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CURRICULUM DEVELOPMENT IN DUTCH PHYSCIS EDUCATION: AN ANALYSIS OF PROJECT INTENTIONS AND OF RENEWAL CHARACTERISTICS IN STUDENT TEXTBOOKS OVER THE PAST 40 YEARS

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Abstract

Dutch upper secondary physics education has been affected by curriculum innovation projects through the years. Commercially published student textbooks have a strong influence on teachers' practices, and therefore play an important role in the implementation of the innovators' intentions in teachers' practices. In this study, intentions of physics curriculum innovation projects during the past 40 years are identified and compared with the content of student textbooks. This enables us to gain a better insight on the effects of former curriculum innovation projects, and in conditions that may increase their effectiveness in influencing those practices. The research design is based on four science educational characteristics: *curriculum emphasis, concept-context approach, concept development approach,* and *scientific skills*. Instruments for the analysing procedure have been developed to identify the presence of the characteristics in curriculum innovation projects documentations as well as the presence in student textbooks. According to the results of this study, the intentions of the *curriculum emphasis* and *concept-context approach* changed to a limit extend throughout the curriculum innovation projects since the 1970s. Intentions of the *concept development approach* differ throughout the years, but the commercial textbooks remain virtually unchanged. Scientific skills receive more attention over the years in both the curriculum innovation projects and student textbooks. Moreover, variations between student textbook series are determined for all characteristics. Authors involvement in curriculum innovation project might influence the designs of student textbooks over the years. The comparisons within this study yield a deeper understanding of the possible contributions of science curriculum innovations on student textbook designs, which provides ingredients for future curriculum developments.

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1 Introduction and problem statement

Visions on science education changes from time to time. In the Netherlands, curriculum development organisations and the national government play an important role in these changing visions and the actual translating of a vision into a curriculum. To achieve the goals of new science curricula, the government invest in the development of science education. One of the major shift in the activities started after the implementation of the educational law in 1968 (Mammoetwet) (Kuiper, 2009; Tessel, 2009). This law gave the opportunity for changing science curriculum standards. Another consequence of the educational law was the implementation of several physics curriculum projects in upper secondary physics education (havo/vwo bovenbouw) over the past 40 years.

There are several activities and approaches within the curriculum development process (Visscher-Voerman & Gustafson, 2004). Thijs and Van den Akker (2009) distinguish five core activities in curriculum development: analysis, design, development, implementation, and evaluation. These activities can take place concurrently, but also may occur in a cyclic way. Curriculum development frequently starts with the initiatives to develop a project (Thijs & Van den Akker, 2009). Thereafter, exemplary curriculum lesson materials may be designed for classroom practices. Analysis and evaluation activities, interwoven with design, development, and implementation activities, are necessary to understand the effects of the curriculum intervention on students, teachers, and schools.

Exemplary textbooks of curriculum innovation projects serve as inspirations for commercial publishers to develop and design student textbooks (Thijs & Van den Akker, 2009). The intentions and evaluations of a curriculum project can provide commercial textbook publishers an understanding of successful approaches to- and effective characteristics of science education. In addition, the intentions can be used as a framework to develop textbooks that meet the core objectives of the project (Thijs & Van den Akker, 2009)

Much effort has recently been placed on research into the effectiveness of curriculum development. Detailed and accurate evaluations can be considered as part of research for curriculum development processes (Tiberghien, Jossem, & Barojas, 1998). These evaluations are essential for the improvement of a curriculum innovation (Kuiper, 2009). Moreover, historical overviews of international science education curricula as well as curriculum innovations in the Netherlands can serve as a solid foundation for further enhancing the current state of education (Atkin & Black, 2003; Kuiper, 2009); these historical overviews enable us to learn from prior successes and failures.

A challenge for curriculum development initiatives is to put intended changes into practice, including effects upon students' achievement. During the development process, an increasing amount of actors become involved: teachers, national exam developers and commercial publishers have their own perspectives on the current curriculum. This is reflected by their practices, such as in their pedagogical skills during a lesson or in their textbook designs. Intentions of curriculum projects have been shown to differ over time, because perspectives change within the development process cycle (Van den Akker, 1998; Kuiper, 2009). In addition, discrepancies occur between how a curriculum was 'intended' to be taught and the actual practice in the classroom (Ogborn, 2002).

For physics education, numerous historical overviews and articles about the Dutch physics curriculum developments for secondary education exist. The publications of Lijnse (2014) and De Vries (2008) show some clear overviews of the physics innovation projects in the Netherlands. However, these and other publications do not give a

clear insight in the ‘what’ (goals and contents) that was initiated by the innovation projects and the ‘what’ that appeared in the physics student textbooks. In fact, there is a lack of understanding with respect to commercial publishers’ positions in physics education developments. They are probably affected by the intentions and evaluations of the innovation projects; this study attempts to shed light on this matter.
The aim of this study is to give an overview of the intentions of physics curricula in the Netherlands and to compare these intentions with published commercial physics student textbooks in the course of the years. This aim is in line with the growing interest in evaluation studies of the Parliamentary commission on education (Dijsselbloem, 2008). This study focuses on an analysis of physics curriculum innovation projects since the start of the Woudschotenconferentie (Woudschoten conference) in 1972. The Woudschotenconferentie is considered to be the first crucial debate of physics education in the Netherlands since the introduction of the Mammoetwet in 1968. In addition, several commercial textbooks were analysed to discover the intentions of the projects in the designs of physics student textbooks.

Student textbooks are useful reference materials, because they provide a coherent set of the best thinking about science and the curriculum (Kesidou & Roseman, 2002). To a large extent, textbooks determine ‘what’ is taught in the classroom as well as ‘how’ this is taught (Tyson, 1997). Teachers continuously use student textbooks and teacher guides to keep themselves informed with the subject- or pedagogical content (Ball & Cohen, 1996). It is still uncertain whether the textbooks fit with the requirements of the national examination programmes or the intentions of the curriculum projects (Van den Akker & Terwel, 2001).

To make a coherent analysis, some pedagogical characteristics were selected. Furthermore, the innovation projects and the textbooks were analysed with respect to having a curriculum emphasis. Roberts (1982) states that “A curriculum emphasis is a message about (rather than within) science behind the scientific concepts”, which can be intended by curriculum developers or textbooks authors”

Research of the curriculum development can reveal the *remains* of formerly intended curriculum innovations. The focus of this study is to analyse the ‘what’ of physics education over the past 40 years. This research could uncover new evidence for do’s and don’ts for future curriculum developments processes. Its results are intended to be used to formulate new design criteria for curriculum development. This leads to the following main research question:

What contributions have physics curriculum innovation projects during the past 40 years in the Netherlands on former and current physics student textbooks for upper secondary education?

To answer the research question following sub-questions are formulated:

- Sub question 1: *Which curriculum emphasis and pedagogical characteristics were intended in the physics curriculum innovation projects during the past 40 years?*

- Sub question 2: *Which curriculum emphasis and pedagogical characteristics can be identified in physics student textbooks of the past 40 years?*

2 Theoretical Background

Curriculum innovations can be analysed and evaluated at several representations. In this section the differences between these representations will be explained to understand the research focus. Furthermore, the theoretical framework will provide a more precise description of the pedagogical characteristics that were used as indicators to analyse the intentions of the curriculum innovation projects and the physics textbooks. For this study, a framework of pedagogical indicators was needed that would help to analyse the intentions of the curriculum innovation projects as well as to keep track of changes in those intentions in the period from 1972 to 2016. Some changing ideas and perspectives of the characteristics over the last decades were taken into account to ensure reliable thoughts on the educational change of physics.

2.1 Curriculum representations

A curriculum can be distinguished in several representations: the intended, the implemented, and the attained curriculum (Van den Akker, 1998). Table 1 provides an overview of these representations.

In general, a curriculum development process starts when people formulate curriculum intentions for a new curriculum. These intentions for an innovative curriculum project can be described as the ideal and formal representations. The ideal representation is the original vision underlying a curriculum innovation. Curriculum developers formulate a project vision and mission which will be published in vision documents, national exam programmes, and policy documents. At the same time, curriculum developers will develop physical products, such as a curriculum framework proposal (e.g. examination program), teaching and learning materials, and examination questions. Ideally, these products are the results of the formulated vision. All the physical products of the innovation can be summarized as the formal representation.

Table 1

Overview of the Curriculum Representations Adapted from Van den Akker (1998)

Curriculum representation		Description
Intended	Ideal	Original vision (vision documents, national exam programme)
	Formal	Physical products of the vision (textbooks, exams)
Implemented	Perceived	Curriculum as perceived by users (teachers)
	Operational	The actual process in the classroom
Attained	Experiential	Learning experience perceived by learners
	Learned	Learning outcomes

In addition, a curriculum has an implemented representation. This representation will be characterized by interpretations of teachers about the innovative project. The implemented representation describes also the actual process outcomes of the project in the classrooms. In other words, this representation illustrates features of the operational curriculum and the curriculum as perceived by their users. So, together they represent what teachers think and do.

A third representation is the attained curriculum representation: the experiences and outcomes of the learners (Thijs & Van den Akker, 2009). In other words, the attained curriculum representation shows the learning experiences and outcomes of students after the project intervention. In fact, the attained curriculum representation describes an evaluation of the innovation project's intentions, especially on the outcomes of the students.

The above constructs can be used to understand this study's focus of curriculum development processes. This study focused on the intended curriculum representations of several physics curriculum innovation projects in the Netherlands. In more detail, the ideal representations of the innovation projects were analysed to understand the intentions of the projects. Moreover, this study was focused on the formal curriculum representations. The student physics textbooks can be assumed as the physical products of the underlying visions of the curriculum innovation projects.

2.2 Curriculum emphasis

Science curriculum innovations are inspired by ideas and theories about how science should be learned. The intentions of 'what' and 'how' to teach science changes from time to time, because of a changing social, economic, and political sense (Atkin & Black, 2003). Historical perspectives of these intentions resulted in the concept of curriculum emphasis: "*a coherent set of messages about (rather than within) science*" (Roberts, 1982). These messages go beyond learning the facts, principles, laws, and theories of the subject matter. It provides students the understanding of 'why' they are learning science. In other words: an emphasis is a message to make science more comprehensible to students. For example, *knowledge and development of science* is one of the seven emphases distinguished by Roberts (1982) and defines the importance of knowledge development in science: it describes how scientists work and it attends to applied skills to become a future scientist.

Furthermore, according to Roberts (1982) there is no correct or true emphasis. All emphases have a shared purpose to make science comprehensible, although they differ in their scope or focus. The seven curriculum emphases of Roberts (1982) can also be combined for practical reasons, Van Driel, Bulte, and Verloop (2008) used all seven in the analysis of chemistry teachers' curricular beliefs. The latter study combined the seven emphases into three curriculum emphases: *fundamental chemistry*, *chemistry technology and society* and *knowledge development in chemistry*.

There are other concepts than curriculum emphasis that propose making sense of science, such as the concept of scientific literacy. Although a definitive definition has not yet been widely accepted, Laugksch (2000) provided a commonly cited definition of scientific literacy as "a set of science content, knowledge elements and attitudes towards science that students should experience and learn". Building upon the framework of Garcia (1985), Chiappetta and Fillman (2007) distinguish four scientific literacy categories to analyse and evaluate science textbooks. These four categories show similarities to the curriculum emphases distinguished by Roberts (1982) and the combined emphases of Van Driel et al. (2008). Both the concepts of scientific literacy and curriculum emphases have been frequently cited in science education analyses and reports (Van der Akker, 1998). Because of the above reasons, this study combines the concept of curriculum emphasis and the concept of scientific literacy as a conceptual category for the analysis instrument.

2.3 Pedagogical characteristics

To understand physics education, several characteristics can be taken into account, such as the physics course content or the pedagogical approaches of teachers. For this study, three 'pedagogical characteristics' were selected because of pragmatic reasons: *concept-context approach, concept development approach,* and *scientific skills*. These characteristics are very useful to determine and distinguish physics education. The following subsection describes the theories behind the selected pedagogical characteristics.

2.3.1 Concept-context approach

The use of contexts in physics education can be powerful to increase students' motivation and content knowledge of the physics domains (Van Weert, 2007). As cited by Van Weert (2007), learning science is only possible by learning about science, by providing context. However, there is limited evidence of the relationship between the use of contexts (in textbooks) and student learning outcomes in physics education (Boersma, Eijkelhof, Van Koten, Siersma, & Van Weert, 2006). Despite this lack of scientific evidence, researchers have proposed that context-based education and the use of contexts in textbooks have positive effects on the comprehensibility of concepts to students (Gilbert, 2006).

The use of contexts in educational practices have been shown to further the interest of students (Bennett, Lubben, & Hogarth, 2006; De Putter-Smits, 2012; Gilbert, 2006). Dutch teachers also experienced the usefulness of context in their classroom practices. They argued that contexts can help to make physics more relevant, but also more attractive to students (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010). The use of contexts and their effects on the cognitive and meta-cognitive development of students does not disappear from attention for further research.

Since the 1950s, attention to science educational research and curriculum development has increased, which has resulted in discussions about the effectiveness of the concept-context approach (Van den Akker, 1998; Kuiper, 2009). The concept-context approach emphasises the interaction between concepts and contexts. In most science education literature, the interaction is formulated as context-based science education (Kuiper, 2009). The definition of context-based science education of Bennett et al. (2006) is one the most accepted formulations in science education: "Context-based approaches are approaches adopted in science teaching where contexts and applications of science are used as the starting point for the development of scientific ideas. This contrasts with more traditional approaches that cover scientific ideas first, before looking at applications" (p. 348).

For this study, the overall idea of the concept-context approach was taken into account. The reason for this is twofold. First, it helps to understand the intentions of the curriculum innovation projects. Furthermore, it can serve as an instrument to analyse physics student textbooks. Bruning and Michels (2013) distinguish the use of context from the position of contexts in science textbooks. Their publication describes several ways of using contexts and different forms of the position of contexts in textbooks. In doing so, it offers an instrument for analysing intentions of innovation projects as well as insights to develop an instrument for analysing student textbooks.

2.3.2 Concept development approach

Learning experiences of students in classrooms will be affected by teachers' pedagogy strategies. There are several strategies or approaches within science education to attain successful learning outcomes of students. Hodson (2014) discusses four categories of learning goals that teachers should take into account for the learning experience: *learning science, learning about science, doing science,* and *learning to address socio-scientific issues*. These overall learning goals show similarities with the previous discussed curriculum emphases. However, teachers' pedagogical skills affect their own learning goals and the learning experiences of students.

There are many educational theories of effective learning that teachers can consult or take into account in their own practices, such as the behaviourism theory, the situated learning theory, and the educational constructivism theory. The educational constructivism theory has offer enormous inspirations in the last decades and on today's science educational practices (Jones & Brader-Araje, 2002). For this reason, it is important to account for this concept in this study.

Since the 1970s, several ideas of constructivism has been developed for the educational context, which were initiated by the personal constructivism ideas of Piaget, the social constructivism ideas of Vygotsky, and the educational constructivism ideas of Mathews (Jones & Brader-Araje, 2002). All ideas and perspectives clarify that students should learn science by active engagement of meaning-making (Jones & Brader-Araje, 2002). More recently, Ogborn (1997) argued that the constructivism approach or concept development for science education has at least four essential characteristics. Students should be actively involved in thinking about knowledge that should be learned, respect for students and their thoughts are necessary, science should be noticed as a result of human development and thinking, and teachers should take students' prior knowledge and misconceptions into consideration when making sense of science (Gilbert, 2006; Ogborn, 1997).

Given the academic attention of educational constructivism or concept development since the 1970s, the theory of concept development approach is used as an indicator to analyse the intentions of former innovation projects in the Netherlands as well as for analysing physics student textbooks.

2.3.3 Scientific skills

Physics student textbook are not only designed to transfer the content knowledge to students. The textbooks are also written in order to help students to learn a wide range of skills, such as communicative skills and problem-solving skills. Today, much attention is given to research and development of the 21st century skills in primary- and secondary education. This is a result of economic and social changes within our society that affect individuals' living environment (Thijs, Fisser, & Van der Hoeven, 2014). These 21st century skills are defined to support students' performances in our future society. An aspect of this citizenship includes some scientific applied skills, for example to educate students for academic careers.

Inquiry-based learning is an approach to stimulate these scientific skills, such as inquiry skills, design skills, modelling skills, and judging skills. All of them are associated to real practices in the science research field. Because of the vastly growing attention for scientific skills in science education, the scientific skills are used as a pedagogical characteristic to analyse the intentions of the curriculum innovation projects and for analysing their appearance in physics student textbooks.

3 Research design

To provide an answer to the research question, four Dutch physics curriculum innovation projects were selected: Project Leerpakket Ontwikkeling Natuurkunde (PLON), Werkgroep Examenprogramma's Natuurkunde (WEN), Stuurgroep profiel 'Tweede Fase' (TF), and Nieuwe Natuurkunde (NiNa) (see Table 2). For the research design, the curriculum emphasis and three pedagogical characteristics, described in the theoretical background, were selected. The curriculum emphasis was distinguished into three emphases. In addition, the pedagogical characteristics are distinguished in the *concept-context approach, concept development approach*, and *scientific skills*. For the analysis of the projects, original projects documentations were analysed and interviews were conducted based on the latter characteristics (see section 3.1). Four textbook series were analysed on the presence of the characteristics. Section 3.2 describes the four characteristics in detail.

3.1 Project analysis

The four most prominent physics curriculum innovation projects over the past 40 years were selected for the analysis. These projects were selected because they played a major role in physics upper secondary education since WO II (De Vries, 2008). All projects have a 'project period' that defines the innovative development activities (e.g. testing pilot exams). Three out of the four projects have also a period with a legal status which indicates their national implementation in physics education (see Table 2).
In more detail, PLON was the first innovative project after the Woudschoten conference of 1972. The project was inspired by physics education innovations in the United States (Boersma et al., 1987). The project focused on changes for the physics content, content structure, and the pedagogy. Afterwards, the WEN was legally defined by the Dutch Ministry of Education. The WEN consisted of a required exam programme for upper secondary education. Another curriculum innovation project within in this study was the TF which changed the entire educational system in the Netherlands. As an example, a major change for the physics subject was the reduction of the amount of lessons (De Vries, 2008). The most recent project is NiNa, which predominantly focused on the basic principles of scientific thinking and methods, and the interaction between the physics content and the society (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010).

Table 2

Overview of the Physics Curriculum Innovation Projects since 1972

Curriculum Project	Abbreviation	Project period	Published advice programme	Legal status period
Project Leerpakket Ontwikkeling Natuurkunde	PLON	1972-1986	1983	x
Werkgroep Examenprogramma's Natuurkunde	WEN	1982-1988	1988	1991-1998
Stuurgroep profiel 'Tweede Fase' – vakontwikkelgroep *Biologie/Natuurkunde/Scheikunde*	TF	1994- 1995	1995	1998-2013
Nieuwe Natuurkunde	NiNa	2005-2010	2010	2013-...

All mentioned projects were analysed on their *ideal curriculum* (see Table 2). Original vision documents, policy documents, consultancy reports, evaluations documents, and national exam programmes of the projects were investigated to identify elements of the four characteristics of curriculum intentions. These elements are described in more detail in the subsequent section (see section 3.2). In addition, the descriptions of each characteristic are written in the developed instruments (see Appendix B to E). Intentions that meet the elements of the four characteristics were collected to understand the *ideal curriculum* of the projects.
Moreover, the project documents were investigated to identify the involvement of textbook authors in the curriculum innovation projects. This analysis contributes to a better insight in the effects of the project intentions on the physics student textbooks.

Furthermore, semi-structured interviews were conducted with two contemporary 'witnesses' (T. Brouwers and B. Snater) involved in one of the curriculum projects to achieve a better insight in the intentions of the projects (see Appendix A for the interview format). More interviews had been planned, but due to this time-consuming activity a *witness meeting* was organised. This meeting was organized to check the right interpretation of the project analysis.
The results of the project analysis were shared with a group of twenty-one contemporary project leaders and educational researchers in physics education. All of them had been involved in one of the physics curriculum innovation projects or physics exam programmes in the Netherlands since the 1970s. During two sessions, the participants discussed the results of the project analysis. They gave their approval and disapproval, and supplementary sources as suggestions for this study. To gather all important information within the discussions, all sessions were recorded with hand-recorders and mobile devices. In addition, three professional independent researchers from the Dutch institute for curriculum development – Stichting Leerplan Ontwikkeling (SLO) - took notes during the sessions.

3.2 Instrument designs and analysis procedures

To understand the contributions of the projects on the content of student physics textbooks, four instruments for analysing student textbooks were developed. The following paragraphs will explain the instrument designs, the analysis procedures, and demonstrate the analysed physics domain and the corresponding student textbooks. Within this thesis a textbook refers to the collection name of the books.

3.2.1 Textbook selection

Four student textbook series for upper secondary education (havo and vwo) were examined in this study: *Interactie-Newton, Scoop-Stevin, Systematische Natuurkunde,* and *Natuurkunde Overal*. *Interactie* was retitled in the 1990s as *Newton,* for this reason these textbooks will be indicated as *Interactie-Newton*. In addition, *Scoop* was retitled as *Stevin* more recently, therefore the textbooks are described as *Scoop-Stevin*. *Interactie-Newton*, *Systematische Natuurkunde,* and *Natuurkunde Overal* were selected because they have a market leader position in Dutch physics secondary education. *Scoop-Stevin* was chosen because this textbook has a long history and is designed by a two-man group as independent authors. All available textbook editions of the past 40 years were collected from the SLO, the Freudenthal Institute, and the library of the University Utrecht. Both the learning and assignment editions were analysed for a complete textbook. In addition, websites of the most recent textbooks were visited for supplementary student sources. The supervisor of this study conducted a reliability check on the analysed textbooks for the presence of the four characteristics.
Table 3 shows the analysed textbook editions in this study. Analysing the complete content of those textbooks was impossible in the available timeframe. The analysis was restricted to the content domain mechanics.

Table 3

Overview of the Selected Physics Textbooks

Published textbook	Educational publisher	Year of edition
Systematische Natuurkunde	Van Walraven	1977, 1978, 1979
	Nijgh*Versluys*	1998
	ThiemeMeulenhoff	2012, 2013, 2014
Interactie-Newton	NIB	1990, 1991
	Thieme	1992, 1993, 1998, 1999, 2000
	ThiemeMeulenhoff	2003, 2004, 2007, 2013, 2015
Scoop-Stevin	Wolters-Noordhoff	1984, 1987, 1990, 1991, 1998, 1999, 2000
	Stevin	2007, 2008, 2014
Natuurkunde Overal	Educaboek	1991
	EPN	2000
	Noordhoff Uitgevers	2012, 2014

Note. Interactie was retitled as Newton. Scoop was retitled as Stevin. The years of editions cover havo or vwo books or both havo and vwo books.

3.2.2 Curriculum emphasis

The seven curriculum emphases formulated by Roberts (1982) and the combined emphases of Van Driel et al. (2008) can be identified in physics student textbooks (Van Berkel, 2005; Roberts, 1988). For this analysis an instrument was designed based on the work of Chiappetta, Fillman, and Sethna (1991). Their original instrument is based on characteristics of the scientific literacy concept. These characteristics show similarities to the curriculum emphases of Van Driel et al. (2008) (see Appendix B). For the analysis of the physics textbooks, these related characteristics were combined to construct a suitable instrument.

The *fundamental chemistry* emphasis of Van Driel et al. (2008) was combined with the *the knowledge of science* category of Chiappetta et al. (1991), because both label the idea of theoretical notions and scientific facts that students should learn. This combined category reflects the transmission of physics knowledge where the students receive information (Chiappetta, Fillman, & Sethna, 1991) and is retitled for this study as the *fundamental laws of physics (FLP)* (see Table 4).

The second curriculum emphasis is defined as *physics, technology and society (PTS)* and is an aggregation of the *chemistry, technology and society* emphasis (Van Driel et al., 2008) and the *interaction of science, technology and society* category (Chiappetta et al., 1991) (see Table 4). *PTS* embed the impact of physics on the society and the interaction between physics, technology, and society (see Appendix B for indicators).

Table 4

Overview of Different Curriculum Emphases

Curriculum Emphases of Roberts (1982)	*Combined Curriculum Emphases of Van Driel et al. (2008)*	*Scientific Literacy Categories of Chiapetta et al. (1991)*	*Curriculum Emphases Categories in this Study*
Solid Foundation Correct Explanation	Fundamental Chemistry	The Knowledge of Science	***Fundamental Laws of Physics (FLP)***
Science, Technology and Society Everyday Applications	Chemistry, Technology and Society	Interaction of Science, Technology and Society	***Physics, Technology and Society (PTS)***
Scientific Skill Development Structure of Science Personal Explanation	Knowledge Development in Chemistry	Science as a Way of Thinking The Investigative Nature of Science	***Knowledge Development in Physics (KDP):*** ***1. How Science Works (hsw)*** ***2. Science in the Making (sm)***

Note. The curriculum emphases in this study are the combination of the distinguished emphases of *Van Driel et al. (2008)* and the scientific literacy categories of *Chiapetta et al. (1991).*

As a third category, *knowledge development in physics (KDP)* is based on the *knowledge development in chemistry* emphasis of Van Driel et al. (2008) that describe student's scientific skills development, attention on the nature of physics knowledge, and how knowledge about physics was developed. The category is divided by the subcategories *how science works* and *science in the making* (see Table 4). *How science works* illustrates scientists' reasoning, thinking, and practices and is referred to as the *science as a way of thinking* category of Chiappetta et al. (1991). An example of this subcategory in a student textbook is a presentation of Newton with a detailed description of his discovery as well as his scientific method and procedure prior to his 'Laws of motion'.
Moreover, the scientific skills development is the main indicator of *science in the making* retitled from the original category of Chiappetta et al. (1991). This category includes criteria to identify whether textbooks present the ability to students to learn and practice the scientific inquiry methods and processes (see Appendix B for detailed indicators)

The analysis was based on a list of descriptors for each category (see Appendix B for details). Scoring schemes of *KDP* and *PTS* includes the distinction of implicit and explicit appearances in textbooks. Implicit presence of the emphasis is an overall appearance of the descriptors that indicate their presence. In other words the emphasis can be implicitly communicated by what is implied or excluded (Roberts, 2007). In contrast with the explicit appearance they show more specific and explicit descriptions of the indicator descriptors. In addition, the category *FLN* was scored when one or more descriptors were found within a chapter or textbook.
Furthermore, the curriculum emphases were also scored by their extent. Textbook chapters were scored with a relative distinction: *presence is weak* and *presence is strong*. This distinction was used to enable differences in attention of the curriculum emphases. When a chapter was scored for a weak presence, the emphasis was presented at a surface level and students would not notice an overarching message of that specific curriculum emphasis. On the other hand, a strong presence of a curriculum emphasis was scored when a complete chapter accentuates the curriculum emphasis and as a student you should recognize the message of the textbook author(s).

3.2.3 Concept-context approach

To understand the presence of different contexts in physics textbooks, the concept-context approach described by Bruning and Michels (2013) was used to analyse the student textbooks. Bruning and Michels (2013) discuss the interaction of concepts and contexts in textbooks and they describe the differences between conceptual or contextual designs of textbooks. Textbooks can be tracked both by a conceptual - and a contextual structure (see Figure 1). In other words, publishers develop textbooks by a choice of content (conceptual structure or context) and by a choice of structure (conceptual or contextual). Bruning and Michels (2013) summarise this as the *position of context*, which is distinguished into four interactions between concepts and contexts: *illustrative context, linking-context, central context* and *context at distance* (see Figure 1).
A book or a chapter with an *illustrative context* has a conceptual structure and the context can be identified as an ad hoc illustration of an earlier addressed concept. A *linking-context* connects several earlier addressed concepts with one overarching context. Only some concepts within the chapter are linked and used in this overarching context. Nevertheless, all concepts within the linking-context constitute a coherent set of concepts of a specific domain, for example concepts from the domain electricity.
Another context position is the *central context* that represents one overarching context embedded in a chapter or a complete textbook. In fact, the central focus of a chapter or whole textbook is context-based and all concepts arise from the context. As a consequence, the chapter or textbook has several concepts from different domains. Finally, the *context at distance* shows a conceptual-based structure with a coherent set

of concepts that are related to a context. A chapter is mostly created by an overarching context with a logical set of concepts from one domain. However, other concepts from other domains can be included that are not linked to the overarching context. Figure 1 shows the concept-context 'window' derived from the publication of Bruning and Michels (2013). This window illustrates the differences between the context positions for the design of student textbooks. All physics textbooks were analysed on the position of context.

The contexts were examined based on three application functions: *context for learning, context for practice*, and *context for testing*. *Context for learning* concerns informative contexts for learning the content of the chapter and the *context for practice* concerns contexts that stimulate students' practices such as questions and scientific skills. Finally, the *context for testing* function concerns contexts for self-testing and attainment purposes.
The details of the analysis instrument and the procedure are described in Appendix C.

Figure 1. Overview Concept-context 'Window' Adapted from Bruning & Michels (2013)

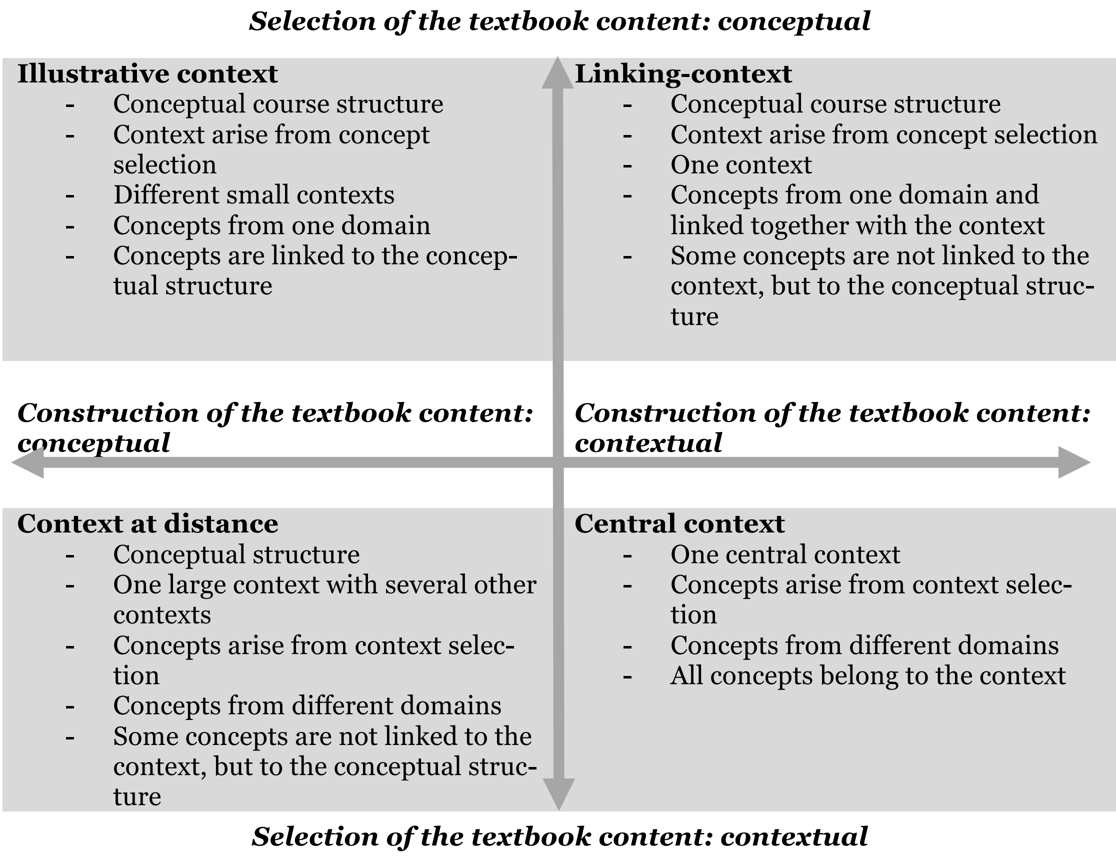

Figure 1. The concept-context window illustrates the differences between the positions of contexts. The position of context arises from both the selection of the textbook content (conceptual or contextual) and the construction of the textbook content (conceptual or contextual).

3.2.4 Concept development approach

To identify the presence of some concept development elements in physics textbooks, an instrument was designed based on a curriculum analysis instrument of Project 2061 (Project 2061, 2002). The original instrument concentrates on the informational-processing perspective of learning, where individual and social aspects of learning meet (Kesidou & Roseman, 2002). In contrast to the instrument of Project 2061, the instrument in this study is not designed to make critical evaluations of textbooks, but only to identify whether textbooks include characteristics of the concept development approach (see Table 5).

Table 5

Overview of the Concept Development Clusters Adapted from Kesidou & Roseman (2002)

Concept development cluster	
I.	Providing a sense of purpose
II.	Taking account of students' ideas
III.	Engaging students with relevant phenomena
IV.	Developing and using scientific ideas
V.	Promoting students thinking about phenomena, experiences and knowledge
VI.	Assessing progress

The concept development instrument contains seven clusters subdivided into two or more characteristics (see Appendix D for details). All clusters embed the concept development approach theory described in the theoretical background of this study. For the analysis, the characteristics of the clusters were scored by a relative degree of presence instead of a wide-ranging quantifying analysis of the concept development expression in textbooks. Therefore, the following indicators were distinguished: *absence, presence is weak*, and *presence is strong*.

These indicators were used as a scoring scheme to measure the degree of presence in the student textbooks. Consequently, the clusters were used as indicators for the project analysis of the curriculum projects intentions. The descriptions of the characteristics and a detailed procedure of the student textbooks analyses are included in Appendix D.

3.2.5 Scientific skills

For the scientific skills analysis, textbooks were analysed on the presence of four skills: *inquiry skills, design skills, modelling skills, and judging skills*. These skills are explicitly mentioned in the Dutch national physics exam programme 2016 domain A5 to A9, because of their importance in science practices (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010).

The inquiry-, design-, and modelling skills can be determined by two presentations: *the cookbook manual presentation* and *the own decision presentation*. If the skills were provided through a following order of fixed steps, then the cookbook manual presentation was scored. All appearances of stimulating students' own creativity and decision making within their use of skills were scored by the own decision presentation (see Appendix E for details).

To make sure that the stimulation of scientific skills usage was identified, the complete textbooks were analysed. It is possible that scientific skills appear in specific chapters other than mechanics chapters. This is why all chapters of the textbooks were inspected.

4 Results

In this section the results of the project analysis are summarized (see Section 4.1.). Thereafter, the results of the student textbook analysis are provided; which report on the presence of the four characteristics in the textbooks (see Section 4.2.). Finally, a comparison between the findings of the project analysis and the student textbook analysis is presented (see Section 4.3).

4.1 Project analysis

For the project analysis a limited number of sources were available to understand the intentions due to a lack of accessible project (vision) documents. Table 6 on page 23 shows the indented curriculum emphasis and the three pedagogical characteristics of the projects together with the corresponding documents. The following subsections describe the intentions of the projects for each characteristic.

4.1.1 Project Leerpakket Ontwikkeling Natuurkunde (PLON)

4.1.1.1 Curriculum emphasis

To make the messages about science comprehensible PLON integrated the curriculum emphases into large contexts. *Fundamental laws of physics (FLP)* was defined as special science that explains the purity of physics as a part of science (Lijnse, 1982, p. 84). The emphasis was also expressed for a context that clarifies the usefulness of physics knowledge for a deeper understanding of inanimate nature and a stronger appreciation of the beauty thereof (Lijnse, 1982, p. 84).
The second emphasis, *physics technology and society (PTS),* shows two intentions. Firstly, students ought to know the importance of technology in their living environment as well as the impact on industry and society (Lijnse, 1982, p. 84). Secondly, students were meant to learn to reflect on the interaction between physics, technology, and society (Lijnse, 1982, p. 85).
Knowledge development in physics (KDP) was expressed as special science to communicate the importance of science research (Lijnse, 1982, p. 84). PLON used the teachers' concerns of physics education that appeared during the Woudschoten conference in 1972 (Hooymayers, 1986, p. 35). Teachers' suggestions of practicals were taken into account by the PLON-group (Hooymayers, 1986, p27, p. 35). The awareness of science research and practicals match the *KDP* emphasis.

4.1.1.2 Concept-context approach

The PLON-group considered contexts as appropriate tools for the understanding of concepts (Van Aalst, 1986, p. 18). Lijnse (1982, p. 84) described several contexts for the understanding of concepts, such as *physics and technology* and *physics and culture*. In addition, PLON created thematic lessons among a central topic, for example *traffic* or *energy and quality* (Eijkelhof, 1986, p. 155, p. 157; Van der Valk, 1986, p. 192). As a first step of the lesson plan development, the PLON-group selected a theme. Thereafter, related concepts were determined to complete the lesson plans (Van der Valk, 1986, p. 193). As a result, PLON intended a context-based approach.

4.1.1.3 Concept development approach

PLON intended almost all clusters of the concept development approach. The *provide a sense of purpose* cluster was aimed by the inclusion of thematic questions and problem statements which ensures the purpose of each lesson (Hooymayers, 1986, p. 34; Van der Valk, 1986, p. 93). The optional elements in the lessons is in line with the *taking account of student ideas* cluster. These options enabled students to master their weaknesses or to broaden their interest (Van Aalst, 1986, p. 20).
Furthermore, practicals are included in their lesson plans to *engage students with relevant phenomena* (cluster III) (Van der Valk, 1986, p. 192). The teacher guides consist of instructions that meet the *developing and using scientific ideas* cluster (Van Aalst, 1986, p. 194). The fifth cluster *promoting students' reflection* was also identified. As

an example, students had to reflect upon their personal situation (Hooymayers, 1986, p. 28). Finally, the cluster *assessing progress* was not identified during the project analysis.

4.1.1.4 Scientific skills

PLON proposed the inquiry skills within the thematic structure of their student textbooks (*Interactie*) to stimulate practicals. These skills were also applied in the basic - and optional sections of the lesson plans (Eijkelhof, 1986, p. 155-156; Van der Valk, 1986, p. 192). Furthermore, judging skills were defined as a general objective: students should learn to reflect upon their personal situation and to reflect upon the world in general (Hooymayers, 1986, p. 28). On the other hand, design- and modelling skills were not described in the reports.

4.1.2 Werkgroep Examenprogramma's Natuurkunde (WEN)

4.1.2.1 Curriculum emphasis

WEN intended the three curriculum emphases as principles for students' knowledge development (WEN, 1988). *FLP* was formulated as an objective for students to understand the physics content, such as laws, concepts, reactions, and models (WEN, 1988, p. 5).

PTS was defined for the understanding of physics knowledge in relation with technical applications, students own environment, the society, and the interaction with other subjects (WEN, 1988, p. 5). Thereby, 'conscious citizenship' was an important element; students should develop a critical attitude towards social problems (WEN, 1988, p. 5). The final emphasis, *KDP,* was described in the WEN advice programme as an essential emphasis. The project reported that students should learn the physics methods and historical - and philosophical aspects of physics (WEN, 1988, p. 5).

4.1.2.2 Concept-context approach

WEN reported a list of concepts with corresponding contexts. (WEN, 1988, p. 18, p. 19). The project distinguished the contexts into *school contexts* and *out of school contexts*. *School contexts* are relevant contexts of experiments, while *out of school contexts* illustrate real-world situations (WEN, 1988, p. 18). Although, according to B. Snater (chairman WEN), the contexts were not required for the physics national exam, but could have been used to support the physics content (personal communication, January 22, 2016).

4.1.2.3 Concept development approach

The project focused on three clusters of the concept development approach. First of all, the *providing a sense of purpose* cluster was illustrated by a concept-context approach to support students' understanding of the physics content (WEN, 1988, p. 18). Secondly, the cluster *engaging students with relevant phenomena* match to the intended practicals which provide experiences with phenomena (WEN, 1988, p. 3-8). Finally, the *developing and using scientific ideas* cluster appeared in the teacher guide. It was expected that teachers would instruct the laws and theories as well as the physics method, historical- and philosophical aspects, and the usefulness of the knowledge in everyday practices (WEN, 1988, p. 5).

4.1.2.4 Scientific skills

WEN introduced inquiry skills as a mandatory element of the school exams (schoolonderzoek). Inquiry skills were defined as fundamental skills for students' own development (WEN, 1988, p. 5, p. 17). In addition, students were supposed to acquire some knowledge on models (WEN, 1988, p. 5, p. 31-32). To achieve this, teachers were required to teach the differences between models and reality (WEN, 1988, p. 7). Moreover, WEN exhibited a focus on the judging skills, such as argumentation skills, reflecting on results, and making well thought decisions (WEN, 1988, p. 17, p. 44).

4.1.3 Stuurgroep 'Tweede Fase' (TF)

4.1.3.1 Curriculum emphasis

The advice exam programme described the intentions of *FLP* implicitly (Stuurgroep Profiel Tweede Fase, 1995). On the other hand, *PTS* was defined by a list of student skills (Stuurgroep Profiel Tweede Fase, 1995, p. 14). As an example, students had to learn the impact of technology in society. The intentions of *KDP* were also expressed in the list (Stuurgroep Profiel Tweede Fase, 1995, p. 14). Knowledge of scientific research was demarcated as an element of *KDP*. Likewise, practicals were cited as relevant activities in the classroom as means to provide an impression of the physics research enterprise (1995, p. 14).

4.1.3.2 Concept-context approach

TF constructed attainment targets for each physics domain to comprise realistic contexts, such as social - and scientific contexts (Stuurgroep Profiel Tweede Fase, 1995, p. 13). These contexts were called context areas; overarching relevant contexts, such as technology and health (Stuurgroep Profiel Tweede Fase, 1995, p. 13). The context areas in the advice exam programme indicates the attention to context-based education.

4.1.3.3 Concept development approach

Limited intentions were identified in the TF documents that meet the concept development approach. TF explained that students should apply their knowledge in several situations (Stuurgroep Profiel Tweede Fase, 1995, p. 10). The previous indicates the presence of the *developing and using scientific ideas* cluster. Indicators of *providing a sense of purpose* were identified by the focus on contexts. However, the TF-group did not define the application functions of contexts.

4.1.3.4 Scientific skills

TF aimed that students should master inquiry skills, such as formulating hypotheses and making observations (Stuurgroep Profiel Tweede Fase, 1995, p. 132-133). Design skills were also defined as relevant elements. For example, students should make and execute their own design (Stuurgroep Profiel Tweede Fase, 1995, p. 132).

Furthermore, modelling skills were not identified in the TF documents. On the contrary, judging skills received a lot of attention in the TF advice programme. These skills were defined by several aims (Stuurgroep Profiel Tweede Fase, 1995, p. 116).

4.1.4 Nieuwe Natuurkunde (NiNa)

4.1.4.1 Curriculum emphasis

NiNa formulated the intentions of *FLP* as features of scientific literacy. For instance, *FLP* will be achieved when students experience the basic principles and concepts of scientific methods and thinking (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010, p. 45). In addition, students ought to know the fundamental principles and laws of physics (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010, p. 33).

Furthermore, *PTS* was illustrated as an important element of the physics course (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010, p. 45). For instance, the project enhanced recommendations of *PTS* elements for the development of lesson materials (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010, p. 11).

NiNa designated the importance of *KDP* to learn scientific methods (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010, p. 45). Objectives were formulated for students' practicing and experiencing physics. These aims had to be achieved by applying scientific skills (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010, p. 23, p. 24, p. 27, p. 29, p. 30, p. 33).

4.1.4.2 Concept-context approach

Context-based education played a significant role in the advice programme (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010, p. 83). The concept-context approach was included in the programme to inform the educational sector. As an example, NiNa advised authors to develop student textbooks with overarching contexts (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010, p. 12). These contexts should present realistic views of the physics enterprise, physics in society, and physics for further career perspectives (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010, p. 12). Exemplary contexts in the advice programme were proposed for teachers' pedagogical approaches, for example to motivate students. (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010, p. 76).

4.1.4.3 Concept development approach

Almost all clusters of the concept development approach were identified during the analysis. The *providing a sense of purpose* cluster was represented within contexts. These contexts were meant to motivate students and to arouse their interests (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010, p. 75). In addition, the exemplary curriculum materials paid attention to *taking account of student's ideas*. The required inquiry - and design skills cover the *engaging students with relevant phenomena* cluster (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010, p. 23-30). Furthermore, the fourth cluster *developing and using scientific ideas* was identified as an aim for students to recall concepts (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010, p. 33). The *Promoting students reflection* cluster was taken into account by the focus on judging skills (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010, p. 33). Finally, the *assessing progress* clusters did not appear in the documentation of the project.

4.1.4.4 Scientific skills

NiNa recommended schools to examine students' scientific skills within the school exams (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010, p. 29, p. 30). In general, the project aimed to stimulate experiments for upper secondary education.

Table 6

Overview of the Intentions of the Curriculum Innovation Projects with the Corresponding Project Documents

	Curriculum innovation project			
	PLON	**WEN**	**TF**	**NiNa**
Project period	1972 - 1986	1982-1988	1994-1995	2005-2010
Legal status period	x	1991-1998	1998-2013	2013-...
Characteristic				
Curriculum emphasis	*FLP* *PTS* *KDP*	*FLP* *PTS* *KDP*	*FLP* *PTS* *KDP*	*FLP* *PTS* *KDP*
Concept-context	*Themes*	*Context terms (contextbegrippen)*	*Context (scientific and societal)*	*Context areas (contextgebieden) and contexts*
Concept development	• *Providing a sense of purpose* • *Taking account of students' ideas* • *Engaging students with phenomena* • *Developing and using scientific ideas* • *Promoting student reflection*	• *Providing a sense of purpose* • *Engaging students with phenomena* • *Developing and using scientific ideas*	• *Developing and using scientific ideas*	• *Providing a sense of purpose* • *Taking account of student's ideas* • *Engaging students with phenomena* • *Developing and using scientific ideas* • *Promoting student reflection*
Scientific skills	• *Inquiry skills* • *Judging skills*	• *Inquiry skills* • *Modelling skills* • *Judging skills*	• *Inquiry skills* • *Design skills* • *Judging skills*	• *Inquiry skills* • *Design skills* • *Modelling skills* • *Judging skills*

Project	***Documents that describe the intentions***
PLON	- Van Aalst, H.F. (1986) *Waar doen we het eigenlijk voor?* - PLON (1983) *Een voorstel voor een experimenteel PLON-Examen Programma voor havo.* - Van der Valk, A.E. (1986) *Regels en instrumenten voor thema-ontwikkeling.* - Eijkelhof, H.M.C. (1986) *Van losse thema's tot een samenhangend curriculum: de revisie van het PLON-havo-bovenbouwproject.* - Lijnse, P. (1982). Blikken naar een nieuwe cursus. In F. Gravenberch, *Konferentie HAVO-bovenbouw* (pp. 81-106). Utrecht: PLON-archief. - Hooymayers, H.P. (1986) *Verwachtingen van leraren en PLON-opbrengsten – (een innovatieve evaluatieve bezinning).*
WEN	- WEN (1988) *Examenprogramma natuurkunde VWO en HAVO*
TF	- Stuurgroep Profiel Tweede Fase (1995). *Advies Examenprogramma's havo en vwo. Biologie, Natuurkunde, Scheikunde.* Enschede: SLO.
NiNa	- Commissie Vernieuwing Natuurkundeonderwijs havo/vwo (2010). *Nieuwe natuurkunde, advies-examenprogramma's voor havo en vwo.* Amsterdam: Nederlandse Natuurkundige Vereniging.

Note. PLON= Project Leerpakket Ontwikkeling Natuurkunde, WEN= Werkgroep Examenprogramma's Natuurkunde, TF= Tweede Fase (vakontwikkelgroep natuurkunde), NiNa= Nieuwe Natuurkunde. FLP = Fundamental laws of physics, PTS = Physics, technology and society, KDP= Knowledge development in physics.
All characteristics are described in the above project documents.

4.2 Student textbook analysis

This section presents the results of the student textbook analysis on the four analysed characteristics: *curriculum emphasis, concept-context approach, concept development approach* and *scientific skills*. Assignment- and learning books were analysed as one unique book. Separate physics books that cover a unique edition are accounted for one complete textbook. For example, *Newton 4 vwo learning book* and *Newton 4 vwo assignment book,* and *Newton learning book 5 vwo* are approached as one and the same textbook. Average mechanics chapters scores were determined for all complete textbooks. Finally, the textbooks were distinguished for their educational level: havo or vwo.

4.2.1 Curriculum emphasis

All student textbooks included the element of *fundamental laws of physics (FLP)* as well as *knowledge development in physics – science in the making (KDP-sm)*. For example, *FLP* was present as well-described theories and fundamental laws; *KDP-sm* by tasks that included calculations or the use of charts.

Physics, technology and society (PTS) had a strong implicit presence in approximately all *Interactie-Newton* and *Scoop-Stevin* textbooks (see Figure 2). For instance, *Newton* contained a lot of social issues together with physics concepts, for example in the chapter's *fuel use* and *energy supply*. The earliest and most recent *Systematische Natuurkunde* books had a weak implicit extent for *PTS*. All other textbooks presented a strong implicit message of *PTS*. The *Natuurkunde Overal* textbooks demonstrated several fluctuations of the *PTS* presence during their existence.

Since the 1990s, explicit descriptions of *knowledge, development in physics – how science works (KDP-hsw)* were implemented in *Interactie-Newton*. Over the years, the presence altered among a weak and strong extent (see Figure 3). *Natuurkunde Overal* showed a strong explicit extent of the emphasis. *Systematische Natuurkunde* continuously changed in its focus on *KDP-hsw* until 1998. Ever since 1998, the textbooks exhibit explicit *KDP-hsw* at a weak level. In contrast, all *Scoop-Stevin* books paid attention to *KDP* more implicitly.

Finally, no major differences of the curriculum emphases were identified between the havo and vwo editions of the analysed textbook series.

Figure 2. *Overview of the Curriculum Emphasis 'Physics Technology and Society' in Student Textbooks*

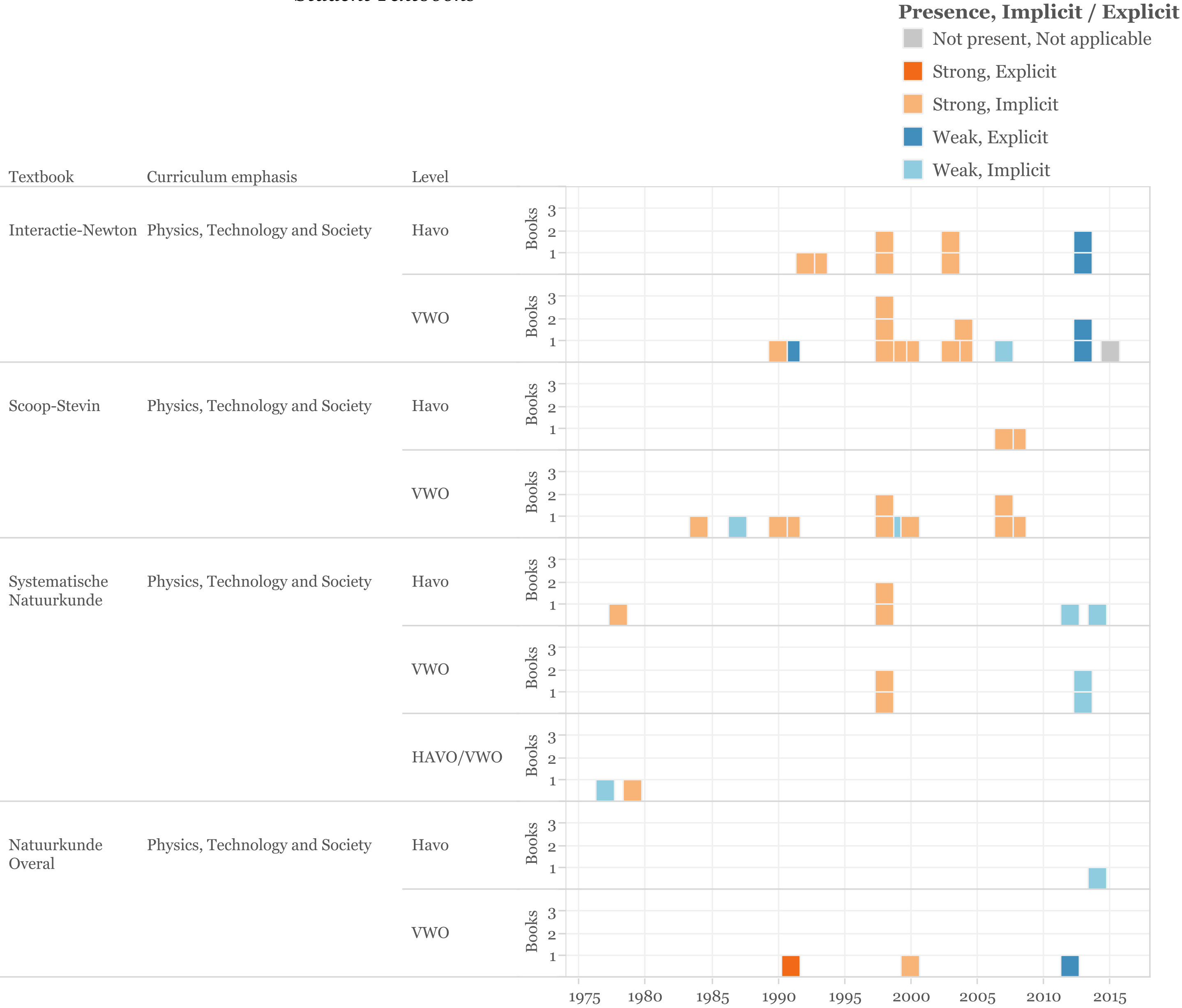

Figure 2. The diagrams illustrate the extent of the curriculum emphasis *physics, technology and society* in the havo, vwo, and havo/vwo textbooks of Interactie-Newton, Scoop-Stevin, Systematische Natuurkunde, and Natuurkunde Overal. Coloured markers indicate the extent of presence. Several markers in one year illustrate the amount of books within a complete published edition.

Figure 3. *Overview of Curriculum Emphasis 'Knowledge Development in Physics – How Science Works' in Student Textbooks*

Figure 3. The diagrams illustrate the extent of the curriculum emphasis *knowledge development in physics – how science works* in the havo, vwo, and havo/vwo textbooks of Interactie-Newton, Scoop-Stevin, Systematische Natuurkunde, and Natuurkunde Overal. Coloured markers indicate the extent of presence. Several markers in one year illustrate the amount of books within a complete published edition.

4.2.2 Concept-context approach

All student textbooks in this study showed illustrative contexts, identified as small contexts that exemplified physics concepts or examples in a task. Only *Interactie* presented central contexts in both havo and vwo textbooks, for example the chapter *Energy supply*. This chapter illustrated several energy sources for human consumption together with concepts from different physics domains, such as electricity and mechanics. The authors of the first *Newton* editions changed the context position compared to *Interactie*. They included linking-contexts in all *Newton* editions. The chapters, for example 'traffic' or 'sports', showed an overarching context with concepts from the domain mechanics.

The exploration of the context application functions did not show any differences between the textbooks; all textbooks comprise *context for learning, context for practice,* and *context for testing*.

4.2.3 Concept development approach

The following subsection will describe the identified presence of the concept development approach for each student textbook. To understand the results of the presence of the several clusters, scorings markers of the characteristics within a cluster were combined (see Appendix D for the characteristics of the clusters).

4.2.3.1 Interactie-Newton

The *providing sense of purpose* cluster was present in all *Interactie-Newton* books with the largest extent in the most recent textbooks (see Figure 4) The second cluster, *taking account of student ideas* appeared since 1998. The havo and vwo textbooks differed from each-other; vwo textbooks showed a stronger presence throughout the years. Another difference between havo and vwo appeared among the *engaging students with relevant phenomena* category. The havo editions showed a strong presence in the earliest and most recent textbooks. In contrast, the vwo books had a strong presence in their latest editions.

Both havo and vwo books took the elements of *developing and using scientific ideas* cluster into account in a strong manner. Within the textbook series the presence of *promote students thinking about phenomena, experiences and knowledge* cluster changed over the years. The *Interactie* books exhibited a stronger appearance of this cluster compared to the subsequent textbooks. With the exception of the 2013 release of the *Newton* book which showed the appearance of this cluster to be strong again.

ICT contributed to the efforts constructive to the concept development approach. The most recent *Newton* textbooks showed opportunities for students in order to assess their progress (cluster IV) by making several tests on the website.

4.2.3.2 Scoop-Stevin

The textbooks of *Scoop-Stevin* did not encompass the *providing a sense of purpose* cluster. In addition, indicators of *taking account of student ideas* were identified and showed some changes in extent throughout the years (see Figure 4). On the other hand, the third cluster *engaging students with relevant phenomena*, was present on an average level in all textbooks.

Furthermore, *Scoop-Stevin* paid more attention to the *developing and using of scientific ideas* cluster. As an example, the editions of 2007/2008 showed the largest extent due to the available tasks on their website. An increasing extent of cluster V (*to promote students thinking about phenomena, experiences and knowledge*) was identified over the years. Finally, the *assessing progress* cluster was present in all textbooks due to the self testing assignments.

4.2.3.3 Systematische Natuurkunde

Throughout the years, *Systematische Natuurkunde* included the *providing a sense of purpose* – and *taking account of students' ideas* cluster on a minimum level (see Figure 5). In contrast, *engaging students with relevant phenomena* was demonstrated at an average level. The 1998 textbooks started with the inclusion of three other concept development clusters. Since then, *developing and using of scientific ideas* appeared. Elements of the clusters *promote students thinking* and *assessing progress* were barely offered in the 1998 editions. During the textbook analysis, limited differences were determined between the havo and vwo textbooks for the concept development approach.

4.2.3.4 Natuurkunde Overal

Natuurkunde Overal did not exhibited major differences with respect to the concept development approach (see Figure 5). Though there were some variations among the textbooks over the years, the overall attention for the concept development remained the same. The *assessing progress* cluster showed a strong presence in the most recent books in comparison with former textbooks. Due to a lack of havo editions, comparisons between the havo and vwo textbooks were not possible.

Figure 4. *Overview Concept Development Clusters in Interactie-Newton* and *Scoop-Stevin*

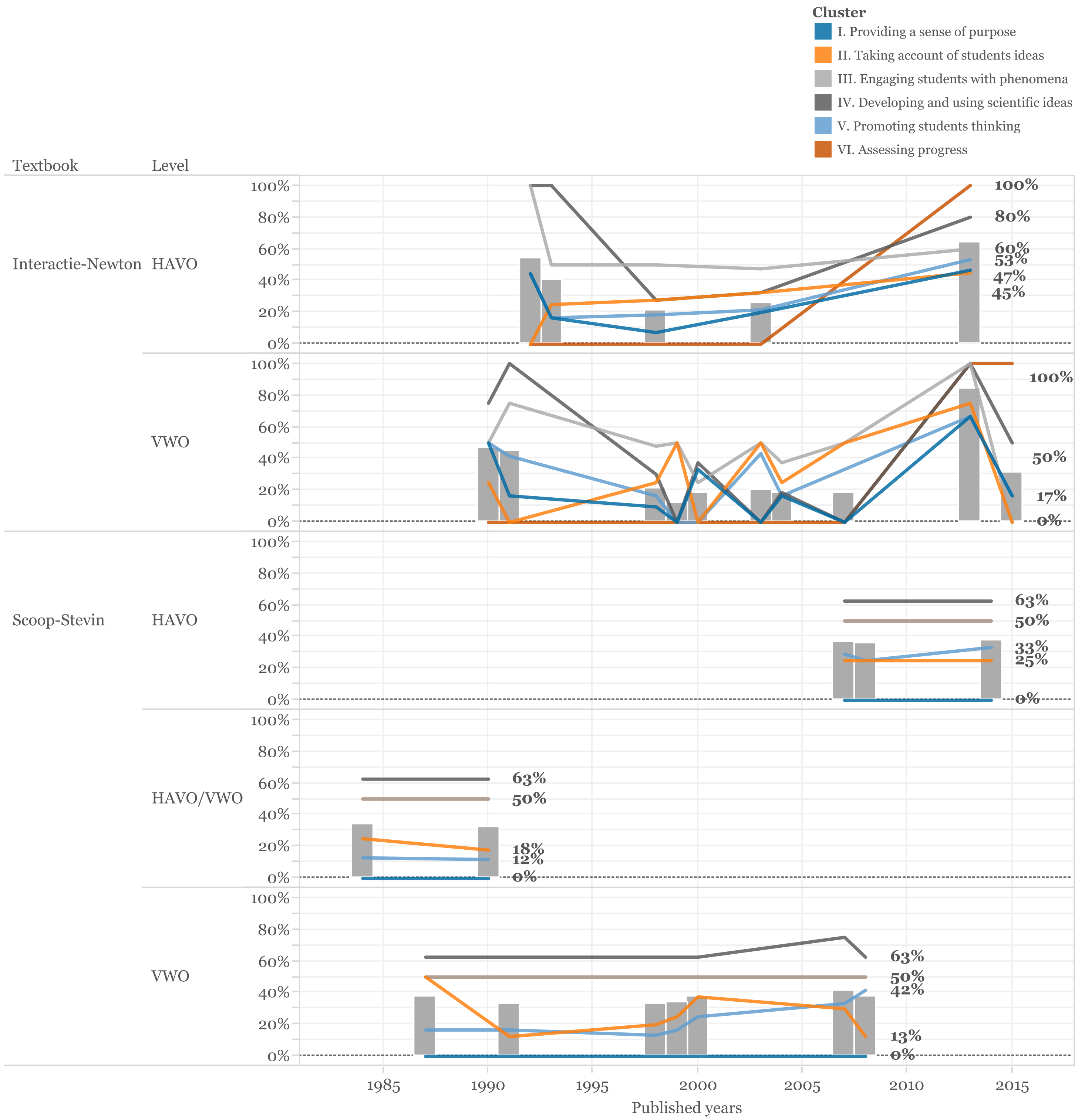

Figure 4. Grey markers show the average presence of the clusters (the coloured lines) for a complete textbook (learning book and assignment book). Percentages illustrate the score (presence) of the maximum achievable score of the clusters. The percentages are measured by a total score of all characteristics of a cluster in all analysed mechanics chapters for both the learning - and assignment books in a particular year.

Figure 5. *Overview Concept Development Clusters Measures in Systematische Natuurkunde* and *Natuurkunde Overal*

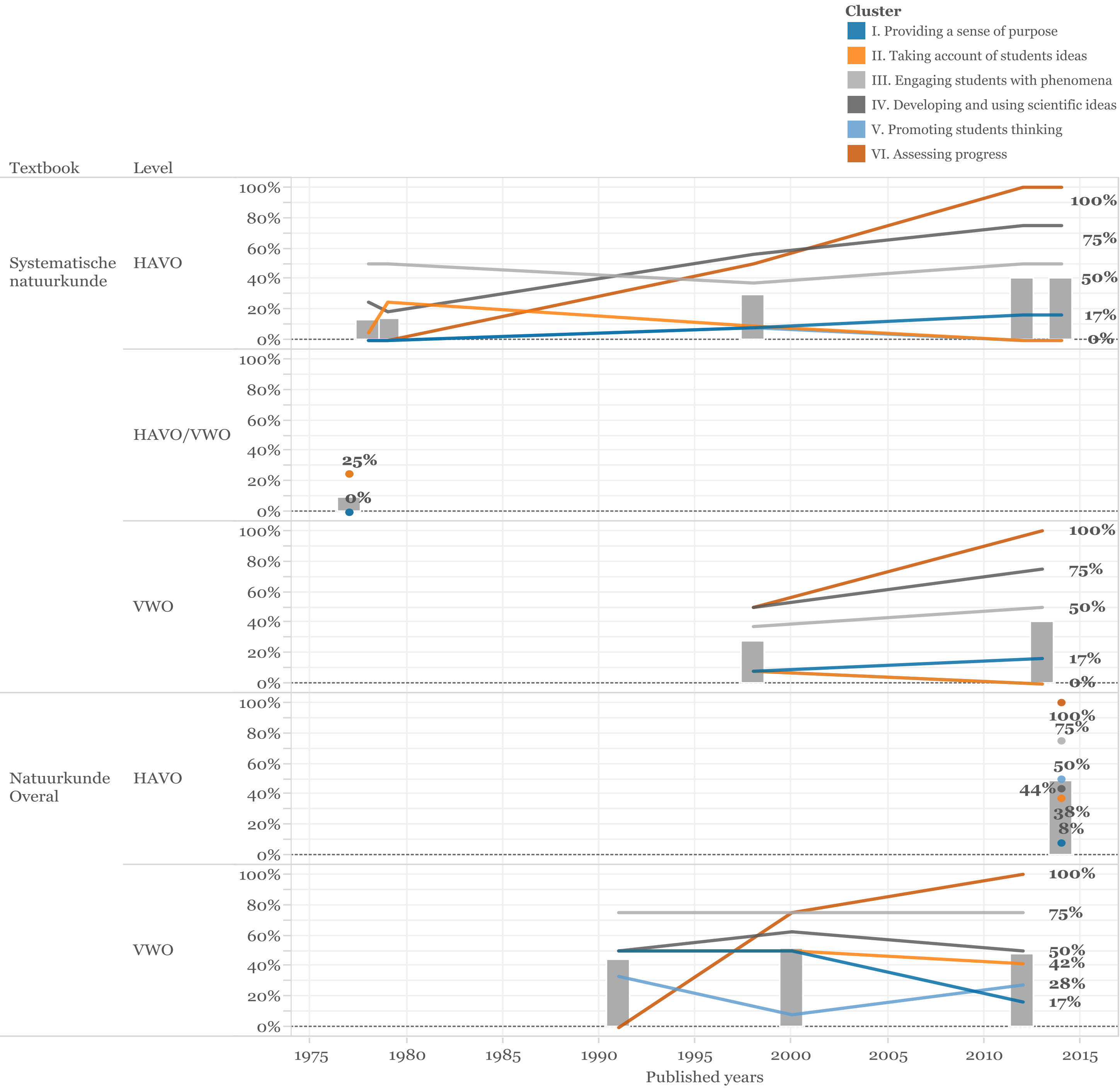

Figure 5. Grey markers show the average presence of the clusters (the coloured lines) for a complete textbook (learning book and assignment book). Percentages illustrate the score (presence) of the maximum achievable score of the clusters. The percentages are measured by a total score of all characteristics of a cluster in all analysed mechanics chapters for both the learning - and assignment books in a particular year.

4.2.4 Scientific skills

The following subsection demonstrates the results of the scientific skills in student textbooks. Table 7 shows the results with the distinction in identification: *own decision presentation* and *cookbook presentation*. The outcomes of *Natuurkunde Overal* and *Scoop-Stevin* havo will not be discussed due to lack of suitable results.

Interactie-Newton contained *own decision* presentations for practicing inquiry skills in all havo and vwo textbooks. Design skills were only exhibited in the havo books. In addition, the vwo books contained design skills in the exemplars of 1998 and 2013. Another difference between havo and vwo was exhibited to the modelling skills in *Interactie*. The havo textbooks consisted of *cookbook* presentations while the vwo books presented the *own decision* method. Both *Interactie* and *Newton* provided student tasks to improve students' judging skills.
The *Scoop-Stevin* vwo books contained inquiry based skills as *cookbook* presentations. These textbooks contained some tasks that stimulated students' inquiry skills. A few *Scoop-Stevin* textbooks showed *cookbook* presentations for practicing design – and modelling skills. Moreover, judging skills were identified in two student textbooks.
Since 2012, *Systematische Natuurkunde* stimulated the inquiry- and design skills by posting experiment assignments on their website. Differences among the presentation style were found: inquiry skills were presented by *cookbook* presentations and design skills by *own decision* approaches. Finally, there are limited indications of stimulating modelling skills in the 1998 vwo books.

Table 7

Overview of the Scientific Skills Presence in the Student Textbooks

	Interactie-Newton		Systematische Natuurkunde		Scoop-Stevin
Level	Havo	Vwo	Havo	Vwo	Vwo
Edition	1992 1998 2003 2012	1990 1998 2003 2012	1977 1978 1979 1998 2012	1977 1979 1998 2012	1987 1990 1998 2007
Inquiry skills	All editions - *Own*	All editions - *Own*	In 2012 - *Cook*	In 2012 - *Cook*	All editions - *Cook*
Design skills	All editions - *Own*	Since 1998 - *Own*	In 2012 - *Own*		In 1990, 1998 - *Cook*
Modelling skills	In 1992 - *Cook* In 2012 – *Own*	In 1990 - *Own* In 2012 - *Own*	In 1998 - *Own*		In 1998 - *Cook*
Judging skills	All editions	All editions	In 1978		In 1987, 1990

Note. Cook= Cookbook method presentation, Own= Own decision presentations. All editions= skills are present in all analysed years editions.

4.3 Comparison between intentions and student textbook designs

First of all, a description of the 'how' aspect will be addressed. This aspect explains the possible effects of the intentions on the analysed textbooks (see Section 4.3.1). Thereafter, comparison between the projects intentions and the analysed textbook characteristics will be provided. In other words, the results of the project– and textbook analysis serves for 'what' was intended and 'what' was included in the student textbooks. (see Section 4.3.2 - 4.3.5).

4.3.1 Personal links to project and textbooks

To understand the personal links of textbook authors with the curriculum innovation projects, the projects documents were analysed to identify authors' contributions in the periods of time. Table 8 shows the period of the project activities and the legal status periods.

Table 8

Overview of the Physics Curriculum Innovation Projects since 1972

Curriculum Project	Abbreviation	Project period	Published advice programme	Legally status periods
Project Leerpakket Ontwikkeling Natuurkunde	PLON	1972-1986	1983	x
Werkgroep Examenprogramma's Natuurkunde	WEN	1982-1988	1988	1991-1998
Stuurgroep profiel 'Tweede Fase' – vakontwikkelgroep *Biologie/Natuurkunde/Scheikunde*	TF	1994- 1995	1995	1998-2013
Nieuwe Natuurkunde	NiNa	2005-2010	2010	2013-..

PLON started in 1972 by a three-man group and grew into a professional curriculum project (Lijnse, 2014). As a result of the PLON activities, the textbooks of *Interactie* were published for physics upper secondary education. This clarifies the results of the comparison between the PLON intentions and the characteristics in *Interactie*. Furthermore, *Interactie* was the precursor of the *Newton* textbooks. A few authors were involved in the authors-team of both *Interactie* and *Newton* (see Table 9). In addition, both *Interactie* and *Newton* textbooks had the same editor in chief (K. Kortland). This might indicate that the intentions of PLON affected the content of *Newton*.

Before the implementation of WEN with a legal status, four or five meetings were held in 1988 for the WEN committee and commercial textbook authors (Jansens, 1988) (see Table 9). The interviewee B. Snater (personal communication, January 22, 2016), chairman of WEN, mentioned that the authors were invited to work on the WEN-programme. During these meetings, B. Snater, the WEN coordinator F. Jansens and the authors were engaged in complex discussions about the intentions of WEN and the possibilities for student textbooks (B. Snater, personal communication, January 22, 2016). Some of these authors created the analysed textbooks in this study. According to B. Snater, all authors were informed by the WEN intentions and they used them for their textbooks designs. Albeit, the authors translated these intentions in several ways (personal communication, January 22, 2016).

Authors could have been inspired by the TF intentions. For instance, one author of *Scoop* (H. Biezeveld) was directly involved as a consultant in the TF development-team (Stuurgroep Profiel Tweede Fase, 1995) (see Table 9). However, there is no proof that the TF intentions inspired the authors of *Scoop*.

In the period 2005-2010, NiNa developed their principles and objectives for upper secondary physics education standards (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010). A few authors (5 out of 14) of the most recent *Newton* books were involved in the development process of NiNa (see Table 9). Four *Newton* authors cooperated as writers for pilot modules. One author acted as a pilot teacher to test the developed curriculum materials. This might be the reason for the equivalent results between the intentions of NiNa and the characteristics in *Newton*.
Furthermore, one *Scoop-Stevin* author (H. Biezeveld) operated in NiNa as a member of the advisory board (see Table 9). It suggests that the intentions were taken into account for the most recent *Stevin* books. All analysed textbooks from 2010 to 2016, could have been affected by the intentions of NiNa due to the distribution of the NiNa programme. The programme offers suggestions for textbooks authors, for example by the inclusion of pilot curriculum materials (Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010).

Table 9

Overview of the Textbooks Authors and their Relationship with the Curriculum Innovation Projects

Textbook	Author	Author and their relationship with the project
Interactie		
1990-1993	PLON-team (editor in chief: K. Kortland)	*K. Kortland* involved in several WEN meetings
Newton		
1998-2000	K. Kortland, H. Van Bergen, R. Langras, P. Over, J. Wijbenga, P. Verhagen	*R. Langras and J. Wijbenga* involved in several WEN meetings
2003-2007	K. Kortland, H. Van Bergen, J. Flokstra, A. Groenewold, R. Langras, P. Over, J. Wijbenga	*K. Kortland, A. Groenewold* and *P. Over* were authors of NiNa modules
2013-2015	B. Blok, M. Dirksen, J. Flokstra, A. Groenewold, K. Hooyman, C. Kootwijk, K. Kortland, P. Lukey, P. Over, P. Siersma	*K. Hooyman* as author of NiNa modules *P. Siersma* as NiNa pilot teacher
Scoop-Stevin		
1984-2008	H. Biezeveld, L. Mathot	*H. Biezeveld* involved in several WEN meetings, as a consultant for TF and as a member of the NiNa advisory board *L. Mathot* involved in several WEN meetings
2014	H. Biezeveld, L. Mathot, R. Brouwer	
Systematische Natuurkunde		
1977-1979	J.W. Middelink	*J.W. Middelink* involved in several WEN meetings
1998	J.W. Middelink, F.J. Engelhard, J.G. Brunt, A.G.M. Hillege, R.W. De Jong, J.H. Moors, H.A.M. Ottink	
2012-2014	B. Van Dalen, J. Van Dongen, R. De Jong, A. Keurentjes, K. Van der Lingen, EJ. Nijhof, H. Vink, H. Ottink	
Natuurkunde Overal		
1991-2000	P.G. Hogenbirk, J. Gravesteijn, J.D. Jager, Th.J.A. Timmers, K.W. Walstra	*K.W. Walstra* involved in several WEN meetings
2012-2014	R. Bouwens, P. Doorschot, G. Van Eekelen, A. Van der Hoeven, M. Van der Lee, J. Van Reisen, A. Vennix	

Note. The periods correspond with the author-teams of the student textbooks.

4.3.2 Curriculum emphasis

Differences between the projects' intentions of the curriculum emphasis were due to the explicitness of the intentions. However, all projects intended the curriculum emphases in a certain way. This indicates that physics education was focused on the *fundamental laws of physics (FLP), physics technology and society (PTS)* and *knowledge development in physics (KDP)* (see Table 10). Numerous elements of *FLP* and *KDP-sm* were offered by the analysed textbooks. *PTS* did not differ in a major extent between the textbooks. Differences within a complete textbook series was also on minimal level, except for a certain amount of *Systematische Natuurkunde* books. In contrast, the elaboration of *KDP-hsw* vary among the textbooks.

Table 10

Overview of the Curriculum Emphasis Intentions by the Curriculum Innovation Projects and the Presence of the Curriculum Emphasis in the Student Textbooks

Curriculum emphasis	Intended by project	General presence in textbook
Fundamental laws of physics	All	All
Physics, technology and society	All	Strong implicit, except for Systematische Natuurkunde 1977 and 2012
Knowledge development in physics	All	- Interactie: strong explicit - Scoop-Stevin: strong implicit - Systematische Natuurkunde: weak explicit - Natuurkunde Overal: fluctuations over the years

Note. Projects: PLON, WEN, TF, and NiNa. Textbooks: Interactie-Newton, Systematsiche Natuurkunde, Scoop-Stevin, and Natuurkunde Overal. 'All' indicates that all projects intended the curriculum emphasis or all textbooks have elements of the curriculum emphasis.

4.3.3 Concept-context approach

All projects intended elements of context-based physics education. Correspondingly, each textbook contained illustrative contexts. Other context positions were identified in the *Interactie-Newton* textbooks: linking-contexts and central-contexts. These positions might have been the result of the developed thematic courses of the PLON-group (Gravenberch, 1982). In addition, a few authors of *Interactie-Newton* were involved in the PLON project. As an overall result of this comparison, *Interactie-Newton* showed different context positions compared to other textbook publishers.

4.3.4 Concept development approach

PLON reported elements of five clusters from the concept development approach. As a consequence, the *Interactie* textbooks showed the strongest extent of almost all clusters in comparison with *Scoop-Stevin* and *Systematische Natuurkunde*. The *Systematische Natuurkunde* textbooks in PLONs' course of the years showed a minor level of the clusters. On the other hand, the published editions of *Scoop* presented a medium extent. The concept development intentions of PLON might have affected the authors of *Scoop* to involve some of these clusters.

WEN formulated the stimulation of the concept development approach by three clusters (I, III, IV). During the legal status of WEN, elements of the clusters *engaging students with relevant phenomena* (III) and *developing and using scientific ideas* (IV) were implemented at a medium level in all analysed textbooks. It suggests an influence of the intentions on the analysed textbooks.
Furthermore, the advice programme of TF illustrated the aspects of *developing and using scientific ideas* (IV). The published *Newton* books during the legal status period of TF contained elements of this cluster. Although, earlier editions showed also the presence of the cluster.
Lastly, NiNa defined their aims for providing concept development by aspects of five clusters. All of them were predominately in the *Newton* textbooks. In addition, the *Stevin* and *Systematische Natuurkunde* books showed the clusters to a minor extent. Differences were determined between the books. However, the overall presence of the clusters was very small to stimulate concept development.

4.3.5 Scientific skills

The comparison between the projects' intentions on the scientific skills and the actual presence in the textbooks is illustrated in Table 11. Outcomes of *Natuurkunde Overal* are not presented due to a lack of suitable results. Moreover, the comparison was only made for the overall results of the havo and vwo books together.
The project analysis shows the objectives of PLON which consists inquiry - and judging skills. These skills were identified in *Scoop* in the course of the years. As a clear result, *Interactie* included the scientific skills intentions of PLON.
Furthermore, *Interactie-Newton* and *Scoop-Stevin* demonstrated their attention to the inquiry - and modelling skills during the legal status period of WEN. Both skills together with the judging skills were defined as important elements. However, judging skills were only identified in the *Interactie* editions.
TF introduced the design skills as an intention for physics education. The *Newton* and *Scoop* editions presented elements of design skills during the legal status period of TF. Though, the design skills were already present in these textbooks before TF was implemented.
Lastly, NiNa aimed to stimulate scientific skills for the physics content. According to this, the textbooks of *Newton* contained aspects of all scientific skills. The authors of *Systematische Natuurkunde* and *Stevin* inserted the inquiry – and design skills or posted them on their website.

Table 11

Comparison Between the Scientific Skills Intentions of the Curriculum Innovations Projects with the Presence of the Scientific Skills in Physics Student Textbooks

Project	PLON	WEN	TF	NiNa
Advice programme published / Intention	1983	1988	1995	2010
Inquiry skills	X	X	X	X
Design skills			X	X
Modelling skills		X		X
Judging skills	X	X	X	X
Textbook / Presence		Interactie-Newton (1990-2012)		
Inquiry skills		X	X	X
Design skills		X	X	X
Modelling skills		X		X
Judging skills		X	X	X
	Systematische Natuurkunde (1977-2012)			
Inquiry skills				X
Design skills				X
Modelling skills				
Judging skills				
	Scoop – Stevin (1984-2014)			
Inquiry skills	X	X	X	X
Design skills	X	X	X	X
Modelling skills		X		
Judging skills	X			

Note. 'X' indicates the presence of an intention, or the presence within a student textbook since the published advice programme till the subsequent advice programme. The table does not show the differences between *cookbook* - and *own decision* presentations.

5 Conclusions and discussion

The overall purpose of this study was to understand the contributions of physics curriculum innovation projects during the past 40 years on former and current student textbooks, focused on upper secondary education in the Netherlands. This study reveals the intentions of the projects characterized in four dimensions: *curriculum emphasis, concept-context approach, concept development approach,* and *scientific skills*. Instruments have been developed to identify the presence of these characteristics in several commercial student textbooks.
The current study provides a historical understanding of physics education. This is in line with the growing attention and interest in curriculum evaluations by the Dutch Ministry of Education (Dijsselbloem, 2008). The developed instruments and the outcomes of this study can be used as a contribution to a deeper understanding of the interplay between curriculum developers and commercial textbook authors. The conclusion and discussion for each characteristic will be described. Finally, a general discussion and recommendations for further research will be provided.

The curriculum emphases, *Fundamental laws of physics (FLP), Physics, technology and society (PTS),* and *Knowledge development in physics (KDP),* appeared as intentions in all project documents as well as in all student textbooks. The analysis results of the *KDP* emphasis showed differences between the textbooks. Only several textbook authors appear to have applied the intentions of *KDP* extensively. Overall, the authors' designs showed minor changes with respect to the elaboration of *KDP* throughout the years. It seems that the authors of the analysed textbooks have their own preference and vision of *KDP* regarding their textbooks designs.
The attention to *PTS* showed a limited change through the subsequent curriculum projects. It might be the case that the increase in explicit emphasis in the textbooks for *PTS* in the last decade is due to other causes than prescriptions or pilot experiences from the subsequent projects and innovations. We can not say from this study what exactly made *PTS* more important in the course of the years.
The emphasis *FLP* showed no change in importance in the investigated years.
Thus, the projects showed no major changes on the emphasis intentions in the past 40 years while the extent of the emphasis varies between the textbook series throughout the years.

The concept-context approach appeared in all investigated curriculum projects and student textbooks. However, the forms in which a context appeared differed between projects as well as between textbooks. All projects stressed the importance to connect concepts to realistic contexts. Each textbook presented at least concepts in 'traditional' illustrative contexts. But from the projects, only the intentions of PLON regarding central contexts appeared in the designs of the *Interactie* textbooks. Moreover, intentions of NiNa may have affected the authors of the *Newton* textbooks to construct linking-contexts. An indication may come from the pilot curriculum materials of PLON and NiNa. The place of contexts in these materials is quit similar in both projects, which indicates projects' similarity in purposes towards contexts (Lijnse, 2010).
Furthermore, some authors within the PLON project were involved in the authors-team of subsequent *Newton* textbooks. In addition, the same editor in chief operated in the designs of the *Interactie* and *Newton* textbooks. This might suggest the influence on the subsequent books by the PLON project through the contributions of these authors and the editor in chief. Altogether, considered the intentions of the curriculum projects, there was only one textbook *(Interactie*-Newton) with other context positions than illustrative contexts. This indicates that other authors are committed to 'traditional contexts' for physics student textbooks since the 1970s even up to today.

The concept development approach appeared in almost all projects and textbooks. The project teams of PLON and NiNa paid more attention to the concept development approach than the innovation committees of WEN and TF. Between the series of textbooks, differences with respect to the concept development approach have been established, the subsequent editions of each of the textbooks have hardly been affected by curriculum innovation projects over the years. It suggests that commercial textbooks differ due to authors' tastes and preferences regarding the concept development approach, and that these tastes and preferences are rather constant and not affected by changes in curriculum prescriptions.

The scientific skills presence differed among the projects and the textbooks. Elements of design skills were present in several textbooks before TF even though these skills had not been discussed in the projects prior. It might be the case that projects' intentions regarding inquiry skills implicitly encompass the design skills.
Inquiry skills have been considered as an important element in physics education. From the investigated curriculum innovation projects, PLON prescribed the inquiry skills in importance. In subsequent projects, other scientific skills rather than inquiry skills were focussed upon. The most recent project, NiNa, stimulated the improvement of all scientific skills by stating them in objectives with a prescribing legal status. As a consequence, textbooks that have been published since the NiNa programme became compulsory, contain numerous features to master scientific skills.

As an overall conclusion, the outcomes of this study gives the impression that the textbook designs reflect the curriculum projects' intentions, such as the intentions of the curriculum emphases and the scientific skills. It seems that project intentions affect the designs of commercial textbooks when textbook authors are involved in the curriculum project. An effective interplay between curriculum developers and textbook authors might ensure the implementation of the curriculum innovations within physics student textbooks. The following points should be taken into account for a deeper understanding of the outcomes of this study.

Variation among the characteristics between the complete textbooks could be explained by difference in taste and preference between textbook authors. In addition, textbook publishers have commercial reasons for conserving a characteristic. In fact, textbook publishers are dependent on the sale of their textbooks. This is accompanied by a strong preference and affiliation of teachers to a specific published textbook and its style. Nevertheless, textbook publishers have to change their designs when new content is prescribed in attainment targets with legal status. For instance, all recent physics textbooks included the domain *quantum mechanics*, simply because it is a mandatory domain in the national physics exam.

The question remains unanswered why some textbooks contain (such as *Interactie-Newton*) intended characteristics of the curriculum innovation projects? Table 9 shows the personal connections of textbook authors with the curriculum innovation projects. The answer of the previous question may be found from the table. Authors involved in the projects build upon their experiences and motivation of a curriculum project. They might use their experience with a little extra effort for writing the textbooks. It should be helpful to identify this explanation by interviews with these and other authors. Thereby, the overall motivation of authors could be checked for their writing and design activities.

The outcomes of this study provide an insight in the influences of curriculum projects on the designs of student textbooks, but they do not explain the complete track, due to our focus on the mechanics chapters. Follow-up research should investigate the presence of the characteristics in other domain chapters, such as electricity. This might

provide an insight into the general aims of the textbooks in comparison to the pedagogical characteristics and curriculum emphases. Furthermore, analysing the complete track of all published student textbooks since the 1970s was not possible due to a lack of available textbooks.
Even with this limited number of textbooks, this study clearly shows striking changes in textbook designs over the past 40 years, such as the introduction of the explicit attention to inquiry skills in textbooks.

The textbook and project analyses were restricted to the four characteristics (or markers) of science education. However, to what extent are these characteristics representative to track down curriculum innovations over the past 40 years? Other characteristics for the analyses were considered in the initial stage of this study, such as the presence of *interdisciplinary* elements in physics education. In spite of that, the selected characteristics in this study can be considered as both necessary and sufficient markers to track the development of physics education through the decades. These characteristics could be taken into account for future evaluation studies of science curricula as well as criteria for developing a new curriculum. Moreover, the four characteristics together with the corresponding instruments from our study could be used to compare the content of science student textbooks in general. This might serve the science teachers to make their choice for a student textbook.

Teacher guides were not available for this study to determine authors' purposes regarding the practical use of textbooks, nor were interviews or other sources to understand what motivated authors in their designs. A first indication of authors' purposes with respect to the use of textbooks by teachers can be found through an investigation of teacher guides. In addition, interviews with textbook authors could reveal their motives regarding teachers' usage of textbooks.
Furthermore, teachers' actual classroom practices have not been examined to understand how teachers may have applied the textbooks. This seems important because the majority of teachers commonly use textbooks in classrooms (Abraham, Gryzbowski, Renner, & Marek, 1990 as cited in Stern & Roseman, 2004). Textbooks comprise the content of the subject and indicate how the content should be taught (Tyson, 1997). Nevertheless, we should assume a gap between the ideal curriculum and the curriculum in action; the implemented curriculum. Further research on contemporary teachers' pedagogical strategies towards using textbooks might enable the understanding of the gap between intentions and the actual process in the classroom. As Ogborn (2002) stated: "there is in a way no such thing as material being taught in the way intended. That way cannot in the nature of communication itself, be transmitted without change".

For a better understanding of the practical usage of textbooks by teachers together with the impact of the projects on the student textbooks, research should be conducted on teachers' practical usage, preferences, and beliefs towards the use of student textbooks. De Vries (2008) discusses some of the teachers' preferences, but this study does not consider particular curriculum or pedagogical characteristics of textbooks. The study of Van Driel et al. (2008) and De Putter-Smits (2012) showed the concerns, preferences, and beliefs of science teachers on three curriculum emphases. The interview formats of these studies together with the categories of analysis of our study could be adapted to investigate teachers' preferences and concerns of the textbooks in respect to the four characteristics.

Teacher education curricula could also be explored to understand the patterns and realization of innovations in the classroom. For instance, experiences of contemporary physics teachers with teacher education curricula might clarify their preferences and concerns towards the innovations and textbook usage (Hall, George, & Rutherford, 1977). This might be important, because 'what' teachers do in their classroom as well as their quality of instruction is the heart of the science education curriculum (Atkin & Black, 2003).

All above considered, curriculum innovations will affect the designs of student textbooks in a certain way. At the same time, different affects are necessary to take into account for the conclusion in which way the student textbooks contribute to the prescribed curriculum innovations. Future curriculum development projects should understand the motives of textbook authors and publishers to attain an implementation of the projects' intentions into commercial student textbook designs.

6 Reference list

Akker, J. van den. (1998). The science curriculum : Between ideals and outcomes. In B. J. Fraser, K. G. Tobin, & Eds (Eds.), *International handbook of science education* (pp. 421–447). Dordrecht: Kluwer.

Akker, J. van den, & Terwel, J. (2001). Tien opgaven voor het curriculum van de bètavakken. *Tijdschrift Voor Didactiek Der Bètawetenschappen*, *18*(1), 95–99.

Atkin, J. M., & Black, P. (2003). *Inside science education reform: A history of curricular and policy change* (Vol. 3). New York, NY: Teachers College Press.

Ball, D. L., & Cohen, D. K. (1996). Refrom by the book: What is -or might be- the role of curriculum materials in teacher learning and instructional reform? *Educational Researcher*, *25*(9), 6–8.

Bennett, J., Lubben, F., & Hogarth, S. (2006). Brining science to life: A synthesis of the research evidence on the effects of context based and STS approaches to science teaching. *Science Education*, *91*, 347–370.

Berkel, B. van. (2005). *The structure of current school chemistry*. Universiteit Utrecht.

Boersma, K., Eijkelhof, H., Van Koten, G., Siersma, D., & Van Weert, C. (2006). *De relatie tussen context en concept*. Retrieved from http://www.betanova.nl/downloads/context/relatie__context__concept.pdf

Boersma, K., Van Aalst, H. F., Schermer, S., Hondebrink, J., Pilgram, P., & de Kievit, R. (1987). *10 jaar leerplanontwikkeling 1975-1985. Instituut voor Leerplanontwikkeling*. Enschede.

Bruning, L., & Michels, B. (2013). *Concept- contextvenster. Zicht Op de Wisselwerking Tussen Conceptenen Contexten in Het Bèta-Onderwijs*. Retrieved from SLO Website: http://www.slo.nl/downloads/2013/concept-contextvenster.pdf/

Chiappetta, E. L., & Fillman, D. a. (2007). Analysis of five high school biology textbooks used in the United States for inclusion of the Nature of Science. *International Journal of Science Education*, *29*(15), 1847–1868.

Chiappetta, E. L., Fillman, D. A., & Sethna, G. H. (1991). A method to quantify major themes of scientific literacy in science textbooks. *Journal of Research in Science Teaching*, *28*(8), 713–725.

Commissie Vernieuwing Natuurkundeonderwijs havo/vwo. (2010). *Nieuwe natuurkunde - Advies-examenprogramma's voor havo en vwo*.

De Putter-Smits, L. G. A. (2012). *Science teachers designing context-based curriculum materials: developing context-based teaching competence*. Technische Universiteit Eindhoven. Retrieved from TUE Website: http://alexandria.tue.nl/extra2/724553.pdf

De Vries, L. (2008). *Verandering Vernieuwing Verbetering? 40 jaar natuurkunde-onderwijs Een kijkje in de keuken van de natuurkundedocent*. Universiteit van Amsterdam.

Dijsselbloem, J. Parlementair onderzoek onderwijsvernieuwing (2008). Retrieved from https://decorrespondent.nl/788/Waarom-Jori-uit-4-vwo-nog-steeds-niet-kan-schrijven/395870420447f86a7c5\npapers3://publication/uuid/FEBB3EEC-3656-458C-9200-A2B1A5386D46

Driel, J. van, Bulte, A., & Verloop, N. (2008). Using the curriculum emphasis concept to investigate teachers' curricular beliefs in the context of educational reform. *Journal of Curriculum Studies*, *40*(1), 107–122.

Eijkelhof, H. M. C. (1986). *Van losse thema's tot een samenhangend curriculum: de revisie van het PLON-HAVO-bovenbouwpakket*.

Gilbert, J. K. (2006). On the nature of "Context" in chemical education. *International Journal of Science Education*, *28*(9), 957–976.

Gravenberch, F. (1982). *Konferentie havo-bovenbouw*.

Hall, G., George, A., & Rutherford, W. (1977). *Measuring stages of concern about the innovation : A manual for use of the SoC questionnaire*. University of Texas,

Austin, Texas.
Hodson, D. (2014). Learning science, learning about science, doing Science: Different goals demand different learning methods. *International Journal of Science Education*, *36*(15), 2534–2553.
Hooymayers, H. P. (1986). *Verwachtingen van leraren en PLON-opbrengsten (een innovatieve evaluatieve bezinning).*
Jansens, W. G. F. (1988). *Werkgroep examenprogramma's natuurkunde - herrinering aan het overleg.*
Jones, M. G., & Brader-Araje, L. (2002). The impact of constructivism on education: Language, discourse, and meaning. *American Communication Journal*, *5*(3).
Kesidou, S., & Roseman, J. E. (2002). How well do middle school science programs measure up? Findings from Project 2061's curriculum review. *Journal of Research in Science Teaching*, *39*(6), 522–549.
Kuiper, W. (2009). *Curriculumevaluatie en verantwoorde vernieuwing van bètaonderwijs* [Oration]. Retrieved from SLO Website: http://www.slo.nl/downloads/2009/curriculumevaluatie-betaonderwijs.pdf/
Laugksch, R. C. (2000). Scientific literacy: A conceptual overview. *Science Education*, *84*(1), 71–94.
Lijnse, P. L. (2010). Een canon van de natuurkunde-didactiek? In *Woudschotenconferentie 45.*
Lijnse, P. L. (2014). *Omzien in verwarring*. Utrecht: FIsme.
Ogborn, J. (1997). Constructivist metaphors of learning science. *Science and Education, 6,* 121-133.
Ogborn, J. (2002). Ownership and transformation: teachers using curriculum innovations. *Physics Education*, *37*(2), 142–146.
Project 2061. (2002). Middle grades science textbooks: A benchmarks-based evaluation. Retrieved from Project2061 Website: http://www.project2061.org/publications/textbook/mgsci/report/crit-used.htm
Roberts, D. A. (1982). Developing the concept of "curriculum emphases" in science education. *Science Education*, *66*(2), 243-260.
Roberts, D. A. (1988). What counts as science education. In P. Fensham, *Development and dilemmas in science education* (pp. 27-54). Psychology Press
Roberts, D. A. (2007). Scientific Literacy / Science Literacy . In S . K . Abell & N . G . Lederman (Eds .), *Handbook of Research on Science Education* (pp. 729-780). New York, NY: Routledge.
Stern, L., & Roseman, J. E. (2004). Can middle-school science textbooks help students learn important ideas? Findings from Project 2061's curriculum evaluation study: Life science. *Journal of Research in Science Teaching*, *41*(6), 538–568.
Stuurgroep Profiel Tweede Fase. (1995). *Advies Examenprogramma's havo en vwo. Biologie, Natuurkunde, Scheikunde*. Enschede: SLO.
Tessel, K. M. (2009). Ander onderwijs met andere doelen Een analyse van de discussie over de middenschool in Nederland.
Thijs, A., & Akker, J. van den. (2009). *Curriculum in development*. Retrieved from http://www.slo.nl/downloads/2009/curriculum-in-development.pdf/
Thijs, A., Fisser, P., & Hoeven, M. van der. (2014). *21e Eeuwse vaardigheden in het curriculum van het funderend onderwijs*. Retrieved from SLO Website: http://downloads.slo.nl/Repository/21e-eeuwse-vaardigheden-in-het-curriculum-van-het-funderend-onderwijs.pdf
Tiberghien, A., Jossem, E. L., & Barojas, J. (1998). *Connecting research in physics education with teacher education. Physics.*
Tyson, H. (1997). *Overcoming structural barriers to good textbooks*. Retrieved from http://govinfo.library.unt.edu/negp/reports/tyson.htm
Van Aalst, H. F. (1986). *Waar doen we het eigenlijk voor?*

Van der Valk, A. E. (1986). C7 regels en instrumentn voor themaontwikkeling, 183–199.
Van Weert, G. (2007). *Makkelijker kunnen we het niet maken, wel leuker*. Retrieved from UVA Webite: https://staff.fnwi.uva.nl/c.g.vanweert/Publicaties/afscheidscollege%20ChGvWeert.pdf
Visscher-Voerman, I., & Gustafson, K. L. (2004). Paradigms in the theory and practice of education and training design. *Educational Technology Research & Development*, *52*(2), 69–89.
WEN. (1988). *Examenprogramma natuurkunde VWO en HAVO*.

7 Appendices

Appendix A: Semi-structured Interview Questions

A. Personalia

Naam:
Werkzaam + functie (huidige situatie):
Datum interview:

B. Achtergrondinformatie

- In welk vernieuwingsproject was u bij betrokken?
- In welke periode?
- Wat was uw functie? Welke activiteiten voerde u uit?

C. Wat werd in curriculumvernieuwingen in de afgelopen 50 jaar beoogd?

Visie en doelen

1. Welke visie en doelen had het project ?
   → didactisch en inhoudelijk? (Te vatten in curriculum emphases?)
2. (Zijn visie en doelen destijds helder beschreven? → In welke bronnen?)
3. Zijn visie en doelen in de loop van het vernieuwingsproject of uw betrokkenheid veranderd?
4. Welke ontwikkelingen lagen ten grondslag aan de beoogde vernieuwingen?

D. Wat typeert het heden ten dage uitgevoerde curriculum?

E. Welke overeenkomsten en verschillen tussen destijds beoogd en nu uitgevoerd curriculum levert een vergelijking van deze typeringen op?

Typering curricula, overeenkomsten en verschillen

5. Welke projectdoelen zijn gerealiseerd? Welke hebben het niet gehaald?
   - Tijdens het project, in de testgroep; *formele* en *uitgevoerde curriculum.*
   - Enige tijd na het project; *formele* en *uitgevoerde curriculum.*
6. Hoe verklaart u het ontstaan van overeenkomsten en verschillen tussen toen en nu?

F. In welke opzichten probeerden de onderzochte curriculumvernieuwingsprojecten door hun opzet en organisatie al vanaf het begin maximale aansluiting te bewerkstelligen tussen beoogde en uitgevoerde curricula?

Systeemontwikkeling vanaf het begin van het project

7. Welk deel van de lerarenpopulatie was in de ontwikkelfase betrokken? In welke rollen?
8. Welk deel van de lerarenpopulatie was in de opschaling betrokken? In welke rollen?
9. Welke organisaties/ personen anders dan projectmedewerkers en -docenten waren betrokken?
10. Werd die betrokkenheid voortgezet in de fasen van invoering en van reguliere uitvoering?

Motivatie, zône van naaste ontwikkeling

11. Kwamen de resultaten van het vernieuwingsproject tegemoet aan de behoeften van docenten toentertijd?
    - In welke mate sloten de curriculum emphases aan?
    - In welke mate sloten de didactische opvattingen aan?
12. Waren er kleine uitvoerbare uitwerkingen in lesvoorbeelden en in toetsvoorbeelden die de doelen van innovatie weergaven?
    - Motiveerden die?
    - Werkten ze in de doorontwikkeling?
13. Stonden de docenten sympathiek tegenover de vakvernieuwing, onderscheiden naar de fase (voor, tijdens of na afloop van het vernieuwingsproject)?
    → onderscheid curriculum emphases en didactische vernieuwingen.
14. Heeft het project leraren in contact gebracht met ontwikkelingen, voorbeelden op zijn/haar vakgebied in andere landen?

G. Welke interventies in het onderwijssysteem (zoals ontwikkeling van lesmateriaal en examens, nascholing), gericht op maximale aansluiting tussen beoogde en uitgevoerde curricula, deden de onderzochte curriculumvernieuwingsprojecten?

Interventies

15. Wat was de implementatiestrategie van het project en welke spelers waren betrokken?
    - Toetsvoorbeelden voor schoolexamens? Vanaf welke fase?
    - Landelijke examens? Vanaf welke fase?
    - Boeken?
    - Professionalisering?
16. Wat waren sterke en zwakke kanten van de implementatie-aanpak? Valkuilen?
17. Welke bijdrage heeft het project gehad op de professionele ontwikkeling van natuurkunde leraren in Nederland? Heeft het project invloed gehad binnen de lerarenopleidingen?

Leiderschap

18. Was leiderschap bij de implementatie toe te schrijven aan een persoon of groep mensen?
19. Overtuigden deze mensen de docenten die nog betrokken moesten worden?

Competenties versterken

20. Zijn leraren die bij het project betrokken waren, in leerplanontwikkeling getraind?
    - Bewust of als neveneffect? (M.n. lesmateriaal, syllabi, compleet curriculum)
21. Zijn leraren die bij het project betrokken waren, in toetsontwikkeling getraind?

H. Afsluiting

22. Welke personen kunt u ons adviseren voor het afnemen van een interview?
23. Heeft u op– of aanmerkingen over de gestelde vragen tijdens dit interview?
24. Wilt u verder nog iets kwijt over dit onderzoek?

Reserve

I. Welke voor leraren betekenisvolle gebeurtenissen in hun ontwikkeling als vakleraar hebben een bepalende invloed gehad op het curriculum zoals zij dat uitvoeren?

25. Hebben de projecten uw manier van denken en functioneren beïnvloed in uw latere werkveld?
26. Hebben de projecten en hun vernieuwingskenmerken uw manier van lesgeven veranderd (nu of toentertijd)?
27. Als u terugkijkt op uw professionele carrière, welke gebeurtenissen zijn u bijgebleven die een bijdrage hebben geleverd in uw ontwikkeling als docent?
28. Welke nevenactiviteiten, zoals nascholing en deelname aan een project, hebben u gevormd als docent?
29. Heeft u verder nog ervaringen en/ of opmerkingen omtrent uw professionalisering als docent?

Appendix B: The Curriculum Emphasis Analysis Instrument

The curriculum emphasis analysis instrument can be used to identify the curriculum emphases within science student textbooks for upper secondary education. According to Roberts (1982), a curriculum emphasis is:

"a coherent set of messages to students about science (rather than within science). Such messages constitute objectives which go beyond learning the facts, principles, laws, and theories of the subject matter it- self-objectives which provide answers to the student question: Why am I learning this?"

Roberts (1982) identified seven curriculum emphases throughout a literature study. In addition, Van Driel et al (2008) combined the seven curriculum emphases of Roberts (1982). To identify the emphases in student textbooks, the following instrument is developed through a aggregation of the emphases of Van Driel et al (2008) and the scientific literacy analysis categories of Chiappetta and Fillman (2007). Detailed information about this aggregation can be read in the theoretical background chapter of this study.
The following subsections describe the characteristics and procedures to identify the three curriculum emphases in student textbooks.

I. Fundamental laws of physics

Check this category if the intent of the text is to present, discuss, or ask the student to recall information, facts, concepts, principles, laws, theories, etc. It reflects the transmission of scientific knowledge where the student receives information. This category typifies most textbooks and presents information to be learned by the reader. Textbook material in this category:

(a) Presents facts, concepts, principles and laws.
(b) Presents hypotheses, theories, and models.
(c) Asks students to recall knowledge or information.

<u>Scoring scheme:</u>

- Absence: 0
- Presence: X

2. Physics, Technology, and Society.

Check this category if the intent of the text is to illustrate the effects or impacts of science on society. This aspect of scientific literacy pertains to the application of science and how technology helps or hinders humankind. In addition, it involves social issues and careers. Nevertheless, the student receives this information and generally does not have to find out. Textbook material in this category:

(a) Describes the usefulness of science and technology to society,
(b) Points out the negative effects of science and technology on society,
(c) Discusses social issues related to science or technology, and
(d) Mentions careers and jobs in scientific and technological fields.

Scoring scheme:

- Absence: 0
- Presence is implicit
  - o Weak: 1
  - o Strong: 2
- Presence is explicit
  - o Weak: 3
  - o Strong: 4

Differences between the implicit and explicit presence of the emphasis:
The emphasis appears implicitly when the above subcategories are intended and be recognized in general throughout the materials. Aspects of the subcategories will be mentioned, but not elaborated in detail. The reader will understand the fact that science could interact with technology and the society, but the author does not explain this explicitly.
The emphasis appears explicitly when one or more of the above subcategories are present in the textbook. The author makes a visible effort to describe the interaction between physics, technology, and the society. Textbook users will explicitly read this by text within the materials.

Differences between weak and strong
The differences of the extent of the emphasis is relative. A weak presence indicates a small quantity of the emphasis. Users are not overwhelmed with the emphasis and the material includes only small items.
The presence is strong if the author makes an abundant visible effort of the emphasis (implicit or explicit). The material contains a large quantity of the emphasis.

3. Knowledge Development in Physics

How science works

Check this category if the intent of the text is to illustrate how science in general or a certain scientist in particular, went about "finding out." This aspect of the nature of science represents thinking, reasoning, and reflection, where the student is told about how the scientific enterprise operates. Elements of this category:

Textbook or chapter ...
(a) Describes how a scientist experimented.
(b) Shows the historical development of an idea.
(c) Emphasizes the empirical nature and objectivity of science.
(d) Illustrates the use of assumptions.
(e) Shows how science proceeds by inductive and deductive reasoning.
(f) Gives cause and effect relationships.
(g) Discusses evidence and proof.
(h) Presents the scientific method and problem solving.

Scoring scheme:

- Absence: 0
- Presence is implicit
  - o Weak: 1
  - o Strong: 2
- Presence is explicit
  - o Weak: 3
  - o Strong: 4

Differences between the implicit and explicit presence of the emphasis:
The emphasis appears implicitly when the above subcategories are intended and be recognized in general throughout the materials. Aspects of the subcategories will be mentioned, but not elaborated in detail. The reader will understand the fact that science concepts are the products of the scientific enterprise.
The emphasis appears explicitly when one or more of the above subcategories are present in the textbook. The author makes a visible effort to describe how science works and how the scientific concepts and theories were discovered. Textbook users will explicitly read this by text within the materials.

Differences between weak and strong
The differences of the extent of the emphasis is relative. A weak presence indicates a small quantity of the emphasis. Users are not overwhelmed with the emphasis and the material includes only small items.
The presence is strong if the author makes an abundant visible effort of the emphasis (implicit or explicit). The material contains a large quantity of the emphasis.

Science in the making

Check this category if the intent of the text is to stimulate thinking and doing by asking the student to 'find out'. It reflects the active aspect of inquiry and learning, which involves the student in the methods and processes of science such as observing, measuring, classifying, inferring, recording data, making calculations, experimenting, etc. This type of instruction can include paper and pencil as well as hands-on activities. A textbook or chapter in this category:

(a) Requires students to answer a question through the use of materials.
(b) Requires students to answer a question through the use of charts, tables, etc.
(c) Requires students to make a calculation.
(d) Requires students to reason out an answer.
(e) Engages students in a thought experiment or activity.

However, if a question simply asks for recall of information or is immediately answered in the text, check Category 1.

Scoring scheme:

- Absence: 0
- Presence: X

Appendix C: The Concept-Context Analysis Instrument

The appendix will describe the textbooks analysis instrument to identify the presence of contexts in science student textbooks. This instrument is based on the publication of Bruning and Michels (2013) that explain the several positions, application functions, topics, and sizes of contexts within student textbooks. Some descriptions of the several contexts are written in the *research design* chapter of this study. In addition, the study was only focused on the position of contexts and the application functions of contexts. For further detailed information about the concept-context approach, I will refer to the (Dutch) publication of Bruning and Michels (2013) which could be obtained from:
www.slo.nl/downloads/2013/concept-contextvenster.pdf/

1. Position of context

The position of contexts is the result of the selection and the construction of the content. Both selection and construction can be conceptual or contextual structured (see Figure C1). As a result, four positions of contexts are distinguished: *illustrative context, linking-context, central context,* and *context at distance*.

Figure C1. Overview of the Interaction Between Concepts and Contexts in the Context Positions – Adapted from Bruning & Michels (2013)

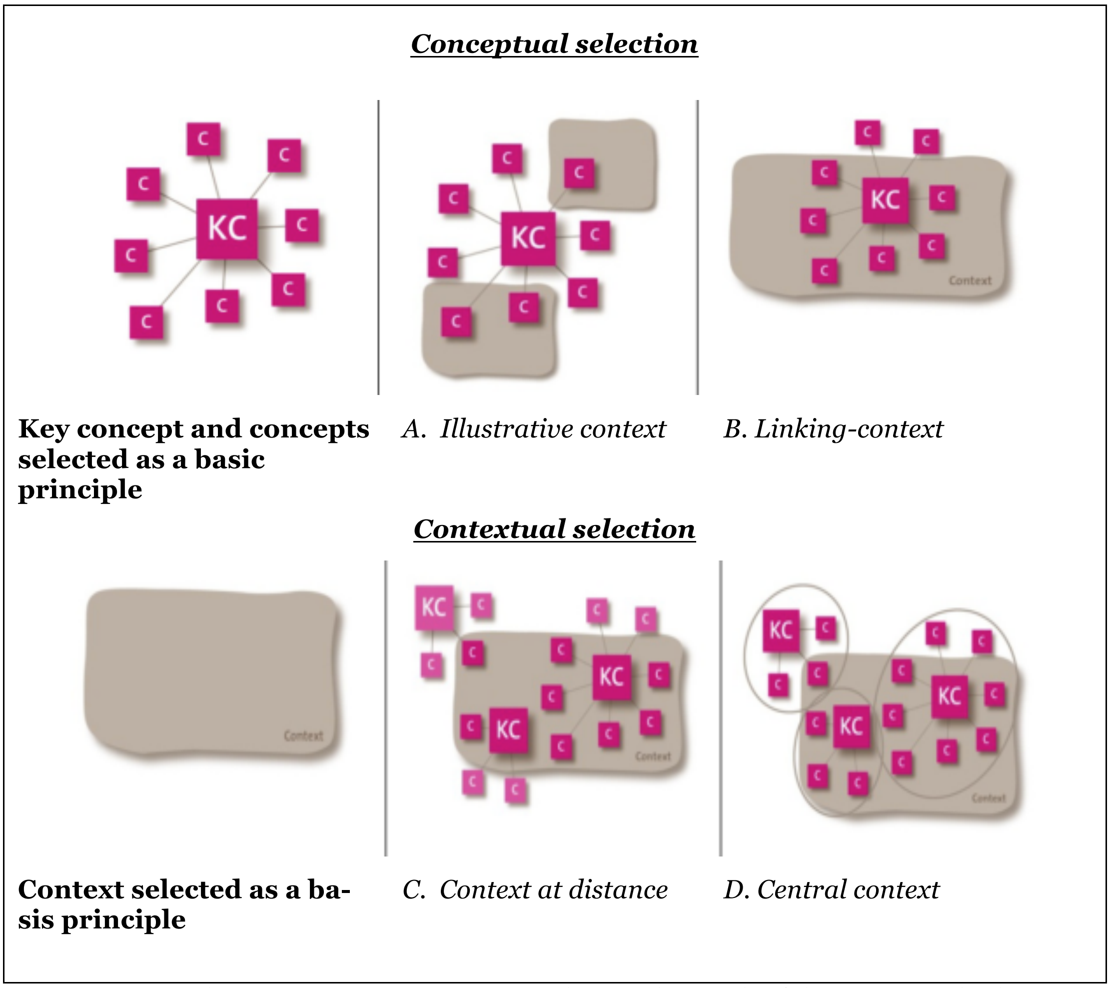

Figure C1. KC= key concept, C= concept. A and B are the result of the conceptual selection. C and D are the result of the contextual selection.

The characteristics of the four context positions are described in Figure C2 as guidelines for the textbook analysis. Examples of the contexts in student textbooks can be read in the publication of Bruning and Michels (2013).

Figure C2. The Adapted Concept-Context Window of Bruning & Michels (2013)

Selection of the textbook content: conceptual

Illustrative context
- Conceptual course structure
- Context arise from concept selection
- Different small contexts
- Concepts from one domain
- Concepts are linked to the conceptual structure

Linking-context
- Conceptual course structure
- Context arise from concept selection
- One context
- Concepts from one domain and linked together with the context
- Some concepts are not linked to the context, but to the conceptual structure

Construction of the textbook content: conceptual

Construction of the textbook content: contextual

Context at distance
- Conceptual structure
- One large context with several other contexts
- Concepts arise from context selection
- Concepts from different domains
- Some concepts are not linked to the context, but to the conceptual structure

Central context
- One central context
- Concepts arise from context selection
- Concepts from different domains
- All concepts belong to the context

Selection of the textbook content: contextual

Figure C2. The concept-context window illustrates the differences between the positions of contexts. The position of context arises from both the selection of the textbooks content (conceptual or contextual) and the construction of the textbook content (conceptual or contextual).

2. Application function

The contexts could have different application functions. Textbooks can be analysed on the presence of *context for learning*, *context for practice*, and *context for testing*. The following indicators can be used to identify the application functions:

- *Context for learning* : context illustrates the concepts to inform students
- *Context for practice* : context within questions and tasks to practice the content knowledge
- *Context for testing* : context within test assignments to test the knowledge of the concepts / content

3. Context topics

Contexts can be distinguished in several topic categories. The following categories can be identified within textbooks:

- *Living environment context* : a context that cover the living and social environment of students
- *Societal context* : a context that cover current and / or significant topics and issues within the society
- *Scientific context* : a context that represent the academic and scientific community
- *Professional context* : a context that present a profession
- *Historical context* : a context that present historical features or events

4. Context size

Textbooks can be distinguished in several sizes. For the analysis of textbooks, researchers could take the size into account for different purposes. It should be noticed that the sizes are based on a relative scale. Those context sizes can be readjusted for researchers own preference. The following sizes can be identified in student textbooks:

- *Small* : a short context, only as a representation or an example. The context describes one or just a few concepts. These contexts are often *illustrative contexts*.
- *Medium* : medium sized contexts with more text, images, and more concepts.
- *Large* : a large context that cover a chapter or subchapter, a lot of concepts are involved.

5. Procedure

Textbooks can be analysed on one (or more) of the above categories. To understand differences between textbooks, chapters or paragraphs, the categories can be marked on the presence of the indicators of the categories. Researchers can create a table, for example in Microsoft Excel, to score/mark the presence (and/or the absence) of the several characteristics of the concept-context approach in student textbooks.

Appendix D: The Concept Development Analysis Instrument

In analysing the certain amount of elements from the concept development approach in student textbooks, the evaluation instrument of Project 2061 was obtained that provide a set of research-based criteria. The criteria are organized in seven clusters, each of which focuses on a specific aspect of supporting the concept development approach. The criteria, in turn, are annotated briefly to provide users with additional guidance. Each criterion is then followed by a list of indicators that the reviewers should to judge how well the curriculum material meets the criterion. Lastly, accompanying each criterion's list of indicators is a rating scheme that describes the relative amount of presence. Reviewer should take the following remarks into account:

- Not all indicators will be identified in each textbook section / chapter (some can only be identified in teacher guides)
- Key ideas are learning goals stated by the author in the textbook, but can also be considered as key concepts of the textbook sections
- The characteristics within a cluster should be scored with the rating scheme of:
    - *absence*
    - *presence is weak*
    - *presence is strong*
- Page numbers of the identified characteristics should be noted for background information

Overview of the concept development clusters and their characteristics

I) Providing a Sense of Purpose

A) Justifying lesson/activity sequence.
B) Conveying lesson/activity purpose.
C) Justifying lesson/activity sequence.

II) Taking Account of Student Ideas

A) Attending to prerequisite knowledge and skills.
B) Addressing commonly held ideas.

III) Engaging Students with Relevant Phenomena

A) Providing variety of phenomena.
B) Providing vivid experiences.

IV) Developing and Using Scientific Ideas

A) Introducing terms meaningfully.
B) Representing ideas effectively.
C) Demonstrating use of knowledge.
D) Providing practice.

V) Promoting Students' Thinking about Phenomena, Experiences, and Knowledge

A) Encouraging students to explain their ideas.
B) Guiding student interpretation and reasoning.
C) Encouraging students to think about what they have learned.

VI) Assessing Progress

A) Aligning assessment to goals.
B) Testing for understanding.

I. Providing a Sense of Purpose

This cluster consists of criteria for determining whether the curriculum material attempts to make its purposes explicit and meaningful to students, either in the student text itself (or through suggestions made to the teacher). The sequence of sections within the textbooks or activities is also important in accomplishing the stated purpose, since ideas often build on each other.

A. Conveying unit purpose

Does the material convey an overall sense of purpose and direction that is understandable and motivating to students?

Indicators of meeting the criterion

- A problem, question, representation (or otherwise identified purpose) is presented to students.
- The author makes a visible effort to make the problem, question, representation (or otherwise identified purpose) comprehensible to students.
- Students are given an opportunity to think about and discuss the problem, question, representation (or otherwise identified purpose).
- The author makes a visible effort to make the sections consistent with the stated purpose and those that are not are explicitly labeled as digressions.
- The material returns to the stated purpose at the end of the unit.

B. Conveying lesson/activity purpose

Does the material convey the purpose of each section or activity and its relationship to others?

Indicators of meeting the criterion

- The author makes a visible effort to express the purpose in a way that is comprehensible to students.
- The material encourages each student to think about the purpose of the activity.
- The material conveys or prompts teachers to convey to students how the activity relates to the unit purpose.
- The author makes a visible effort to convey to students how the activity relates to the unit purpose.
- The material engages students in thinking about what they have learned so far and what they need to learn/do next at appropriate points.

C. Justifying lesson/activity sequence

Does the material involve students in a logical or strategic sequence of lessons or activities (versus being just a collection of lessons or activities)?

Indicators of meeting the criterion

- The author makes a visible effort to facilitate a logical or strategic sequence of activities.
- The author makes a visible effort to convey the rationale for this sequence.

II. Taking Account of Student Ideas

Fostering understanding in students requires taking time to attend to the ideas they already have, both ideas that are incorrect and ideas that can serve as a foundation for subsequent learning. This cluster consists of criteria for determining whether the curriculum material contains specific suggestions for identifying and addressing students' ideas.

A. Attending to prerequisite knowledge and skills

Does the material specify prerequisite knowledge/skills that are necessary to the learning of the key ideas?

<u>Indicators of meeting the criterion</u>

- The author makes a visible effort to alert students to prerequisite ideas or experiences that are being assumed.
- The material adequately addresses (provides instructional support for) prerequisites in the same unit or in earlier units (in the same or other grades). (The material should not be held accountable for addressing prerequisites from an earlier grade range. However, if a material does address such prerequisites they should count as evidence for this indicator.)
- The material makes adequate connections (provides instructional support for connections) between ideas treated in a particular unit and their prerequisites (even if the prerequisites are addressed elsewhere).

B. Addressing commonly held ideas

Does the material attempt to address commonly held student ideas?

<u>Indicators of meeting the criterion</u>

- The material explicitly addresses commonly held ideas.
- The author makes a visible effort to include questions, tasks, or activities that help students progress from their initial ideas, for example, by
  - explicitly challenging students' ideas, for example, by comparing their predictions about a phenomenon to what actually happens
  - prompting students to contrast commonly held ideas with the scientifically correct ideas, and resolve differences between them
  - extending correct commonly held ideas that have limited scope.

III. Engaging Students with Relevant Phenomena

Much of the point of science is to explain phenomena in terms of a small number of principles or ideas. For students to appreciate this explanatory power, they need to have a sense of the range of phenomena that science can explain. The criteria in this cluster examine whether the curriculum material relates important scientific ideas to a range of relevant phenomena and provides either firsthand experiences with the phenomena or a vicarious sense of phenomena that are not presented firsthand.

A. Providing variety of phenomena

Does the material provide multiple and varied phenomena to support the key ideas?

Indicators of meeting the criterion

- Phenomena could be used to support the key ideas.
- Phenomena are explicitly linked to the relevant key ideas.

B. Providing vivid experiences.

Does the material include activities that provide firsthand experiences with phenomena when practical *or* provide students with a vicarious sense of the phenomena when not practical?

Indicators of meeting the criterion

- The author makes a visible effort to provide efficient firthand experiences (when compared to other firsthand experiences) and, if several firsthand experiences target the same idea, the set of firsthand experiences is efficient. (The efficiency of an experience equals the cost of the experience [in time and money] in relation to its value.)
- The author makes a visible effort to provide students with a vicarious sense of phenomena experiences, when there are no firsthand experiences (e.g., text, pictures, video). (Please note that if the material provides only firsthand experiences, this indicator is not applicable.)

IV. Developing and Using Scientific Ideas

Science literacy requires that students understand the link between scientific ideas and the phenomena that they can explain. Furthermore, they should see the ideas as useful and become skilful at applying them. This cluster consists of criteria for determining whether the curriculum material expresses and develops the key ideas in ways that are accessible and intelligible to students, and that demonstrate the usefulness of the key ideas and provide practice in varied contexts.

A. Introducing terms meaningfully

Does the material introduce technical terms only in conjunction with experience with the idea or process and only as needed to facilitate thinking and promote effective communication?

Indicators of meeting the criterion

- The material links technical terms to relevant experiences that develop the idea as the term is used (rather than just having students learn definitions of terms).
- The material restricts the use of technical terms to those needed to communicate intelligibly about key ideas.

B. Representing ideas effectively

Does the material include accurate and comprehensible representations of the key ideas?

Indicators of meeting the criterion

- Representation is accurate (or, if not accurate, then students are asked to critique the representation).

- The author makes a visible effort to make the representation comprehensible to students.
- Representation is explicitly linked to the real thing.

C. Demonstrating use of knowledge

Does the material demonstrate/model *or* include suggestions for teachers on how to demonstrate/model skills or the use of knowledge?

Indicators of meeting the criterion

- The material consistently carries out the expected performance (e.g., the student text explains a particular phenomenon using the kinetic molecular theory). (Teacher's guides often include responses to questions posed in the student text. If the material does not instruct the teacher to use the answers to model the use of knowledge, such responses do not count as instances of modelling.)
- The performance is step-by-step.
- The performance is explicitly identified as a demonstration of the use of knowledge or skill.
- The material provides running commentary that points to particular aspects of the demonstration and/or criteria for judging the quality of a performance.

D. Providing practice

Does the material provide tasks/questions for students to practice skills or to use knowledge in a variety of situations?

Indicators of meeting the criterion

- The material provides a sufficient number of tasks in a variety of contexts, including everyday contexts.
- The material includes novel tasks.
- The material provides a sequence of questions or tasks in which the complexity is progressively increased.
- The material provides students first with opportunities for guided practice with feedback and then with practice in which the amount of support is gradually decreased.

V. Promoting Students' Thinking about Phenomena, Experiences, and Knowledge

Engaging students in experiences with phenomena (category III) and presenting them with scientific ideas (category IV) will not lead to effective learning unless students are given time, opportunities, and guidance to make sense of the experiences and ideas. This cluster consists of criteria for determining whether the curriculum material provides students with opportunities to express, think about, and reshape their ideas, as well as guidance on developing an understanding of what they experience.

A. Encouraging students to explain their ideas

Does the material routinely include suggestions for having each student express, clarify, justify, and represent his or her ideas? Are suggestions made for when and how students will get feedback from peers and the teacher?

Indicators of meeting the criterion

- The author makes a visible effort to routinely encourage students to express their ideas.
- The author makes a visible effort to encourages students not only to express but also to clarify, justify, and represent their ideas (a material is not expected to encourage students to clarify, justify, and represent ideas each time they are asked to express their ideas; however, in the course of teaching a particular key idea the material should provide students with opportunities to clarify, justify, and represent ideas).
- The author makes a visible effort to provide opportunities for each student (rather than just some students / group) to express ideas.
- Material includes specific suggestions on how to help the teacher provide explicit feedback to students *or* includes text that directly provides students with feedback.
- Material includes suggestions on how to diagnose student errors, explanations about how these errors may be corrected, and recommendations for how students' ideas may be further developed.

B. Guiding student interpretation and reasoning

Does the material include tasks and/or question sequences to guide student interpretation and reasoning about experiences with phenomena and readings?

Indicators of meeting the criterion

- The author makes a visible effort to include specific and relevant tasks and/or questions for the experience or reading.
- The questions or tasks have helpful characteristics such as
    - framing important issues
    - helping students to relate their experiences with phenomena or representations to presented scientific ideas
    - helping students to make connections between their own ideas and the phenomena or representations observed
    - helping students to make connections between their own ideas and the presented scientific ideas
    - anticipating common student misconceptions
    - focusing on contrasts between student misconceptions and scientific alternatives.
- There are scaffold sequences of questions or tasks (as opposed to separate questions or tasks).

C. Encouraging students to think about what they have learned

Does the material suggest ways to have students check and reflect on their own progress?

Indicators of meeting the criterion

- The material engages (or provides specific suggestions for teachers to engage) students in monitoring how their ideas have changed and does so periodically in the unit.

Take the following into consideration:
Absence: The author makes a visible effort to give students an opportunity to revise their initial ideas based on what they have learned (without asking them explicitly to think about how their ideas have changed).
Presence is weak: The author makes a visible effort to engage (or provides specific suggestions for teachers to engage) students in monitoring how their ideas have changed, but does so infrequently in the unit.
Presence is strong: The author makes a visible effort to engage (or provides specific suggestions for teachers to engage) students frequently in monitoring how their ideas have changed.

VI. Assessing Progress

This cluster consists of criteria for evaluating whether the curriculum material includes a variety of aligned assessments that apply the key ideas taught in the material.

A. Aligning assessment to goals

Are assessment items included that match the key idea?

Indicators of meeting the criterion

- The specific ideas in the key ideas are necessary in order to respond to the assessment items.

Take the following into consideration:
Presence is weak: specific ideas are sufficient
Presence is strong: specific ideas are necessary

B. Testing for understanding

Does the material include assessment tasks that require application of ideas and avoid allowing students a trivial way out, like using a formula or repeating a memorized term without understanding it?

Indicators of meeting the criterion

- Assessment items focus on understanding of key ideas.
- Assessment items include both familiar and novel tasks.

Appendix E: The Scientific Skills Analysis Instrument

To understand the presence of scientific skills in student textbooks, the scientific skills can be distinguished in four skills: inquiry-, design-, modelling-, and judging skills. These skills can be considered as the most important skills within the scientific enterprise. Thereby, these skills are suitable for students to learn and practice the needs for future careers in the scientific field and for further higher education.
Thus, the scientific skills are distinguished in:

- Inquiry skills
- Design skills
- Modelling skills
- Judging skills

<u>Indicators of meeting the criterion:</u>
The skills can be identified in two different ways: *the cookbook manual* and the *own decision*. The cookbook manual presentation indicates the appearance of the skill as a cookbook. Students are only encouraged to use these skills by following an order of steps, without making their own decisions.
The own decision method goes beyond following an order of steps. This presentation provides students to think, to reason, and to experience the skills by their own decision. As an example, students are asked to formulate their own research question, to design their own experiments or to interpreted their results without guidance.

<u>Rating scheme:</u>

- Absence
- Cookbook manual presentation
- Own decision presentation

<u>*Take the following into consideration:*</u>

- The identification of judging skills should not be distinguished by the above rating scheme. Judging skills are either *absent* or *present*.
- If textbook chapters or sections include both the *cookbook manual presentation* and *own decision presentation*, then the *own decision presentation* should be marked.

The following descriptions define the scientific skills, retrieved from Commissie Vernieuwing Natuurkundeonderwijs havo/vwo, 2010, p. 29-30):

Inquiry skills	Students can analyse and give answer to a context question with the use of relevant concepts and theories, transform them into a specific subject research, and perform the research. The students can draw conclusions from the research results by reflecting with well taught arguments and relevant mathematical skills.
Design skills	Students can design and perform their design, based on a problem statement in a context. The student can test and evaluate their results with relevant concepts and theories, and can reflect on their results with well taught arguments.
Modelling skills	Students can analyse a problem statement within a context, and transform the statement into a manageable problem and a model. The student can perform modelling results, reflect on the results, and interpreted the results by using relevant arguments and mathematical skills.
Judging skills	Students can give arguments about situations in the environment or technical applications in contexts. The student can distinguish the arguments into scientific arguments, societal considerations, and personal perceptions.