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States of matter explanations in Slovenian textbooks for students aged 6 to 14

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The basic aim of this study is to investigate the content of textual and pictorial material of Slovenian science textbooks and notebooks on topic states of matter. The paper presents the results of the analysis of educational material from two randomly selected publishers for students aged 6 to 14 in the Slovenian primary and the lower secondary school. One topic area (states of matter) was selected to be analysed. The first part of the analysis includes exercise and images analysis according to the selected framework, and the second one content analysis identifying key concepts and connections between them according to the national curriculum recommendations. Results show quite a few similarities between the analysed programmes (number of pages, type of items) but some differences could be detected when comparing the type of images in the educational material. The content analysis of the selected textbooks also shows that they retain the content directed by the national curriculum, but the ways (examples, content of the images etc.) in which authors present the topic differ.

Keywords*:* content analysis, science textbooks, states of matter

Introduction

Research in the last 30 years has shown that it is common for students to have misconceptions or other learning difficulties with different science concepts at all levels of education, from primary to university level. Misconception studies in science are a vast area of research, as can be seen at http://www.ipn.uni-kiel.de/aktuell/stcse/, where Reinders Duit collects the bibliography of the field and includes about 8400 entries of references up to March 2009. Students' misconceptions can have different sources (e.g. teachers' inadequate teaching, students' low attention while following the educational process, students' superficial individual learning of the material from personal notes, students' inaccurate reading of the textbooks, and also poorly prepared textbooks by the author(s).

Textbooks and Science Learning

Given the impact of textbooks on learning, because textbooks are one of the primary sources from which students obtain knowledge, the inadequate and inconsistent scientific knowledge presented in science textbooks will negatively affect students' ideas (Irez, 2009). Irez (2009) also argues that uniformed ideas presented in a textbook could affect students' learning in a direct or indirect way. The focus of this paper will be the analysis of the selected textbooks in the light of

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possible misconceptions that can be induced during students' learning process, and the structure and characteristics of text and pictorial elements that are presented in the textbook.

Valverde, Bianchi, Wolfe, Schmidt, and Houang (2002) stated that "Textbooks help define school subjects as students experience them. They represent school disciplines to students" (p.1). Textbooks also facilitate topic selection by teachers and provide an orientation in the way these topics are taught (Martínez-Gracia, Gil-Quílez, & Osada, 2006). Many teachers also rely on the textbook in deciding what and how to teach, especially when they are teaching outside their area of expertise (Stern & Roseman, 2004). Textbook authors have freedom to develop their own approach to the delivery of national curricula and examination specifications, and so textbooks represent a considerable diversity (Martínez-Gracia et al., 2006). Concern has been expressed that information in text books is not always found to be accurate (Clifford, 2002). It is also important to emphasise that teachers, as facilitators of learning, should be aware of the problems and limitations of the text book their students are using (Haggarty & Pepin, 2002).

Science Learning with Textbooks

A cognitive theory of multimedia learning (Mayer, 1997) suggests that in multimedia learning the learner engages in three important cognitive processes. The first cognitive process, selecting, is applied to incoming verbal information to yield a text base and is applied to incoming visual information to yield an image base. The second cognitive process, organizing, is applied to the word base to create a verbally-based model of the to-be-explained system, and is applied to the image base to create a visually-based model of the to-be-explained system. Both processes should be used by the learner when using the textbook. Finally, the third process, integrating, occurs when the learner builds connections between corresponding events (or states or parts) in the verbally-based model and the visually-based model. This theory suggests that it is better to present an explanation in words and pictures together than solely in words. This is also confirmed by different studies (Levie & Lentz, 1982; Vasu & Howe, 1989) that emphasize a combination of both visual and verbal methods as being ideal. Visual-verbal learning allows students to reconcile the two modes and compare carefully the information available in the picture with the explanation in the text (Reid, Briggs, & Beveridge, 1983).

Considerable attention has been devoted to the effect of visual learning on the acquisition of knowledge and the understanding of relationships and processes in science education (Mandl & Levin, 1989). Illustrations are the basis of visual learning in the science classroom and include representations found in typical science textbooks, such as photographs, diagrams, charts, graphs, drawings, and tables (Cook, 2008). In a study of six science textbooks, Mayer (1993) found that 55% of the printed space was accounted for by illustrations. Cook (2008) suggested that because illustrations are a large part of science textbooks, more attention must be focused on understanding the impact visual images have on students and their learning. Ametller and Pinto (2002) summarised that visual presentations play a very important role in the communication of science concepts.

Research also shows (Dimopoulos, Koulaidis, & Sklaveniti, 2003) that images contribute to the higher level of meaning of the text. They also concluded that modern textbooks integrate more images in the text than did textbooks in the past. This indicates the influence of modern technologies that facilitate the application of different visualization materials to present science and technology through media. Visualization material is often a quite transparent and unproblematic method to represent reality and communicate science and technology. On the other hand, Stylianidou, Ormerod and Ogborn (2002) summarised that images could present additional problems for students' understanding the message of the specific topic explained in the textbook, so they emphasise that more attention should be paid to constructing the pictorial representations for textbooks, especially by: (1) mixing the symbolic and real entities in an image (hybrid image), (2) highlighting some elements of the image, (3) encoding different meanings of similar symbols in different ways, (4) constructing and placing of the verbal elements in the image, (5) paying attention to the layout when one image is created by several pictures, and (6) realizing that compositional structures are used to read meaning into images.

However, students also have difficulty in identifying and understanding the concepts that are unique to particular science phenomena. Therefore, pictorial material must include information to elicit students' prior knowledge, and information to foster comprehension of new concepts presented in a textbook. It is also important that the colours used in illustrations be carefully selected, since many students interpret differently the colours representing different features in the picture (Cook, 2008).

Research also shows that around 90% of students learn science using some form of text, but important conclusions are that science texts do not significantly contribute to quality learning in science education (Peacock & Gates, 2000). Science textbooks demand that the learner integrates quite complicated science concepts, together with language abilities (scientific vocabulary and syntax and also capability of reading, writing and oral communicating), visualization materials (different images, symbols, comic-strip style) and format in the science text. They are multi-modal texts made up of different expressive methods (Lemke, 1998). Textbooks also describe links between real world phenomena and scientific theories (Ahtineva, 2005) and determine the content to be taught as well as basic guidelines for teaching procedures. Trends in International Mathematics and Science Study (TIMSS) showed that about 50% of weekly teaching time is used by teachers to teach by textbooks (Wang, 1998).

Curriculum and Textbooks Development

It is also recommended that the learning goals stated in the national curriculum should lead the content analysis of the educational material (Kesidou & Roseman, 2002). Curriculum material research suggests that curriculum development drives the assessment development, and that assessment is designed to align to the actual content included in the learning material. Such a statement could be accepted because a lot of assessment tasks appear tailored to fit incidental details of the learning material rather than some important generalisation of scientific ideas to be remembered by students at the end of a learning process (Stern & Ahlgren, 2002).

A specific challenge for the textbook authors in Slovenia, especially at higher levels of primary school (grade 7 to 9; students aged 12 to 14) and secondary school (grade 1 to 3; students aged 15 to 17), may be posed by introducing explanation of the phenomena at the so called macroscopic level at submicroscopic (particulate or atomic, molecular or ionic) and symbolic (symbols of elements, formulae and chemical equations) level. These topics can now be found in the 8th grade chemistry curriculum (students aged 13), and are not present in earlier grades. Numerous research studies shows that only when adequately merged can these representations help students to develop a conceptual understanding of chemical phenomena (Devetak, 2005; Juriševič, Devetak, Razdevšek-Pučko, & Glažar, 2008).

The chemistry learning model explains the theory, in which all three levels of chemical concepts should be represented by the teacher or educational material using adequate visualization methods and language. This educational process should occur in a social context, where learning takes place. Chemistry learning should be implemented in such a way that complex and abstract chemical concepts can be connected together in the students' learning process to form adequate mental models of these concepts in students' long-term memory. These

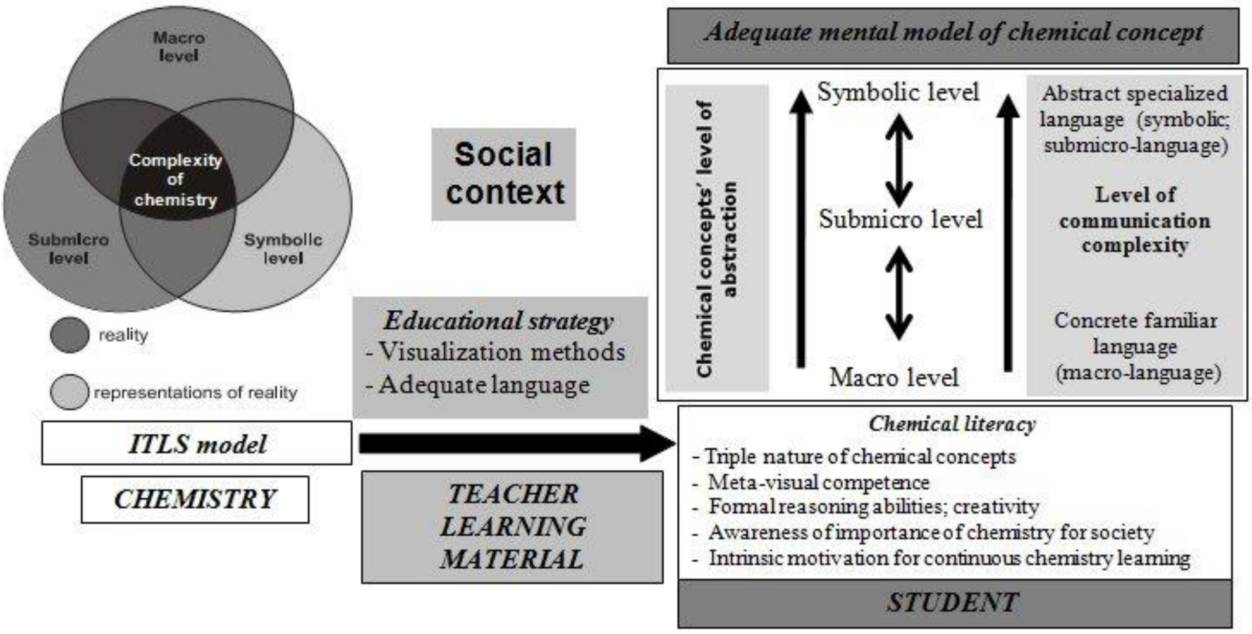

Figure 1. Chemistry learning model (developed from Juriševič et al., 2008; Gilbert & Treagust, 2009)

models should represent the highest level of chemical literacy that a person can develop, and should be defined on different levels as presented in Figure 1.

The analysis of Korean chemistry textbooks' pictorial elements (pictures of macroscopic and submicroscopic level) accompanied by the text explaining the pictures (Han & Roth, 2005) shows that difficulty in understanding the particulate nature of matter may result from the different processes of interpretation and meaning - making between inscriptions depicting the macroscopic and models based on the submicroscopic level.

Teachers and Textbooks

An important aspect is also the teachers' ability to critically analyse curriculum materials, because the teacher should have the authority and resources to select the most appropriate materials and to take the decision about when, where and how to make them useful for his/her teaching (Wang, 1998).

Research shows that students differently recognize the objects depicted in the illustrations presented in textbooks (Constable, Campbell, & Brown, 1988), and that many illustrations in textbooks depicting science processes assume prior knowledge on the part of the student (Cook, 2008). Cook (2008) stated that teachers often anticipate that most students understand the visual images presented in science textbooks, but Billings and Klanderman (2000) pointed out that student misconceptions can be generated in the process of interpreting illustrations, and many stem from the lack of prior experience with the subject in their daily lives (Wu, Krajcik, & Soloway, 2001). Teachers must help students develop the basic skills of visual communication, specifically by teaching them to critically evaluate the form and content of visual communication (Cook, 2008). Students need to be taught how to read illustrations in order to avoid potential causes of confusion (Stylianidou et al., 2002), and teachers need to be aware of students' difficulties when reading images (Ametller & Pinto, 2002).

There are also reports on the tendency towards changing and improving the school science programme on the basis of its analysis. It is also important to emphasise that authors and publishers should take into account, when developing educational material, the science education research results, where prudent suggestions are made for teachers to overcome the students' possible learning problems. To reach this cooperation, new partnerships between the researchers and curriculum developers need to be established so that teachers and students would have access to the best quality textbooks possible.

Purpose of the Study and Research Questions

Students' material should be adequately prepared at the text level and appropriately supported with different images. Author(s) of these educational materials can present the concepts in the form of text or different pictorial elements and can have an influence on developing students' understanding of these concepts. If the material is presented inadequately it can cause the students to develop their mental models incorporating misconceptions. This material is also very important for teachers and they use it for lessons planning. Before using this material for teaching, teachers should critically evaluate it. No attempt has been made in Slovenia to systematically analyse textbooks used by teachers in science education in primary school, therefore this study has focused on the most commonly used textbooks in Slovenian primary schools to fill this gap.

The main aim of this study is to investigate how the concept of states of matter is presented to the 6- to 14-year-old students in Slovenian textbooks and notebooks. Two research questions are: (1) What are the characteristics of the textual and pictorial material in the selected science and chemistry educational material (textbooks and notebooks)?, and (2) What are the characteristics of textual and pictorial material in the selected science and chemistry educational material (textbooks and notebooks) on a topic of states of matter?

Method

Sample of Textbooks

Slovenia has a rather centralised educational system, because there is a national curriculum that all teachers should implement in their classrooms. Pupils enter primary education at age 6 (Grade 1) and finish it by the age of 14 (Grade 9). After primary school they enter different secondary schools that last from 2 to 4 years. In this study we focused only on the textbooks used by teachers to teach science in primary school. Primary education is compulsory for all pupils in Slovenia. Teachers should follow the educational aims that are specified in the curriculum for science subjects. Science is taught as integrated into different subjects at the lower level of primary school, but as separate subjects at higher levels. There are different school subjects at the lower level of primary education, such as: (1) Knowing the Environment - grade 1 (age level 6 years) to 3 (age level 8 years); (2) Science and Technology - grade 4 (age level 9 years) and 5 (age level 10 years); and (3) Science in grade 6 (age level 11 years) and 7 (age level 12 years). At age 13 (grade 8) and 14 (grade 9), students take part in separate science subjects, chemistry, biology and physics.

For each subject textbooks were published by different publishers and different authors. Five major publishers are involved in the textbook development for the primary school in Slovenia. The textbooks comprise the text and pictorial material with more or less additional tasks for students' active learning. The notebooks include additional explanations of the content presented in the textbook, with emphasis on the students' more or less difficult problem solving activities and practical experimental work. The content of all textbooks is shaped by the national curriculum for science subjects (Table 1) and they are certified by the national commission for textbook approval.

The paper presents an analysis of the most commonly used textbooks and notebooks from two Slovenian publishers: Modrijan textbook A (*TA*) and DZS textbook B (*TB*) for students aged 6 to 14. The list of analysed textbooks is shown in Table 2. There are no textbooks listed for the last grade of primary school (Grade 9) because students do not learn about states of matter in grade 9 according to the national curriculum.

None of the publishers had developed a notebook for grade 1, but all active learning activities were incorporated into one textbook for pupils, because at age 6 pupils do not read and they learn by active interaction with the teacher. There was only one chapter analyzed in each textbook. The selected chapter explained the concepts connected with states of matter. The topic was selected because pupils start to learn about different states of matter in grade 1 (age 6) and upgrade the knowledge by more abstract concepts explaining the phase transitions between different states of matter and also explanations of the phenomena at particulate (submicroscopic) level up to the 9th grade (age 13).

Table 1. National science curriculum learning goals.

Grade / pupils' age	**Science national curriculum learning goals**
1 / 6	Substances and objects, liquids, decantation, shaping the bodies by kneading and cutting, weather phenomena.
2 / 7	Substances and their properties; substances in different states of matter (ice, snow, liquid water, steam). Mixing of substances, changing properties of substances, weather phenomena, clouds and wind.
3 /8	Change of matter during heating, air properties.
4 /9	Grained substances as a model for liquids; influence of heat and cold on substance change (melting and decanting of wax and water freezing), atmospheric precipitation, compressing, hardness , density of the substance.
5 / 10	Deposition of liquids, solids and gases; states of water and its properties; condensation and evaporation, processes of water cycle, air and water properties during heating and cooling.
6 /11	Liquid current.
7 /12	Criteria for distinguishing chemical and physical changes.
8 /13	Particles (atom, ion, molecule), arrangement of particles and state of matter.

Table 2. Textbooks analysed in this study

Author(s)	Year of publication	Publisher	Textbook and notebook title / Abbreviation	Grade/ student's age
Bajd, B., Ferbar, J., Krnel, D., Pečar, M.	1999	Modrijan	The environment and me **/ TA** (no separate notebook)	1 / 6
Hrvatin Kralj, D., Strgar, J., Vrščaj, D., Udir, V.	2000	DZS	I observe, I do research and I think / **TB** (no separate notebook)	1 / 6
Antić, M., Bajd, B., Ferbar, J., Krnel, D., Pečar, M., Grgičević, D.	2000	Modrijan	The environment and me 2 **/ TA**	2 / 7
Vrščaj, D., Strgar, J., Hrvatin Kralj, D., Udir, V.	2000	DZS	I observe, I do research and I think 2 / **TB**	2 / 7
Antić, M., Bajd, B., Ferbar, J., Grgičević, D., Krnel, D., Pečar, M.	2001	Modrijan	The environment and me 3 **/ TA**	3 / 8
Vrščaj, D., Strgar, J., Hrvatin Kralj, D., Udir, V., Popit, S.	2001	DZS	I observe, I do research and I think 3 / **TB**	3 / 8
Krnel, D., Bajd, B., Oblak, S., Glažar, S. A., Hostnik, I.	2005	Modrijan	From an ant to the Sun 1 **/ TA**	4 / 9
Skribe-Dimec, D., Gostinčar-Blagotinšek, A., Florjančič, F.	2002	DZS	We do research and we build / **TB**	4 / 9
Krnel, D., Bajd, B., Oblak, S., Glažar, S. A., Hostnik, I.	2006	Modrijan	From an ant to the Sun 2 **/ TA**	5 /10
Skribe-Dimec, D., Gostinčar-Blagotinšek, A., Florjančič, F., Zajc, S.	2003	DZS	We do research and we build 5 / **TB**	5 /10
Krnel, D., Bajd, B., Kordiš, T., Oblak, S.	2005	Modrijan	Science 6 **/ TA**	6 / 11
Glažar, S. A., Kralj, M., Slavinec, M.	2004	DZS	Science for 6th grade of elementary school / **TB**	6 / 11
Bajd, B., Devetak, I., Kralj, M., Oblak, S.	2003	Modrijan	Science 7 **/ TA**	7 / 12
Brancelj, A., Glažar, S. A., Janžekovič, F., Slavinec, M., Svečko, M., Turk, T.	2002	DZS	Science for 7th grade of elementary school / **TB**	7 / 12
Glažar, S. A., Godec, A., Vrtačnik, M., Wissiak Grm, K. S.	2004	Modrijan	My First Chemistry 1 **/ TA**	8 / 13
Gabrič, A., Glažar, S. A., Slatinek-Žigon, M.	2004	DZS	Chemistry Today 1 / **TB**	8 / 13

Data Analysis Framework

The methodology used to analyse the selected textbook is mixed (qualitative and quantitative) in nature. As the main aim of this study is to assess the nature and quality of the textbooks most commonly used in Slovenian primary schools, we expected that the analysis would reveal some characteristics that refer to the text, accompanying pictorial material, students' and teachers' activities, and questions that students have to answer at the end of a specific activity that the curriculum material anticipates.

As for all research, so also for content analysis of textbooks, a set of criteria or frameworks should be followed. Wang (1998) discussed a series of published research studies analysing the instrumentation used in the data gathering process and also evaluated the criteria for selecting the amount of textbook material for analysis and the problems with its reliability.

One topic area (states of matter) was selected to be analyzed. Conceptual or content analysis was performed by identifying key concepts and connections between them according to the national curriculum recommendations – learning goals. This analysis was performed following the central idea of Weber's (1995) content analysis directive: content analysis in classifying words of a text into a smaller number of content categories (cited in Wang, 1998). Students' textbook and notebook criteria for texts and images analysis discussed below were based on the qualitative analysis guidelines (Bogdan & Biklen, 2003; Dimopoulos et al., 2003; Vogrinc, 2005; Carvalho, Silva, & Clément, 2005).

The selected frameworks for analysing the material were: (1) *General information of the textbook and notebook* [Number of pages covering the selected topic], (2) *Textual material* [giving explanations - Yes/No; stimulating discourse - Yes/No; stimulating observations of the phenomena - Yes/No; teachers' demonstrations - Yes/No; giving guidelines for individual students' experimentations - Yes/No; giving instructions for other practical work (i.e. project work, field work …) - Yes/No; emphasizing problem solving strategies - Yes/No, and tasks at the end of the unit - Yes/No; type of items (E – Open-ended; O – Optional), Bloom's cognitive level (K – knowledge; C – comprehension; Ap – application; A – analysis; S – synthesis; E – evaluation)], and (3) *Pictorial material* [*Type I:* (a) Realistic (R) – images that present reality according to the human optical perception (photograph or drawing), (b) Conventional (C) – graphs, diagrams, maps, molecular structures … constructed according to the techno-scientific consensus in the most condensed way, and (c) Hybrids (H) – images that combine the realistic and conventional one (Dimopoulos et al., 2003); *Type II:* (a) Macroscopic (M) image, and (b) Submicroscopic (S) image (Johnstone, 1982) was defined according to the chemistry learning model (see Figure 1). The analysis was performed by two independent researchers, and where the researchers came to different results of the analysis the opinion of the third reviewer was taken into account and all three came to the mutual consensus.

Results

Results of the analysis are presented evenly for both textbooks in tables 3 and 4. Altogether students could read 89 pages of the TA and 78 pages of the TB material analysed: 56% of all TA pages analysed fall into the textbook and 44% into the notebook category. The analysis of the TB revealed that the arrangement of the number of pages in textbooks and notebooks was somewhat different (textbook 53% and notebook 47%). It can be also concluded that textbooks and notebooks for 5th grade (10-year-old students) devote most of their pages (TA: f = 26/21%; TB: f = 28/14%;) to the states of matter. These results correspond to the amount of concepts connected with states of matter regulated by the national curriculum, especially because in grade 5 pupils first learn more in-depth about this topic.

In all analysed textbooks, the authors stress the narrative role of the text, stimulate discourse between the students and the teacher, and between the students themselves, and also stimulate observations of the phenomena linked with the states of matter. They also anticipate students' experimentation, and emphasise problem solving. But only some of the analysed textbooks give guidelines for students' other practical work or anticipate teachers' experiment demonstrations.

According to the proportion of the pages in a specific analysed textbook, for a specific grade, dedicated to the topic analysed, there is also a corresponding number of items or exercises for students to master their knowledge and different pictorial material. The textbooks selected for analysis from two major Slovenian publishers (DZS and Modrijan), with more pages dedicated to the topic states of matter, include also more items for self-evaluating students' knowledge, and exercises and different pictorial material were incorporated into the text.

More than half of the exercises were included in the notebooks (their basic function) in both materials analysed (TA: f = 67/69%; TB: f = 55/58%), but TB included almost 10 % fewer exercises into the notebook than TA. On the other hand, TA did not include any of the items into the textbooks after grade 3 (age 8). Most of the items in the analysed textbooks are open-ended (TA: f = 69/72%; TB: f = 80/84%), where students have to write down an answer, and only 28% of items were optional in TA and even fewer - 16% - in TB, respectively. On average 72% of items presented in the analysed textbooks (TA: f = 68/71%; TB: f = 70/74%) fall into the first three (lower) Bloom's cognitive levels (knowledge, comprehension and application). It is also important to emphasise that on average only 20% of the items (TA: f = 20/21%; TB: f = 18/19%) correspond to the lowest cognitive level – knowledge and most of them, on average 38% assess students' comprehension (TA: f = 35/37%; TB: f = 38/40%). Results also show that, on average only 28% of them (TA: f = 28/29%; TB: f = 25/26%) evaluate students higher cognitive level of states of matter knowledge, but none of the items fall into the highest category of Bloom's taxonomy – evaluation.

It can be concluded from the results presented in table 3 that there are, on average, 252.5 (TA: f = 279; TB: f = 226) different images incorporated into the analysed educational material, this corresponds on average to 3.0 (TA: 3.1 images/page; TB: 2.9 images/page) images per analysed page. Most of the images, on average 73% (TA: f = 197/71%; TB: f = 170/75%), were comprised in the textbooks, and on average only 69 (27%) of images (TA: f = 82/29%; TB: f = 56/25%) in notebooks published by DZS and Modrijan. All analysed pictorial material was classified into two types: type I and II. Images according to type I in the analysed topic mostly (339 images; 67% of all images) fall into the category of realistic ones (photographs or drawings) (TA: f = 185/66%; TB: f = 154/68%). Results also show that on average 81.9% (TA: f = 148/80%; TB: f = 129/84%) of all realistic images were included in the analysed textbooks, compared with the corresponding analysed notebooks. Other types of images were included into the analysed educational material much less often; e.g. 102 (20%) conventional images (TA: f = 64/23%; TB: f = 38/17%) and 61 (13%) hybrid images (TA: f = 27/10%; TB: f = 34/16%). According to the analysis, all images up to grade 8 fall into the category of macroscopic pictorial material (type II). Only in grade 8 (age 13) do students upgrade their knowledge of state of matter also at submicroscopic level, where they learn the particulate level of chemical concepts. Both analysed textbooks explain the world of particles and their arrangement in different states of matter with three drawings. In TA the pictures bind macroscopic and submicroscopic levels of a concrete substance (water) into one entity (Figure 2), but in TB the images separately define the states of unspecific substances (Figure 3). The distances between the particles on both submicrorepresentations of solid and liquid are too large. The image of TB also represents movement of the particles with lines beside a particle (liquid and gaseous state), but in the solid state the same type of lines represents some sort of intraparticle bonds.

The content analysis of the selected textbooks (Table 4) shows, that the textbooks retain the content directed by the national curriculum. The analysed textbooks from both publishers try to explain the concepts in a way that 6-year-olds (Grade 1) could understand, and adequately follow the upgrading of science concepts. By analysing the course of this upgrading, it could be concluded that both learning materials, through text and pictorial material, follow the pupils' mental development, so that teachers could use their abilities efficiently enough. According to the results, the contents of the analysed textbooks fall into the framework of the specific subject, and teachers could use both textbooks to reach the aims that the national curriculum directs.

Discussion

It can be concluded that, in general, the analysed textbooks published by two major Slovenian publishers (DZS and Modrijan) meet the guidelines suggested by the national curriculum (see Table 1 and 4). Conclusions can be made by summarising the results according to the research questions asked in our research.

Research Question 1: What are the characteristics of the textual and pictorial material in the selected science and chemistry educational material (textbooks and notebooks)?

Text and pictorial material in both analysed educational materials is adequate according to the students' level of development. On average the text in both analysed materials tries to stimulate discourse between students and students and teachers, phenomena observation, students' experimentations, and problem solving strategies. Item analysis showed that open-ended tasks at lower (knowledge, comprehension and application) cognitive levels prevail in textbooks and notebooks. The number and quality of different sorts of pictorial material shows that the analysed educational materials are adequately equipped with the number of pictorial explanations of the scientific phenomena, but most pictures fall into the category of realistic photos or drawings. Conventional and hybrid images can be mainly found in textbooks and notebooks dedicated to older students (age 11 and above).

Research Question 2: What are the characteristics of textual and pictorial material in the selected science and chemistry educational material (textbooks and notebooks) on a topic of states of matter?

Analyses of the pictorial material revealed that the analysed educational materials from both Slovenian publishers try to illustrate the states of matter with realistic images at macroscopic level. Students become familiar with the particulate level of states of matter in 8 grade, where submicroscopic representations are introduced, but the macroscopic components of the concepts regarding states of matter are presented in more detail in grade 5 (age 10). These characteristics of the textbooks are also similar to those recommended in the national curriculum for school courses of science and chemistry from grade 1 to 9 (age 6 to 14). The analysed educational material also tries to incorporate such didactical approaches, especially by stimulating group work, through which the social context of learning is expressed and problem solving strategies, which influence the development of responsible citizens equipped with social skills.

Table 3. Results of the compared quantitative analysis of the selected textbooks and notebooks from two publishers.

Categories of the analysis	Textbook A (TA); publisher Modrijan								Textbook B (TB); publisher DZS							
	G1	G2	G3	G4	G5	G6	G7	G8	G1	G2	G3	G4	G5	G6	G7	G8
General																
No. of all pages in textbook	41+	69	77	72	86	96	111	110	53	71	70	103	94	161	145	121
No. of all pages in notebook	47	61	67	56	56	83	90	114		63	79	103	110	80	97	108
No. of analysed pages in textbook	7	6	8	6	14	3	4	2	9	4	4	4	12	2	4	2
No. of analysed pages in notebook	/	7	8	7	12	2	2	1	/	5	2	7	16	2	3	2
Text																
Narrative	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Stimulating discourse	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Stimulating phenomena observation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Anticipates teachers demonstrations	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No	No	Yes	No
Anticipates students experimentation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Guidelines for other practical work	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Emphasises problem solving	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Items, exercise, problems																
No. in textbook	13	7	3	0	0	0	0	0	7	7	13	0	0	1	5	7
No. in notebook	/	14	15	10	20	4	2	2	/	5	2	10	20	6	5	7
Type and No. in textbook *(E – open-ended; O – optional)*	E 8 O 11	E 5 O 2	E 2 O 1	/	/	/	/	/	E 7 O 0	E 7 O 0	E 13 O 0	/	/	E 0 O 1	E 5 O 0	E 7 O 0
Type and No. in notebook *(E – open-ended; O – optional)*	/	E 7 O 7	E 12 O 3	E 10 O 0	E 17 O 3	E 4 O 0	E 2 O 0	E 2 O 0	/	E 2 O 3	E 1 O 1	E 9 O 1	E 15 O 5	E 6 O 0	E 3 O 2	E 5 O 2
Bloom's level and No. in textbook *(K – knowledge; C – comprehension; Ap – application; A – analysis; S – synthesis; E – evaluation)*	K 9 C 6 Ap 2 A 2 S 0 E 0	K 2 C 2 Ap 2 A 1 S 0 E 0	K 0 C 1 Ap 0 A 2 S 0 E 0	/	/	/	/	/	K 1 C 1 Ap 3 A 2 S 0 E 0	K 3 C 2 Ap 1 A 1 S 0 E 0	K 4 C 4 Ap 4 A 0 S 1 E 0	/	/	K 0 C 0 Ap 0 A 0 S 1 E 0	K 0 C 2 Ap 1 A 1 S 1 E 0	K 1 C 4 Ap 0 A 2 S 0 E 0
Bloom's level and No. in notebook *(K – knowledge; C – comprehension; Ap – application; A – analysis; S – synthesis; E – evaluation)*	/	K 3 C 7 Ap 1 A 3	K 2 C 5 Ap 2 A 3	K 1 C 2 Ap 2 A 4	K 2 C 8 Ap 4 A 5	K 1 C 3 Ap 0 A 0	K 0 C 1 Ap 0 A 1	K 0 C 0 Ap 0 A 1	/	K 0 C 2 Ap 3 A 0	K 0 C 0 Ap 0 A 1	K 0 C 4 Ap 1 A 3	K 4 C 10 Ap 1 A 5	K 2 C 4 Ap 0 A 0	K 2 C 1 Ap 0 A 2	K 1 C 4 Ap 0 A 1

Table 3. *Contiuned.*

		S 0 E 0	S 3 E 0	S 1 E 0	S 1 E 0	S 0 E 0	S 0 E 0	S 1 E 0		S 0 E 0	S 1 E 0	S 2 E 0	S 0 E 0	S 0 E 0	S 0 E 0	S 1 E 0
Pictorial material																
No. of images in textbook	30	35	33	20	53	6	14	6	26	23	26	22	48	5	12	8
No. of images in notebook	/	17	17	12	25	6	3	2	/	17	2	4	24	1	2	6
Type I and No. in textbook *(R – Realistic; C – Conventional; H – Hybrids)*	R 26 C 2 H 2	R 29 C 3 H 3	R 26 C 5 H 2	R 19 C 0 H 1	R 34 C 14 H 5	R 3 C 0 H 3	R 12 C 0 H 2	R 2 C 3 H 1	R 6 C 5 H 15	R 23 C 0 H 0	R 26 C 0 H 0	R 21 C 0 H 1	R 36 C 9 H 3	R 4 C 1 H 0	R 9 C 1 H 2	R 4 C 3 H 1
Type I and No. in notebook *(R – Realistic; C – Conventional; H – Hybrids)*	/	R 6 C 10 H 1	R 9 C 8 H 0	R 4 C 7 H 1	R 11 C 9 H 5	R 2 C 3 H 1	R 3 C 0 H 0	R 2 C 0 H 0	/	R 8 C 4 H 5	R 2 C 0 H 0	R 2 C 0 H 2	R 10 C 10 H 4	R 1 C 0 H 0	R 2 C 0 H 0	R 0 C 5 H 1
Type II and No. in textbook *(M – macroscopic; S – submicroscopic)*	M 30	M 35	M 33	M 20	M 53	M 6	M 14	M 3 S 3	M 26	M 23	M 26	M 22	M 48	M 5	M 12	M 5 S 3
Type II and No. in notebook *(M – macroscopic; S – submicroscopic)*	/	M 17	M 17	M 12	M 25	M 6	M 3	M 2	/	M 14	M 2	M 4	M 24	M 1	M 2	M 2 S 4

Table 4. Results of the qualitative content analysis of selected textbooks compared with the national curriculum guidelines

Textbook B (TB); DZS	Textbook A (TA); Modrijan	National curriculum	
Liquids and their properties (mixing and floating), weather phenomena, water changes in winter and in summer.	Substances, liquids, their deposition, and mixing.	Substances and objects, liquids, decantation, shaping the bodies by kneading and cutting, weather phenomena.	Grade 1 (age 6)
States of water; solid and liquid; freezing, mixing of substances, snow, fog, liquid water.	State of matter changes, the same substance can be solid, liquid or gas; ice, water, freezing, solidifying and melting are reversible processes, mixing and separating of substances, weather, clouds and wind.	Substances and their properties; substances in different states of matter (ice, snow, liquid water, steam). mixing of substances, changing properties of substances, weather phenomena, clouds and wind.	Grade 2 (age 7)
Changes of substances on air, light and in water, air properties.	Gas; heating of water turns it into steam (evaporation); on cold surfaces steam changes back to liquid; not all substances change as water does (e.g. sugar), air properties.	Change of matter during heating, .air properties.	Grade 3 (age 8)
Kneading, compressing, hardness, density, states of matter; water and other substances; solids, liquids, and gases, changes of substances during heating and cooling.	States of matter (water and other substances; (solids, liquids, gases); camphor seems to disappear (direct change of state from solid to gas); some substances, after heating can not be changed back to their original form.	Grained substances as a model for liquids; influence of heat and cold on substance change (melting and decanting of wax and water freezing), atmospheric precipitation, compressing, hardness , density of the substance.	Grade 4 (age 9)
Volume of substance, melting, freezing, evaporating, boiling, condensing, water cycle.	Solids, liquids and gases; properties change during decanting, shaping the solids and compressing the gases; condensation and water cycle.	Deposition of liquids, solids and gases; states of water and its properties; condensation and evaporation, processes of water cycle, air and water properties during heating and cooling.	Grade 5 (age 10)
Liquid current.	Currents in nature.	Liquid current.	Grade 6 (age 11)
Substance heating, states of water in nature, and their properties; melting and boiling points, sublimation, chemical and physical change	Substances in the environment and their properties, substance cycles, chemical and physical changes of matter	Criteria for distinguishing chemical and physical changes.	Grade 7 (age 12)
States of matter at submicroscopic level, arrangements of particles (Figure 2).	States of matter on submicroscopic level (water), arrangements of particles, plasma as fourth state of matter (Figure 1).	Particles (atom, ion, molecule), arrangement of particles and state of matter.	Grade 8 (age 13)

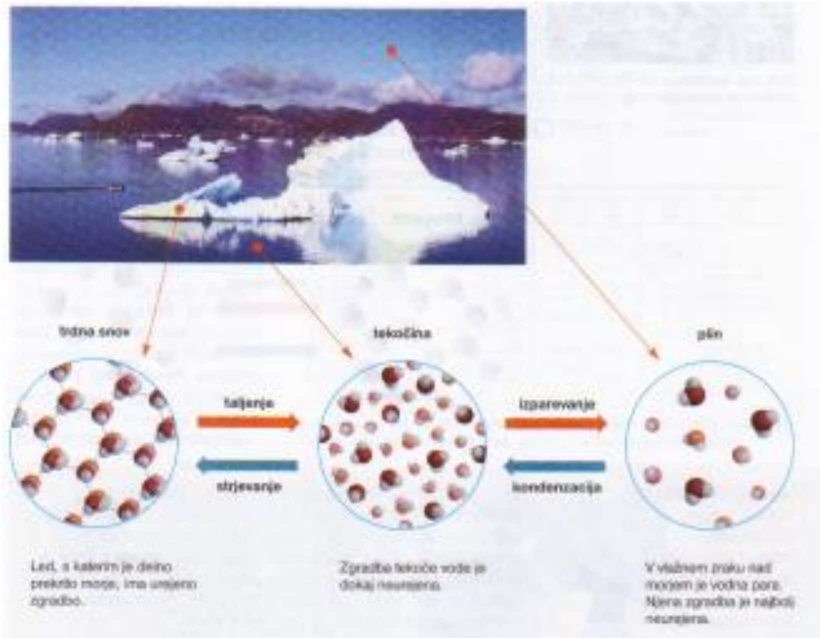

Figure 2. States of matter presented in TA (Gabrič, Glažar, & Slatinek-Žigon, 2004)

Slovenian students show different misconceptions of submicroscopic level of states of matter (Devetak, 2005), and because of this students should have more access to educational material that emphasises the submicro level of thinking. The states of matter topic is an important one to introduce this sort of thinking even at lower levels of elementary education (students aged from 10 and above). The analyses of the selected textbooks and notebooks shows low proportions of these approaches, and teachers using this educational material should additionally introduce the connections between all three levels of chemical concepts (see Figure 1) into their teaching. Taking into account some other research (Bunce & Gabel, 2002; Papageorgioua & Johnson, 2005; Tien, Teichert, & Rickey, 2007; Kelly & Jones, 2008), teachers should apply the submicro level of science concepts to educational strategies even for students aged 10 or 11. According to this, Slovenian educational material ought to introduce the submicro level before grade 8, as can be seen in some foreign textbooks (Hollins, 1998). The authors should be careful about how to explain the macroscopic phenomena at submicro level, because research (Han & Roth, 2005) shows that the difficulties that students experience may also derive from the textbooks' explanations of specific phenomena at macroscopic and submicroscopic level.

Researchers emphasise that all who are involved in textbook analysis should be aware of the difficulties regarding this kind of quantitative and qualitative research. Not only science education researchers, but also textbook authors and teachers who use this material, should be able to analyse textbooks to obtain data for their work. According to these conclusions there is a "pressing need to further provide teachers with proper tools and skills that help them to make decisions" (Wang, 1998, p. 16) as to which textbook to select for their students to use, because "teachers usually select the textbook on the basis of their easily accessible surface features rather than the principles that organise their content and the form of presentation" (Dimopoulos, Koulaidis, & Sklaveniti, 2005, p. 174).

Figure 3. States of matter presented in TB (Gabrič et al., 2004)

Additional research is needed to analyse educational material published by Slovenian publishers according to the specific criteria, indicators and scoring schemes at pictorial and textual level. Students' and teachers' views of the educational material used ought to be gathered using quantitative (questionnaires) or qualitative approaches (semi-structured interviews, direct school practice observations or audio and/or videotaping …). Further research ought also to clarify the situation in Slovenian textbooks from the several points of view, for example: (a) students' prior knowledge, (b) coherent explanations of the real-world phenomena using key science ideas, (c) possibilities for students to develop an understanding of key science concepts through active learning, (d) opportunities for students' self-evaluation of their in-depth understanding of science concepts, and (e) analysis of the pictorial material according to the three levels of chemical concepts (i.e. macro, submicro and symbolic level). Teachers' guides and CD media, including additional material to the published textbooks, that on the basis of ICT technology helps students to deepen their knowledge of the topics introduced in the textbooks, should also be investigated according to similar guidelines. These teachers guides are a very important source for teachers' lessons planning, and because this material is not usually reviewed in Slovenia, special attention should be paid to it. After a careful and systematic analysis of the whole collection (textbook, notebook and teachers' guide) of the educational material used in schools, a complete picture of the material quality used by the in-practice teachers would be established.

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6-14 yaş öğrenciler için Slovenya ders kitaplarındaki maddenin halleri

Bu çalışmanın temel amacı maddenin halleri konusunda Slovenya fen ders kitaplarının metinsel ve resimsel materyalin durumunu incelemektir. Makale Slovenya'daki 6-14 yas öğrencileri için rastgele seçilen iki yayınevinden eğitimsel materyalin analizinin sonuçlarını sunmaktadır. Maddenin halleri konusu analiz için seçilmiştir. Analizin ilk adimi seçilen kavramsal çerçeveye göre alıştırma ve imaj analizini ihtiva etmektedir. İkincisi anahtar kavramları ve ilişkileri analiz etmektedir. Sonuçlar analiz edilen programlar arasında birkaç benzerlikler göstermektedir, fakat eğitimsel materyaldeki imajların tipleri kıyaslandığında bazı farklılıklar tespit edilmiştir. Seçilen ders kitapların analizi ders kitaplarının müfredat tarafından önerilen içeriği bulundurduğunu fakat yazarların konuyu farklı bir biçimde sunduklarını göstermektedir.

Anahtar kelimeler: içerik analizi, ders kitapları, maddenin halleri