analytical	Tech.app.
	Socket		Relation	Analytical	Tech.app.
	Plug		Relation	Analytical	Tech.app.
	Pole		Relation	Analytical	Tech.app.
	Lamp		Relation	Text	Tech.app.
	Switch		Relation	Text	Tech.app.
	Wire		Relation	Text	Tech.app.
	Socket		Relation	Text	Tech.app.
	Plug		Relation	Text	Tech.app.
	Pole		Relation	Text	

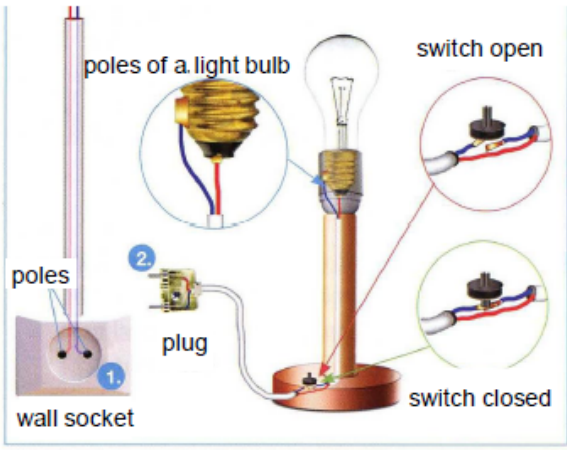


The glow filament glows when the electric current runs through the wire.

Figure 1a. Sample from the Finnish Textbook (Cantell et al., 2008, pp. 48)

▲ Battery has two poles

Figure 1b. Sample from the Finnish Textbook (Cantell et al., 2008, pp. 48)



From both poles (1) of the socket runs a wire to the electric centre of home.
Inside the electric wire of the table lamp are two small wires, which connect the poles of the light bulb to the plug (2).

Figure 1c. Sample from the Finnish Textbook (Cantell et al., 2008, pp. 49)

Figure 1. Some information given besides visual representations (in Appendix A)

Appendix B. Example of Thai textbook analysis table

Information in the textbook	Concept based on Physics terminology	Type of knowledge	How the concepts are introduced	Representation	Use of concept in context
In an experiment of **electric devices** connection e.g. **wires, lamps, batteries**, and other materials for checking they are **resistors** and **conductors** or not? The results of experiment are....	Electric devices Wires Lamps Batteries Resistors Conductors	Procedural	Just used	Text	STS
Materials which have the electric resistible feature called **resistors.** The **electric current** cannot run through the circuit.	Resistors	Conceptual	Relation	Text	STS
You already know the element of **electric circuit,** now we should know about the **electric devices** and writing of their symbols	Electric circuit Electric devices	Conceptual	Relation	Text	Tech.app.
When we connect the **battery**, **wire,** and l**amp** making the **lamp** glows. It means that there is an **electric current** runs on. By **electric current** runs from a **plus pole** of **battery** through the **switch** and l**amp** to a **minus pole** of **battery.** It's called **closed circuit.** On the contrary, if we connect incompletely and **the lamp** doesn't glow. It's called **open circuit**. Therefore, the **battery, wire,** and **lamp** are the main elements of simple **electric circuit.** The **switch** functions as cutting and connecting the **circuit.**	Battery Wire Lamp Electric current Electric current Plus pole Battery Switch Lamp Minus pole Battery Closed circuit Lamp Open circuit Battery Wire Lamp Electric circuit Switch Electric circuit	Procedural Procedural Procedural Conceptual Conceptual Conceptual Conceptual Conceptual Conceptual Conceptual Conceptual Conceptual Conceptual Conceptual Conceptual Conceptual Conceptual Conceptual Conceptual	Relation Relation Relation Relation Relation Just used Relation Relation Relation Just used Relation Just used Relation Just used Relation Relation Relation Relation Relation Relation	Text Text Text Text Text Text Text Text Text Text Text Text Text Text Text Text Text Text Text Text	Tech.app Tech.app Tech.app Ideal Ideal Tech.app. Tech.app. Tech.app. Tech.app. Tech.app. Tech.app. STS Tech.app. STS Tech.app. Tech.app. Tech.app. STS Tech.app. STS
Batteries are coupled **in series** so the **plus pole** of the first **battery** is connected with **a wire** to **the minus pole** of the second **battery** and then connect to the **lamp**. The **voltage** of **batteries** coupled **in series** is bigger than the **voltage** of one **battery.** The use of **battery** will be longer.	Batteries In series Plus pole Battery Wire Minus pole Battery Lamp Voltage Batteries In series Voltage Battery Battery	Procedural Conceptual Procedural Conceptual Conceptual Procedural Conceptual Conceptual Conceptual Conceptual Conceptual Conceptual Conceptual Conceptual	Relation Relation Relation Relation Relation Relation Relation Relation Relation Relation Relation Relation Relation Relation	Text Text Text Text Text Text Text Text Text Text Text Text Text Text	Tech.app. STS Tech.app. Tech.app. Tech.app. Tech.app. Tech.app. Tech.app. Ideal Tech.app. STS Ideal Tech.app. Tech.app.