A methodological tool for approaching the didactic transposition of the natural sciences in kindergarten school: the case of the "states and properties of matter" in two Greek curricula

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Abstract

The natural sciences teaching objects that are included in curricula do not constitute simplifications of scientific knowledge, but arise as the result of certain "didactic transpositions" that constitute objects of research. In this article we present an approach to Greek kindergarten curricula texts, which was attempted through qualitative text analysis and aimed to define the official teaching proposals regarding the "States and Properties of Matter". The specific teaching object was selected among others as a discipline representative example. We describe the process of text analysis, the categories that emerged, as well as the possibilities of data interpretation offered by the use of a data presentation table, in conjunction with the aims of the study.

Keywords

Didactic transposition, kindergarten curriculum, qualitative text analysis

Résumé

Les objets d'enseignement des sciences naturelles compris dans le curriculum formel ne peuvent pas être considérés comme des simplifications du savoir

scientifique ; ils sont le résultat des transformations didactiques, qui constituent des objets de recherche. Cet article présente une approche des textes officiels de deux curriculums grecs pour l'école maternelle. En adoptant la perspective de l'analyse qualitative du contenu, on essaye de reconstituer le programme officiel concernant «les propriétés et les états de la matière», comme exemple représentatif des objets d'enseignement des sciences naturelles. L'article met l'accent sur la description des procédures d'analyse des textes, la détermination des catégories créées, ainsi que sur les possibilités offertes par un tableau synthétique d'organisation des données en fonction des objectifs de la recherche.

Mots-Clés

Transposition didactique, curriculum de l'enseignement préscolaire, analyse qualitative du texte

Introduction

This article constitutes part of a wider research currently being carried out which uses the theory of *didactic transposition* as its theoretical framework, and studies the way in which preschool teachers approach the curriculum aiming at its implementation in everyday teaching. Restricting the range of research to the level of lesson planning, it was deemed necessary to approach two kinds of data: on the one hand data provided by the official curriculum and, on the other, data concerning the planning of educational activities by preschool teachers. In this article we will exclusively present data emerging from the curriculum analysis.

Following a brief description of the research theoretical framework and the research questions, we will focus our effort on the presentation, application and discussion of an analysis tool which was created as a framework for approaching the contents of the official kindergarten curriculum.

Theoretical Framework

Creating natural sciences curricula for the different educational grades is not the result of simplifying scientific knowledge, but a product of a series of transformations that presuppose the *decontextualisation* of academic knowledge from the conditions within which it was created and its *recontextualisation* according to the terms and restrictions imposed by the educational context (Chevallard, 1991; Johsua & Dupin, 1993; Bernstein, 1996; Koulaidis & Tsatsaroni, 1996; Koliopoulos & Ravanis, 2000).

These modifications, as well as the "distance" which ultimately occurs between

scientific knowledge and school knowledge, were studied by Chevallard (1991) in the Didactic of Mathematics. He proposed the concept of *didactic transposition* as a theoretical tool for modeling these didactic phenomena. The didactic transposition process is developed in two phases: during the first phase, scientific knowledge is transformed into knowledge to be taught (or school knowledge), as it is expressed in the formal curriculum, while during the second phase, the teacher effects new transformations of school knowledge aiming at adapting it to the particular educational context, thus changing the school knowledge contained in the curriculum into taught knowledge (Chevallard, 1991).

The final product of the didactic transformations is very different to the initial scientific knowledge, to the point where the relation between them is merely a reference relationship. The two types of knowledge – scientific and school knowledge – have taken shape within different contexts in order to serve different needs and aims. Certain researchers, in order to emphasise the difference between these two types of knowledge, refer to the context of *school epistemology* that defines school knowledge (Johsua & Dupin, 1993).

The theory of *didactic transposition*, besides being used in the Didactic of Mathematics, was also used as a research framework in the Didactic of Natural Sciences (Johsua & Dupin, 1993; Koliopoulos & Ravanis, 2000), in the Didactic of Language (Bronckart & Plazaola Giger, 1998; Petitjean, 1998) and in the Didactic of Professional Education (Raisky, 1996). Further processing of this theory resulted in the extension of its application frameworks in two directions. On the one hand, towards the widening of the initial reference field so that various other types of knowledge – besides scientific knowledge – would be included and, on the other hand, towards adding a third level of didactic transpositions.

In particular, the recognition that the origins of school knowledge are highly diverse, since the curriculum contains knowledge that is created within different reference fields (Astofli et al., 1997), led Johsua (1996) to propose that the "scientific knowledge" initial reference field should be replaced by the "expert knowledge", and Martinand (1986) to use, for the same reason, the notion of "social reference practices". Thus, the theory of *didactic transposition* can be extended to disciplines other than mathematics, such as experimental, technological, artistic, and expressive disciplines (Colomb, 1999; Develay, 1992). In any event, Johsua (1996) underscores the fact that, in every case, whether a practical or a scientific initial reference field is considered, scientific knowledge occupies a focal point in the process of didactic transposition. Discussing the breadth of the didactic transpositions of knowledge from the initial frame of reference to the final receiver, i.e., the pupil, Develay (1992, 1995) suggests a third level of transposition, in which taught school knowledge is transformed by the children into pupil knowledge.

Thus, the three levels of transpositions to which the researchers refer are schematic representations of a complex educational reality consisting of the modification and recontextualisation of knowledge, with many subjects which, at different times, take on roles of varying significance, and many factors that regulate the entire course of the didactic transposition. To sum up, the theory of *didactic transposition* can function as a framework for the study and analysis of didactic phenomena that concern the modifications of knowledge from the moment it is taken out of the initial frame of its creation until it becomes knowledge acquired by the pupil. The concept of the *level*, which schematises a complex educational reality into particular sections, offers the researcher the possibility of distinguishing different frameworks within the transposition process, and allows the definition of the order of succession of these frameworks as well as the study of the knowledge interpretation attempted by each framework.

Taking into account the series of different frameworks in the transposition chain of school knowledge, we realise that the curriculum, the syllabus, and manuals intended for the pupil and the teacher, are of great importance, since they are the result of the initial process of didactic transpositions. These texts express the official version of school's scientific knowledge, and it is from them that the next phase of didactic transpositions will begin, on the teacher's initiative.

In kindergarten, the lowest grade of education, things become more complex due to the particular characteristics of children's thought. There are no manuals to mediate between the pupil and the teaching object, and as a result this role is undertaken exclusively by the teacher who can use the curriculum and/or a teacher's guide based on the curriculum, as points of reference towards the achievement of the expressed aims.

Kindergarten is the first environment where a systematic effort is made to introduce children into the world of the natural sciences and it marks the beginning of the process of young children's scientific literacy (Dafermou, Koulouri & Mpasagianni, 2006). During the past 20 years, kindergartens in Greece have worked based on two curricula: from 1989 to 2002 the Greek Ministry of Education and the Greek Pedagogical Institute proposed a structured curriculum based on Piaget's theoretical framework; from 2003 to the present, the curriculum implemented is inspired by interdisciplinary pedagogy (see Eurybase – Descriptions of National Education Systems and Policies http://eacea.ec.europa.eu/education/eurydice/eurybase_en).

In both the Piagetian Curriculum (P.C.) of 1989 (Greek Ministry of Education – Greek Pedagogical Institute, 1991) and the Interdisciplinary Curriculum (I.C.) (Greek Ministry of Education – Greek Pedagogical Institute, 2002), clear aims are set, in regard to familiarising the children with the concepts and phenomena of Physics. In this article we will limit ourselves to the first level of the didactic transposition, i.e. the approach

to and analysis of sections of the texts of both curricula which are related to the natural sciences. Thus, we will use units related to the "States and Properties of Matter", as a representative teaching object from the world of Physics.

Methodological Approach

From the two curricula, we approached the text sections in which contents concerning the teaching object of "States and Properties of Matter" are presented, i.e. we analysed official documents that predated the study (Bogdan & Biklen, 2003; Smith, 2000). Aiming to promote the teaching content of the two curricula in terms of the particular teaching object, we analysed the documents focusing on the *literal* meaning of the texts (Mason, 2002), that is, the meanings expressed directly through the texts. Using the *context unit* as our data coding unit, i.e. the part of the text (word, phrase, sentence or sentences) that contribute more completely to making the meaning understood and thus to making more valid coding decisions, (Smith, 2000), we set up categories which characterise the research material.

Definition of the research material

We analysed texts from two manuals of the Interdisciplinary Curriculum (I.C.) currently being implemented: the Cross-Thematic Curriculum Framework for Kindergarten (C.T.C.K.) (Greek Ministry of Education – Greek Pedagogical Institute, 2002) and the Guide for the Kindergarten Teacher (G.K.T.) (Dafermou, Koulouri & Mpasagianni, 2006). We also deemed it important to analyse texts from the Piagetian Curriculum (P.C.), since for over ten years it has been the curriculum of reference for kindergarten teachers and, as such, it exerts an inevitable influence on established perceptions and practices. Therefore, we also analysed the Activities' Manual for Kindergarten (A.M.K.) (Greek Ministry of Education – Greek Pedagogical Institute, 1991) of the P.C., which constituted the only official manual for the kindergarten teacher and which included, besides the analytical texts, the curriculum itself in the form of tables.

In both the I.C. manuals for kindergarten, the broader learning area of the "Study of the Environment" is defined, which includes clear proposals for the familiarisation of the children with concepts and phenomena concerning the world of Physics (Greek Ministry of Education – Greek Pedagogical Institute, 2002). In the P.C. we see similar teaching contents, especially in a section of the 4th Part of the A.M.K. entitled "Children's Education and Mental Development" (Greek Ministry of Education – Greek Pedagogical Institute, 1991). The careful reading of these texts led to the conclusion that the teaching proposals related to the "States and Properties of Matter"

are also included in other parts of the manuals. For this reason, we studied the whole manuals to locate the units that ultimately constituted the texts of analysis. These are presented in Table 1.

Table 1

Textbook units that were analysed

Piagetian Curriculum		Interdisciplinary Curriculum	
A.M.K. - Tables*	**Number of pages**	**C.T.C.K. - Tables***	**Number of pages**
Fourth Part, Education & intellectual development of the child (p. 197-200)	4	Child & Environment: A program for Planning & Developing Activities for the Study of the Environment; Natural Environment & Interaction (p. 22-27)	4
A.M.K. - Texts		**G.K.T. - Texts**	
Fourth Part, Education & intellectual development of the child (p. 195-196 & 201-235)	36	Chapter 10: Study of the Environment: Making the most of the environment & learning about the world (p. 215-288)	73
Methodological Recommendations (p. 307-335)	27	Chapter 11: Creation-expression: encouraging creativity & imagination 11.1 Artistic expression (p. 303)	1
Total number of pages:	**67**	**Total number of pages:**	**78**

* These are particular tables that contain concise proposals for knowledge to be taught, objectives and/or aims, as well as educational activities.

Document analysis

The texts were analysed with the help of the QSR Nvivo 2.0 qualitative data analysis software, which facilitated the organising, storing, reproducing and retrieving of coded data (Welsh, 2002; Roberts & Wilson, 2002). Initially, the selected texts were studied in order to locate references related to the "States and Properties of Matter". In the P.C. as well as in the I.C. we located many such references, which explicitly suggest the teaching of certain concepts and phenomena related to the "States and Properties of Matter", however these units were not explicitly connected to each other. For each curriculum, we created a teaching object category entitled "Matter", in which we included words, phrases or short texts that refer to teaching contents related to the "States and Properties of Matter". We chose the study of units related to the "States

and Properties of Matter" as a representative example of a teaching object from the world of Physics, since it seems, in both curricula, to constitute the most widely referenced teaching object compared to all the other proposed teaching objects from the world of Physics.

Analysis and Data Presentation

The category of the teaching object "Matter", which was initially created, was treated as a data source for further analysis (Mason, 2002) so that we could draw additional information towards two directions: the definition of sub-categories of teaching contents and the highlighting of the teaching methodology guidelines in each case. More precisely, in terms of the contents of the teaching object "Matter", in the P.C. we located 4 recommended teaching units, while in the I.C. we recorded 7. Some of these units are common to both curricula, while others were only located in one curriculum. In Table 2 we present the teaching units located in each curriculum.

Table 2

The contents of the didactic object "Matter" in both curricula

Units of the didactic object "Matter"		**Piagetian Curriculum**	**Interdisciplinary Curriculum**
General didactic unit:	Matter-materials, properties	✔	✔
	Liquids, solids	—	✔
	Mixes	—	✔
Didactic sub-units:	Dissolving	✔	✔
	Permeability	—	✔
	Absorbency	—	✔
	Weight	✔	—
	Flotation	✔	✔

The check mark (✔) is used to indicate the presence of related references, while the dash (—) indicates a lack thereof.

The study of the references classified under the category of the teaching object "Matter" led us to the conclusion that the teaching proposals located in the two curricula provide information which either defines mainly the concepts to be taught or the wider conceptual frameworks, or also includes issues of teaching methodology. Moreover, the texts we analysed, being parts of curricula, were created in order to serve particular teaching functions, are addressed to teachers, and express the meanings they choose, using a special terminology (e.g. objectives, activity) and a

particular phrasing. In our attempt to highlight the didactical meanings of the information transmitted by the texts, we divided the encoded references in two kinds: references of either a *conceptual* or a *methodological* dimension. At the same time, we characterised them as *aims* (*goals* or *objectives*), *activities*, or *other curricular elements*.

In particular, we defined as references of a *conceptual* dimension the ones that define the objects to be taught or particular contents thereof. These references either do not provide any information regarding the teaching management of the learning process, or include methodological information of a general nature. We defined as references of a *methodological* dimension the ones that contain specific proposals regarding teaching approaches, thus providing guidance towards the adoption of certain teaching strategies. Moreover, references located in the texts of analysis, concerning the development of specific scientific competencies, such as *systematic observation*, *descriptions*, *formation of hypothesis*, were also defined as references of a *methodological* dimension, since they directly orientate teachers to adopt analogous teaching strategies. Examples of references of the two dimensions are presented in Table 3.

Table 3

Examples of conceptual and methodological references in both curricula

		References of a *conceptual* dimension	References of a *methodological* dimension
Piagetian Curriculum	**4th Part tables**	"[Getting to know objects – by acting on them – in terms of] […] the make-up of their matter."	"Activities that stimulate the child's perceptive function to make associations between objects which lead to the knowledge of the natural features of objects and […]"
	4th Part texts	"[Getting to know objects] a) In terms of their natural properties."	"By encouraging young children to be curious, to hypothesise and to draw conclusions, we help them to classify their material into objects that sink and objects that float."
Interdisciplinary Curriculum	**C.T.C.K.**	The children are encouraged […] to discover their particular features [of various materials]	"[to observe and describe the changes that occur in certain materials under particular circumstances] (e.g. when they are mixed together)
	G.T.	"The natural properties of water." "Solubility: Water dissolves certain substances but not others."	"To identify the problems which occur during the transportation of liquids." "Put a large pebble and a rubber toy in a basin of water. Do they float or do they sink?"

We have placed in brackets sections of context, i.e. words or phrases that precede or follow the encoded reference, when it is deemed that they contribute to the fuller understanding of the meaning.
Brackets containing three dots indicate that a part of the text has been omitted.

As *goals & objectives* we defined references which in the texts are termed aims, goals or objectives. These are usually expressed as follows: "to … [a verb] … [content to be taught]". We distinguished two types of *aims*: *general* aims and *particular* aims. *General* aims are the ones that refer to the teaching object and/or the teaching methodology in a general way and thus require important decisions to be made by teachers, either in regard to the teaching contents of the intervention, or in regard to the teaching methodology. *Particular* aims are the ones that specifically define both the teaching content of educational activities and the teaching methodology (Cohen, Manion & Morrison, 1998). Examples of general and particular aims are presented in Table 4.

TABLE 4

Examples of general and particular aims from the texts of both curricula

		Piagetian Curriculum	**Interdisciplinary Curriculum**
Aims	***General***	"To get to know objects […] in terms of […] the make-up of their matter"	"To discover basic characteristics surrounding the properties of materials." "To perceive the natural properties of water." "To approach the concept of absorbency."
	Particular		"To observe and describe the changes that occur in certain materials under certain circumstances (e.g. when they're mixed together)." "To find out the problems which occur when liquids are transported."

The term *educational activities* is used to describe references which the texts term as such and/or references that direct the teacher towards adopting specific educational actions in order to teach the object "Matter". There are extensive descriptions of *activities* in which the consecutive stages of realisation are presented, as well as brief proposals.

In the following two excerpts we present examples of extensive descriptions of *activities*, while the third excerpt is an example of a brief proposal of an *educational activity*:

> "On a scale we place two identical glasses containing an equal amount of sand. The two plates of the scale are at the same level. The one glass is as heavy as the other. We then empty the contents of one of the glasses, fill it with leaves or cotton, and ask the children to predict the weight of each glass. Immediately after, the children empirically "weigh" the two glasses (holding one in each hand), they accept or reject their predictions, and find out that the glass we filled with cotton

or leaves is lighter. We then verify their empirical observation with the scale" (Greek Ministry of Education – Greek Pedagogical Institute, 1991, p. 255-256).

"[…] 2. The teacher asks the children to carry water (as above), putting at their disposal a series of vessels to be used: watering cans, bottles, glasses, pots, plates, sieves, ladles, spoons, etc. She then observes and records what they do (for example: Do they choose a particular vessel or do they just pick up the first one they come across? Do they change vessels in order to find one that is more suitable, or do they insist on using the ineffectual vessel with which they happened to start off? Do they use their hands, alone or in collaboration with their classmates, to block whatever holes or leaks their vessels may have? etc.) and what they say (for example: "let's run quickly so the water doesn't pour out", "put your hand there to stop it from pouring out", "we have to walk along slowly", etc.). […]" (Dafermou, Koulouri & Mpasagianni, 2006, p. 232-233).

"Put a large pebble and a rubber toy in a basin of water. Do they float or do they sink?" (Dafermou, Koulouri & Mpasagianni, 2006, p. 228).

Under the category *other curricular elements* we classified references of a *conceptual* or a *methodological* dimension which do not belong to the two previous categories. Such references are, for example, titles, theoretical comments inserted in the text, vocabulary suggested to the teacher, scientific reference knowledge selected for the teacher, clarifications regarding teaching guidelines. Representative examples of references that were termed *other curricular elements* are presented in Table 5.

Table 5

Examples of references that were termed other curricular elements

		Piagetian Curriculum	**Interdisciplinary Curriculum**
References of a *conceptual* dimension	**Titles**	"[1st particular unit: Getting to know objects:] a) In terms of their natural properties"	"B. The different natural states of water" "IV. Water as a solvent"
	Reference knowledge		"Solubility: The water dissolves certain substances but not others"
References of a *methodological* dimension	**Illustration captions**		"Recording of solutions with visible and invisible soluble substances"
	Various explanations, comments & suggestions	[The properties of things] [...] to float or not to float [are conceivable and understood by preschoolers and offer us many opportunities to discuss and discover.]	"[Words that are linked to the topic] [...] waterproof"

After completing the classification process of all the references codified under the category of the teaching object "Matter", we created for each particular teaching unit a table in which we entered the references, presenting, in combination, the didactical meanings as well as data related to the exact location of the references. In Table 6, data related to the teaching sub-unit "Flotation" in the P.C. are presented as an example.

TABLE 6

Example of a combined presentation table of data related to the teaching sub-unit "Flotation" in the P.C.

	Curricular elements	Text units of the A.M.K.			Total references for each curricular element	Total references for each dimension
		4th Part Table	4th Part Texts	Methodol. Proposals		
References of a *conceptual* dimension	*General aims*			*1*, 2**	2	3
	Other curricular elements			*3**	1	
References of a *methodological* dimension	*General aims*					6
	Particular aims					
	Activities	1		*6**	2	
	Other curricular elements		1	*4*, 5*, <u>7*</u>*	4	
	Total references in each text unit of the A.M.K.	1	1	7		9

An asterisk indicates references/sections of a unified text, which describe in detail an educational activity.
Italic numbers mark the code number of each reference, according to the sequence in which it was located in the particular unit of the Activities Manual for the Kindergarten Teacher (A.M.K.).
Underlining indicates references/illustrations.

Table 6 contains data that concerns the number of references of a *conceptual* and/or *methodological* dimension, in relation to the particular curricular elements (*aims, activities, other curricular elements*), as well as the text unit in which the references were located. The presentation of this specific example allows us to see that there is more information of a *methodological* nature (6 references) rather than of a *conceptual* (3 references) and that most relative information comprises parts of the last chapter of the A.M.K. dedicated to general teaching guidelines. Searching for the teaching proposals of the P.C. concerning the phenomenon of flotation in the 4th Part of the A.M.K., where most of the information regarding the teaching approach of concepts and phenomena from the world of Physics is presented, we found only two related references of a *methodological* nature (one in the texts and one in the pivot table), which are fragmentary, since they are not accompanied by *aims* or clarifications of a

conceptual nature. There is more information offered regarding the teaching approach to the phenomenon of flotation in the final chapter of the A.M.K. It concerns both the *conceptual* and the *methodological* dimension of knowledge and it is accompanied by an illustration (see reference 7* in Table 6), but all of it belongs to one continuous text, in which an educational *activity* is presented in detail.

Discussion of the Possibilities Offered by the Analysis Processes and the Combined Presentation Table

The main purpose of our methodological choices was to create a tool for the analysis and presentation of data, which would allow the detailed and systematic description of the teaching information provided by the curricula texts, regarding concepts and phenomena from the world of Physics. The initial establishment of a teaching object category entitled "Matter", comprising all the references related to the "States and Properties of Matter" identified in the texts of both curricula, and the consideration of these references as data for further analysis and processing, brought to the fore a variety of elements that define the officially proposed teaching framework. The combined presentation table (see example in Table 6), which was created as a result of the entire process of analysis, highlights the choices of kindergarten curricula, in terms of the definition of particular knowledge contents to be taught, as well as in relation to the teaching methodology through which it should be approached. But what is most important is that the choices of these two curricula can be studied in the light of the didactic orientation that they will inspire in kindergarten teachers, as they move on to the second level of the didactic transposition.

Moreover, the combined structured presentation of the texts' teaching information facilitates a comparative study, as much as between the different teaching units of the same curricula, as between the teaching units of different curricula.

Besides providing descriptive information concerning the contents of the curriculum's texts, the methodological planning we described allows the use of these data in the next level of the research, where we will attempt to gather data through interviews with teachers and to analyse the teaching choices teachers make as they organise specific teaching interventions. Correlating data found in the curriculum's texts to the teachers' teaching choices will allow us to identify relationships as well as the possible influence of official teaching proposals in the way in which teachers function while planning related teaching interventions, i.e. when they try to transpose the curriculum's official teaching proposals into scheduled teaching actions.

Thus, through the specific approach to the curriculum material which we propose, it is possible to pose and systematically answer questions, such as: Does each curriculum propose corresponding teaching contents for the teaching object "Matter"

and does it define them accordingly? Through what kind of information are the teaching contents of the teaching object "Matter" presented in each curriculum: through general aims, particular aims, activities, or other elements of a conceptual or a methodological dimension? During the process of transposing scientific knowledge to be taught into actual school knowledge, do teachers carry out transpositions relative to those recommended in the curriculum or different ones? In which cases do teachers carry out different transpositions than those officially recommended?

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