The Effect of Graphical Processing on Multiple-Text Use

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Abstract

Students face difficulties when they have to integrate multiple texts into one coherent whole. When they do not succeed in integrating information into a unity, comprehension and deeper understanding of the information from multiple texts will not take place. In this study, the use of a graphical, instructional strategy was compared to a non-graphical strategy in order to investigate whether graphical processing may be beneficial for multiple- text integration and comprehension of third-grade, pre-university track students (3 VWO). 22 students processed the information graphical, by generating a concept map and 29 processed the information non-graphical, by generating a traditional summary in the control group. Difference of integration between the conditions has been compared with the number of propositions between definitions originating from the texts. Comprehension of the information presented in the multiple texts was compared among the conditions with a post-test. There was no difference found in scores on integration and comprehension between the two conditions, graphical processing did not affect students' integration and comprehension. Further research is necessary to gain more knowledge on how and with what tools multiple-text integration and comprehension can be improved.

Keywords: multiple- text integration, multiple- text comprehension, (non)-graphical strategies

Introduction

Rapid updating and development of technology during the past decade have provided students of all ages more opportunities to use electronic devices at school. In the year 2014, eight million iPads were bought by schools around the world for educational intentions (Smith & Santori, 2015). The growing use of electronic devices in combination with improved internet access has resulted in growing availability of, and accessibility to search engines and information sources (Macklin & Fosmire, 2019).

The use of more electronic devices in education, in combination with improved internet access, has increased students' exposure to multiple- text use and reading of supplementary sources for learning (Strømsø, Braten, & Britt, 2010). Therefore, learning across multiple texts has become a common part of education (Beker, van den Broek, & Jolles, 2019). The newly, accessible information that can be found because of the technological developments has given opportunities to encompass a broader range of skills, practices and deeper knowledge (Goldman, 2015). However, learning to manage the multiple text sources is necessary for the construction of a broader range of skills, practices and acquiring deeper knowledge (Strømsø, et al., 2010). This managing of the texts by selecting on usefulness and reliability in order to learn, includes retaining overload information, conflicting arguments and finding out how all the texts and concepts are related to each other to understand the topic the students are working on. When they are able to carry out these processes, integration of the information can take place (Afflerbach & Cho, 2009; Alexander & DRLRL, 2012; Strømsø, Bråten, & Brante, 2020).

Despite the importance of right integration for comprehension, research indicated that students struggle with the requisite steps necessary for integration. Problems with combining and viewing information from different and sometimes conflicting viewpoints makes it difficult to integrate the information (Britt et al. 1999; Cerdán & Vidal-Abarca 2008;

Rouet 2006; Rouet & Britt, 2011; Wiley et al., 2009). The current study aims to investigate whether a graphical processing strategy, in the form of a concept map, can be beneficial for the integration and comprehension of information from multiple texts.

Theoretical Framework

The development of increasing accessibility to information can be considered as positive. As a result of this increase, students can broaden their knowledge because of information becoming more accessible via the electronic devices and internet. (Goldman, 2015). However, broadening of knowledge is difficult and the increased accessibility can also be marked as challenging. Students are not always able to learn and expand their knowledge from reading, which lies in the unsuccessful creation of a coherent unity from the information (Beker et al., 2019). In order to create this, first students have to integrate the presented information. When the information is integrated into a whole, students are able to expand their knowledge and therefore building a coherent unity should be the first step for successful multiple-text use (Britt, Rouet, & Durik, 2018). This unity is dependent on a combined memory representation of crucial definitions which are linked across multiple texts (Beker et al., 2019). For example, when students carry out an assignment on sustainable energy and search the internet, lots of textual information is found. Even after succeeding in finding this relevant literature learning from reading does not immediately take place. For this reason, students first have to link definitions and phenomena across the multiple texts in order to create a unity of the topic and overcome unsuccessful integration which may result in less enriched knowledge representations (Beker, Jolles, & van den Broek, 2017; Britt & Rouet, 2012). Furthermore, new knowledge schemes will not be constructed when a coherent unity of the presented information is absent (Beker et al., 2019). However, when students are able to connect and integrate information across texts, better knowledge representations and knowledge schemes will be constructed (Beker et al., 2017; Britt & Rouet, 2012). Therefore,

integration and the following comprehension of multiple texts are of great importance in order to make multiple- text use successful.

Multiple-Text Integration and Comprehension

In order to investigate what strategies can help students to integrate and comprehend texts, it is first needed to know what is meant with the term ‘text’. For this study, the definition of text is based on what previously was defined by Blachowicz and Ogle (2017) with help of other authors. ‘Text’ is any document that presents linguistic information in order to convey meaning (Blachowicz & Ogle, 2017; Ricoeur, 1991).

In the present study, the integration of knowledge is the organisation of meaningful phrases originating from the presented texts into one coherent whole, the knowledge representation (Beker, et al., 2019). As mentioned, integration of the information across textual sources is crucial for processing multiple texts and constructing an understandable unity of the specific topic (Britt et al., 2018). The process of integration of information consists of two parts where the first part is the activation of the textual source content in the working memory of the reader which integrated across texts. Second, the information is represented in the students’ memory and propositions of the read text are stored. Propositions are relations across texts, such as linked definitions or phenomena (Common Core State Standards, 2010).

Since we talk about the context of reading for learning, comprehension of the textual sources is important. In the present study, comprehension of textual sources is defined as being able to give meaning to the information of the texts and acquiring deep understanding of the presented texts (Britt, Rouet, & Durik, 2017). Insight into comprehension and integration of single texts by students is important in order to determine and understand the strategies that they use. Strategies used in reading single texts can help to determine and provide insights into what additional helpful strategies students might need during reading

multiple texts (Bråten, Anmarkrud, Brandmo, & Strømsø, 2014). In common learning situations at school students are expected to integrate the information of different texts about one specific topic into a coherent whole (Strømsø et al., 2010). For example, when students are asked to research a topic they are not familiar with, they start visiting websites to gather information and read more about that specific topic. When searching for information students read different texts on the internet and from this information they will try to construct a knowledge representation of the topic. In order to successful construct this representation, they first need to integrate the information of different texts into a coherent whole. From this whole, students create meaning and broad knowledge schemes.

When the information is integrated successful, it can serve as prior knowledge in future. For multiple- text use, prior knowledge supports the intertextual strategy use and it helps students to infer or recall relations from previously read multiple texts more successfully (Le Bigot & Rouet, 2007; Rouet, Favart, Britt, & Perfetti, 1997). After recalling prior knowledge, deeper understanding and the encompassing of more, new knowledge is fostered (Britt et al., 2018). Correctly integrating and creating knowledge schemes is important, therefore factors that affect this successful integration should be investigated.

Factors Affecting Integration and Comprehension

Text characteristics influencing single text understanding. In order to gain more insight into textual factors affecting the integration and comprehension of multiple texts, there has to be clear how single-text understanding takes place and which textual factors affect this process. To understand this, Kintsch (1988) proposed the ‘construction-integration model’ of single-text understanding to illustrate specific layers that contribute to single-text understanding. The specific layers are referring to characteristics of the text. Those are the *surface code* which is the exact word use and sentences use that indicate the complexity of the text. This can be for example the length of the sentences or difficulty of the words that are

used in the text. The *text base* refers to the internal meaning of the text that holds the concrete information. An example of a text base for a biology lesson can be an explanation about photosynthesis. The *situation model* refers to the situation that is interpreted in the text for instance the topic of the text which is explained. In the example of the biology lesson, the story that is used to explain the photosynthesis is the situation. The *genre* of the text is the last layer of importance and is the document type, such as a newspaper article or an internet source. Kintsch (1988) stresses the importance of the layers in order to integrate the new knowledge because these layers help readers to give meaning through source determination. Determination takes place by indicating what type of text there is read or what the internal meaning of the text is. Readers add up those layers to create understanding and to comprehend the text which fosters the connection of the new information with prior knowledge of the reader (Kintsch, 1988).

Multiple- text integration and comprehension. To understand how successful multiple- text use takes place, Perfetti, Rouet & Britt (1988) used previously conducted researches to construct the 'documents model'. According to this model, the *intertext model* and *situation model* contribute to the overarching documents model which is necessary for constructing meaningful knowledge representations by integrating information. The intertext model is constructed by using details of the source and the document node. Details of the source can be the author, setting or the form of the source. This set-up is partly reliant on the model of Kintsch (1988) in which as well is focussed on details of the source. The intertext model is complemented with the node of the document which incorporates the rhetorical goals of the source for example the intention to inform or persuade the readers of the document. The situation model represents the content of the source which is the presented information. When the information of the created intertext model and situation model of the multiple documents are linked to each other, readers are able to create a meaningful representation and can

integrate this new knowledge (Perfetti, Rouet, & Britt, 1988). For example, when readers are presented multiple texts on the process of photosynthesis, students are more likely to successful construct an intertext model when the authors and the document nodes are closely related among the two texts. When students can link this information to the situation presented in the texts, there is more chance on successful integration of new meaningful knowledge representations. For successful creation of these representations, learners should be encouraged to pay attention to the details of the text to create a complete intertext model. A situation model is described as being easily to create due to the natural focus of readers on the presented information (Perfetti et al., 1988).

Integrated Framework of Multiple Text use. Along with textual factors affecting the integration and comprehension of multiple texts, also the phases of reading which encompass personal, internal factors are necessary to identify to comprehend how integration and comprehension take place (Bråten & Strømsø, 2009; List & Alexander, 2019). The Integrated Framework of Multiple Text use (IF-MT) of List and Alexander (2019) helps to better understand how multiple-text integration and comprehension take place from the personal perspective of the reader.

List and Alexander (2019) distinguish three phases that are needed for the comprehension of multiple texts. During the first phase of *preparation*, objective features and personal perceptions determine how students will start reading. The *objective features* are guidelines and expectations which are constructed before reading the text. *Personal perceptions* are beliefs and traits that can differ among students like personal motivation or the cognitive products that students use. The second phase is the *execution of reading* where List and Alexander (2019) distinguish three internal strategies for reading; behavioural, cognitive and metacognitive strategies. The *behavioural strategy* is a physical performance of, for example, searching for specific information in the text. The *cognitive strategies* that List

& Alexander (2019) describe in the framework are mental processes focussed on intra-text processing which is the comprehension and relevance determination of a single text. Of interest for the present study is this inter-textual processing in which List & Alexander (2019) elaborate on cross-textual linking and the reasoning about the links. For their framework, List & Alexander (2019) mention additional strategies for supporting cross-textual linking. One of these strategies is the use of graphic organisers. Referring to previously conducted research of Daher & Kiewra (2016) and Firetto, (2013), List & Alexander (2019) emphasize the relevance of using the organisers as organization strategy because they facilitate the cognitive process of cross-textual linking (Daher & Kiewra, 2016; Firetto, 2013). Furthermore, the *metacognitive strategies* are associated with the strategies that students use for monitoring their comprehension, epistemic beliefs and their cognitive product formation. Those first two phases of preparation and execution work towards the third phase of outcomes. *Outcomes* can be cognitive or affective where the *cognitive outcome* is the increase in knowledge and the *affective outcome* is the change in previously stored knowledge and interest (List & Alexander, 2019). The three phases described offer insights into procedures that are carried out by the reader affect multiple- text reading. However, for successful multiple- text reading additional support is needed in order to enhance positive outcomes of the factors described in the Integrated Framework of Multiple Text use.

Enhancement of Text Comprehension

In the phases previously mentioned by List and Alexander (2019), personal strategies are indicated which foster the process of integration and comprehension of the information from the multiple texts. Adapting to these personal strategies with external instructional strategies can improve the outcomes of integration and comprehension (Chang, Sung, & Chen, 2001; Katayama & Robinson, 2000).

As List and Alexander (2019) mentioned based on the research of Daher & Kiewra

(2016) and Firetto (2013), an example of an external supporting instructional strategy is the use of a graphic organiser. Chang, Sung & Chen (2002) conducted a study in which they discussed the generating of a concept map as a graphical strategy, in order to investigate whether this enhanced the comprehension of one single text that was presented. In this study, participants were divided into three different conditions on concept mapping. A control group processed the texts by only reading them. The three conditions differed on the amount of guidance that was provided. The first group corrected an already existing concept map, the second group constructed a concept map with scaffolding and the third group generated a concept map on their own, without any guidance. Overall, generating a concept map appeared to be an effective graphical processing strategy in comparison to the control group. Nevertheless, there was a difference found in the strength of the results among the conditions due to the effects of cognitive load during the processing. The participants of the more guided conditions showed better comprehension as results of less cognitive load during the task in comparison to the less guided conditions. However, unless the cognitive load, concept mapping appeared to be more effective than not using a graphical strategy to integrate information (Chang et al., 2002).

Concept Maps

A concept map is a tool to graphically represent and organize knowledge (Novak & Cañas, 2006). In a concept map, a node-link diagram is constructed in which the nodes represent a concept of the read information and each link indicates a relationship between the two nodes that it connects which are called ‘propositions’ (Novak & Gowin, 1984; Schroeder, Nesbit, Anguiano, & Adesope, 2017). With those propositions, students can reason what kind of relation there is between concepts, in order to increase comprehension of the presented information (Novak & Gowin, 1984).

Different from textual representations of knowledge, a concept map provides a visual

overview of relations between concepts that is easy to interpret (Novak & Cañas, 2006). Since concept maps are graphically constructed, students are not restricted to the order bound lines of a piece of paper or online format which enables students to easily link definitions and phenomena of different texts. This spatially organising provides a clear overview of the links across different texts which supports integration of information (Novak & Gowin, 1984; Novak & Cañas, 2006).

Chang, Sung and Chen (2002) already indicated that the characteristics of processing information with the use of a concept map appeared to be effective regarding the integration of information and comprehension of a single text. It is interesting to explore if the use of concept mapping as instructional strategy positively affects the comprehension of integrated information from multiple textual sources as well (Chang et al., 2002).

Concept Map Use for Multiple-Text Integration and Comprehension

Constructing, correcting or studying a concept map is proved to be more beneficial for increasing comprehension of information than handling texts only by reading them (Chang et al., 2002). However, still is not clear what the effect is of concept mapping on multiple-text integration and comprehension. In the current study will be studied what the effect of making a concept is on multiple- text integration and comprehension to gain more insight into graphical, instructional strategies. This will be explored in comparison with a common instructional text processing strategy which is not graphical organised. This study aims to answer the following research questions: *''What is the effect of using concept maps on multiple-text integration compared to a non-graphical strategy?''*. For this research question, two types of links will be studied to differentiate between different strategies. There will be investigated whether students make more links within one text by studying 'one-text-links' and if students are able to make links across texts indicated by 'multiple-text-links' when they graphically process the presented texts. The multiple-text-links are of great interest, indicating

the integration of information multiple texts which is hard for students to accomplish. The other research question to study possible increased comprehension is *''What is the effect of using concept maps on multiple-text comprehension compared to a non-graphical strategy?''*.

Method

Participants

The research sample consisted of 78 students from the third grade of the pre-university track of one Dutch school, aged 14 or 15 years (N=78, 32 girls, 43 boys, 2 did not mention gender, M_{age} = 14.61, SD=.49). For the study, informed consent is obtained passively. When parents rejected participation of their child, they could mail the researcher. No parents objected. All students were informed about their rights during the experiment and were asked consent before they entered the learning environment. Students were informed that they could withdraw their participation at any moment without giving a reason. All students continued and agreed on the consent and started to work on the experiment. The students were randomly assigned to one of the two conditions of the instructional strategy: concept map or summary.

After entering the learning environment, the students were asked to fill in two descriptive questions. Three students did not complete this questionnaire or did not continue to the learning task. These students were excluded from the experiment and not taken into account for further analysis. Of the students who continued, 24 other students were excluded from further analysis based on the product they had made or based on their test-score. Difference in product was recognised when it contained only copy-pasted text from the original texts or when students only had put a few words on the map and handed this in. These concept maps or summaries could not be analysed because it was not constructed with own words of the students or had too little content to analyse. The students who were excluded based on their test differed from the mean scores due to multiple open questions that were not answered. After contact with the teacher of the students about this appearance, those 24

students were excluded from the research sample. After the exclusion, 51 students remained in the research sample (N= 51, M_{age}= 14.6, SD= .49). From this sample, 21 students were divided to the concept mapping condition and 29 to the summary condition. Because assigning participants to the conditions was done randomly in order to have similar groups on learner characteristics and reading ability, the groups can still be considered as similar on student characteristics but different on size.

Design & Materials

For this study, an experimental design is applied with the type of the instructional strategy as the independent variable. The two dependent variables are the test score in order to measure the comprehension and the performance of the students on the instructional task to measure the level of integration.

Inquiry learning space. To test whether students are able to integrate multiple texts into one coherent whole and if a graphical strategy works better, two Inquiry Learning Spaces (ILS) were created with the Graasp interface of golab.eu (de Jong, Sotiriou, & Gillet, 2014). One ILS was created for the concept map condition and one ILS was created for the control condition in which students made a summary. Both versions had the same explanations, descriptive questions and texts.

The introduction (*introductie*) in Figure 1 and the explanation (*uitleg*) in Figure 2 looked identical for both conditions and contain similar information. At the introduction page, the experiment and the set-up of the ILS are explained. At the end of the introduction page, students were asked to confirm that they comprehended the presented information and that they are willing to participate and agreed on the use of their processing product for the analysis. The students who comprehend and agreed on the terms were forwarded to the following explanation page. At the explanation page, the students were provided with

additional information regarding the structure of the ILS and the processing task. At this page, students were asked to register their age and gender.

Figure 1. Representation of the introduction page of the concept map ILS.

Figure 2. Representation of the explanation page of the summary ILS.

After the registration of age and gender, the students continued to the three pages were the texts were presented which are identical for both conditions. When students had read the texts they continued to the processing of the texts. The two versions of the ILS differed on the instructional strategy, the 'Concept Map ILS' included the *concept map-app* and the 'Summary ILS' included the *input box-app* to create a summary. In Figure 3, the ILS for the experimental condition with *concept map app* is presented. With this app, the students could construct their own concept map of the three texts. In the middle, the app created a new

concept after one click. In this concept box, students could type a definition or explanation found in the text. With the tool bar on the left, the concepts could be linked or removed.

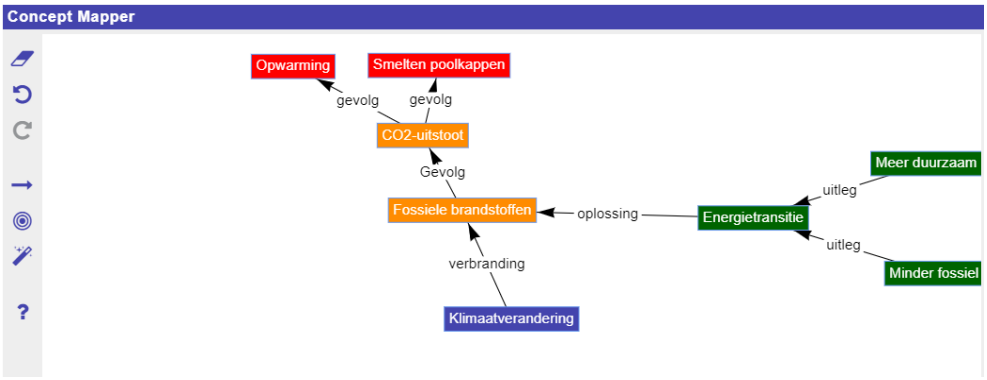

Figure 3. Representation of the Concept Mapper app in the concept map condition.

In Figure 4, the ILS for the control condition is presented. This ILS contained the *input box app*. With this tool, students in the control condition could make a summary. The students could type the information they wanted to include in the white block in the middle.

Figure 4. Representation of the Input Box app in the summary condition.

Texts. The texts in the ILS were created based on an already existing textbook for geography education, ‘De Geo’ of ThiemeMeulenhoff (Ten Brinke, De Jong, Jutte, Padmos, & Van Veen, 2016) and edited with help of a geography teacher. The outline of the paragraph from the textbook on climate change was used to organize the texts and incorporate the right information for this study. By composing texts with the described strategy we were able to create texts that were on the right level of complexity for third grade students.

It was chosen to write three texts for this study, which all had an informative character and contained information about the topic ‘climate change’. Text one contained information about causes of climate change, text two described the effects of it and text three concluded with providing information about measures to diminish climate change. The complexity of the texts is the same for all three texts due to the use of the existing textbook. Only length differed, text one contained 358 words, text two contained 259 words, and text three 258 words.

Test. In order to investigate how well students comprehended the presented information after graphical or non-graphical processing, students made a test in ‘Qualtrics’. With this test was examined how well students could recall information and was tested whether they could explain the described phenomena about climate change on their own. Students could earn 36 points in total when all questions were answered correctly.

Students had to answer 15 multiple choice questions. The purpose of these questions was to test whether the students could indicate the right cause-effect relationship between the two definitions of the question. An example of one of the questions is *‘How can energy transition reduce the global warming rate?’*

In addition to these questions, students had to answer four open-ended questions. The purpose of the multiple choice questions was to test whether students could describe cause-effect relationships about the questioned definitions correctly. An example of a question is *‘What influence does energy transition have on greenhouse gas emissions?’*

Procedure

In total, two sessions were planned to conduct the experiment. Every session took 40 minutes. The total duration was one hour and twenty minutes. In this time, students read the texts, processed the texts and made the test.

Session 1. First, students received instructions from their teacher about the activities of the experiment and received instructions on how to register for the ILS. After they were logged in, written instructions about the task and the informed consent were presented. Students were asked to fill in descriptive questions. After these questions, the students received written explanation about the task. Subsequently, they were asked to read the three texts which were presented in the ILS. Afterwards the students were asked to, depending on the condition they were divided to, process the texts and produce a concept map or summary. The students had 40 minutes for the activities of session 1. The teacher timed this and let the students know when they had to stop. After this students logged off and closed the ILS.

Session 2. During the second session, students were asked to log in with their previously used code. The teacher of the students commissioned them to study the product they made in session 1 for ten minutes. After the ten minutes were over, they received the link to the test. The students had 25 minutes to complete the test.

Analysis

Coding

Concept maps and summaries. The content of the concept maps and summaries was analysed in order to identify how students created links between the information from the texts that were required to read. The products were analysed on correctly linked definitions or phenomena. There were no required or standard sentences that should be met to indicate this correct link, the correct proposition of two concepts that are related to each other was enough. The students of both conditions received the same texts, therefore the same links could be created between concepts and ideas. However, students in the concept mapping condition were requested to present those links graphically while students of the control group used text to indicate links. In Figure 5 and 6 an example is presented of links that are made in both

conditions. In both figures have students made the link between isolating homes in order to save energy. In Figure 5, this link is presented graphically by first posing the statement ‘better isolating of houses’ which is indicated in the yellow box. The student linked this with an arrow to the effect in the green box ‘less wasted warmth’. In Figure 6, this same link is made but is represented textually. Here, the students states that *‘... at home, there can be improved as well by better isolating the house.’* Both students indicated the same link but represented the content differently.

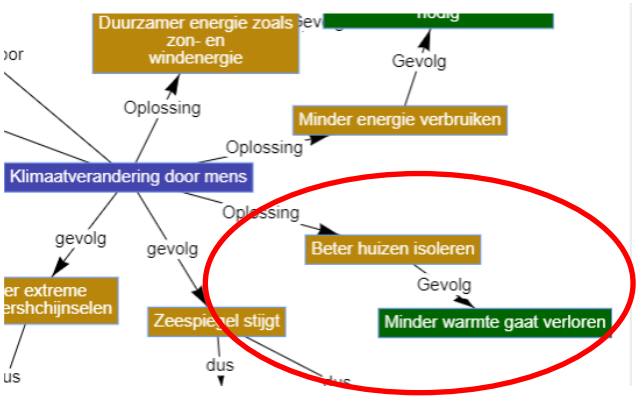

Figure 5: Graphical represented link on saving energy by isolating houses.

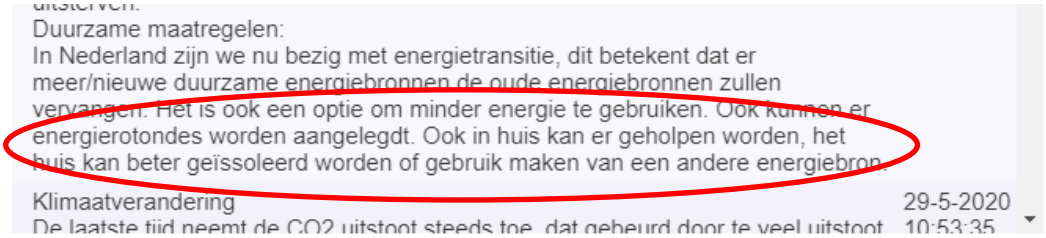

Figure 6: Textual represented link on saving energy by isolating houses.

The links made in the concept maps and in the summaries were both analysed using the same scheme (Appendix A). In the analysis, two types of links are distinguished. Links created between pieces of information that were presented in the same text are referred to as ‘one-text-links’. Links that are created between pieces of information originating from different texts are referred to as ‘multiple-text-links’. The scheme presented in the appendix provides a list with possible links that could be made. The colour of the boxes indicates from which text the information originates. A maximum of 27 one-text-links and 23 multiple-text-

links could be made. The coding and analysing of concept maps was done in Graasp, the summaries were coded in Atlas. For the links made in the products, Cohen's Kappa was calculated, and found to reflect a moderate level of inter-rater agreement between the first corrector and the second corrector (K=.20).

Multiple choice questions. The multiple choice questions were analysed on correctness. Only one answer of the options was correct. For every correct answered question, students received one point which could count up till a maximum score of 15 points. The number of points on the multiple choice questions is analysed separately from the open ended questions among the two conditions and as total score combined with the score on the open ended questions.

Open ended questions. The answers on the open ended questions were coded and scored in Atlas with help of the definition scheme (Appendix A). The questions examined the stored knowledge originating from the texts that were required to read. Answers given on the open questions were scored on correctness of used and explained knowledge. Students could receive five points for open question one, two and four. For open question three, there were six points to earn. The number of points depended on the correctness and completeness of their answers. In total, students could earn 21 points for the open questions. The minimum score on the open questions could be zero when students did not answer any question correctly.

For the open questions, Cohen's Kappa was calculated, and found to reflect a good level of inter-rater agreement between the first corrector and the second corrector (K=.64). The number of points on the open ended questions is analysed separately among the two conditions and is combined with the score on the multiple choice questions to form the overall test score.

Constructs. The constructs that are analysed with the processing products and the test, are integration and comprehension. Integration is measured with the number of links made in the products, and has three levels; the '*one-text-links'*, '*multiple-text-links*' and the total number of links. To study if students of one particular condition made more links, the difference in one-text- and multiple-text links are separately analysed among the two conditions. To examine the overall performance, the total number of points on the products is analysed among the two conditions.

Comprehension of the texts is measured with the number of points that students received in the test. The test results contained the points on the multiple choice and open ended questions. To test the comprehension, the results on the multiple choice questions and the open ended questions were analysed separately to test if the students of one particular condition performed better on one specific type of question. The total number of points obtained is analysed to test whether one of the two conditions outperformed the other and better comprehended the texts.

Results

Descriptive Statistics

Table 1

Descriptive Statistics on Number of Links and Test Scores

	Concept Map				Summary			
	M	*SD*	Min	Max	*M*	*SD*	Min	Max
Links	5.18	3.55	1	12	6.55	2.49	3	12
Test	12.64	5.17	5	24	12.64	4.95	7	24

Integration

In order to answer the research question *"What is the effect of using concept maps on*

multiple-text integration compared to a non-graphical strategy?" the difference in number of links was studied. The total number of links is the sum of the two types of links, the one-text-links and the multiple-text-links between-text links.

An independent *t*-test was carried out to compare the total number of links made by students of the concept map condition (*n*= 22) to the total number of links made by the students of the summary condition (*n*= 29). The Shapiro- Wilk statistic was significant for the concept mapping condition (*p*= .044) indicating that the normality assumption was violated. However, after visual inspection in combination with a sample of >40 participants and a non-significant Levene's test, assuming equal variance, there was decided to continue with the *t*-test. The *t*-test was not statistically significant indicating that there is no difference between the total number of links of the concept mapping group and the summary group, $t(51)= 1.62$, $p=.112$.

To specify whether there was a difference in the number of multiple-text-links between the two conditions, a MANOVA was conducted. However, the assumptions were violated and after inspection there was concluded that this was the consequence of the almost absence of multiple-text-links for both conditions. Therefore, there was decided to only investigate whether the conditions differed on number of one-text-links that were made. Theoretical foundation for this absence will be discussed in the discussion section.

To analyse the integration of the definitions originating form one text, a *t*-test was conducted to analyse whether there was a difference between the two conditions. With underlying assumptions not being violated, the test was carried out. The *t*-test showed no statistically significant difference between the total number of links of the concept mapping group and the summary group $t(51)= 1.90$, $p=.064$. Thus, the results showed no significant difference in the number of one-text-links that were made between the two conditions.

Comprehension

In order to answer the research question *''What is the effect of using concept maps on multiple-text comprehension compared to a non-graphical strategy?''* the difference in number of points on the test will be studied. An independent samples *t*-test was conducted to compare the total scores on the test achieved by the students who made a concept map (*n*=22) to the students who made a summary (*n*=29). Assuming that all underlying assumptions were met, the test was carried out. The *t*-test resulted in no significant difference between the total score of the concept mapping group and the summary group, $t(49)=.11$, $p=.913$. Overall comprehension, what was tended to measure with the total score that students achieved, appeared not to differ among the two groups.

To analyse the comprehension of students and test whether one of the conditions performed better on one of the type of questions, a MANOVA was carried out. The univariate normality was assessed with the Shapiro-Wilk test and boxplots. The assumption of normality was not assumed. However, after contact with an expert and taking into account the cell sizes of the conditions, the MANOVA test was still carried out, also because of the robustness of a MANOVA test to violated normality to a significant degree. Furthermore, no multivariate outliers were indicated, supporting the assumption of multivariate normality. There were no very strong correlations between the dependent variables, meaning that there was no multicollinearity. Additionally, the assumption of homogeneity of variance-covariance could be assumed because of a non-significant Box's M at an alpha level of .001. Outcomes of the test showed no significant effect of the condition students were divided to. Thus, students who made a concept map did not perform better on one of the types of questions than the students who made a summary, $F(2, 48)= .714$, $p= .495$. The analysis of the dependent variables showed no individual effects for the concept map and summary variables.

Discussion

Learning from reading multiple texts is dependent on students' integration and comprehension of these texts (Afflerbach & Cho, 2009; Alexander & DRLRL, 2012; Strømsø et al., 2020). In general, students have difficulties with this integration of multiple texts which, as consequence, hampers their integration and understanding (Cameron et al., 2008; Rouet, 2006). The current study compared two instructional strategies, graphical and textual processing, in order to determine whether graphical processing might positively affect students' integration and comprehension of multiple texts. However, there was no difference found in integration and comprehension between students who used graphical processing as opposed to students who used textual processing. Still, our study supported previous finding indicated by the absence of 'multiple-text-links' which shows difficulties with integrating multiple texts.

Concept Mapping as Strategy for Multiple- Text Integration

In the current study, students who processed texts graphically did not show better integration of information than the students who processed the texts textual. There was no difference found in one-text-links between the conditions, indicating that none of the two groups showed better integration of information from one text. Both conditions showed almost absence of multiple-text-links, which indicated that information from the presented texts was not combined and integrated. Results found in this study confirm the findings of Cameron et al. (2008) and Rouet (2006) that students experience difficulty with linking definitions of multiple texts with each other to incorporate it into a bigger, coherent whole. This places importance on further investigation of what type of instructional strategies might help students with better integrating multiple texts.

An initial explanation for absent multiple-text-links and no better integration of the texts when processing them graphically rather than textually may be the identical text

characteristics of the texts that the students read in this study. As mentioned by Perfetti et al. Britt (1988), paying attention to the intertext characteristics in order to create an intertext model is of great importance for building meaningful knowledge representations by integrating information. The texts in the experiment were deliberately written with one textbook to ensure that the texts were on the right and same difficulty level. However, the style of the three texts is due to this choice identical and written by one author. Students might have recognized this identical writing style which also shows similarities with the textbook which is used during geography education. This similar writing style might not have encouraged the students enough to pay attention to other characteristics of the texts. Without this specific focus, the construction of an intertext model is hard, which might have hampered the construction of the intertext model in this study (Perfetti et al., 1988). Due to this incomplete intertext model, a complete documents model is absent. This affects the definitive integration of meaningful knowledge representations. A complete document model in which the intertext characteristics and the situation model are linked is needed, in order to create new meaningful representations.

Concept Mapping as Strategy for Comprehending Multiple Texts

Graphical processing of multiple texts did not result in better or worse comprehension. Students' personal characteristics, such as motivation, might underlie the absence of an effect. List and Alexander (2019) mentioned in their study that personal characteristics may influence the comprehension outcomes due to personal perceptions and motivation of students. Motivation influences persistence to complete a task and as a results, students who lack motivation to persist in completing the task will be less likely to process the presented information correctly. Not correctly processing the information will result in worse integration and in less understanding of the presented information (List & Alexander, 2019). The teacher of the students who participated in the experiment mentioned that students

showed problems related to lacking motivation in the weeks before the experiment took place due to the home based education. For this study, the students had to carry out the experiment at home and therefore, students who might have had difficulty to persist and fulfil the task could not be motivated to go on and could easily get off the task. Not persisting in the task and not remaining focused might have been one of the reasons for not seeing benefits in comprehension after generating a concept map.

Other factors influencing the motivation for the experiment might have been the interest in the topic and the prior attitude towards the assignment. Even though there was nothing asked about interest or the attitude of the students, it might have been of importance to explain current results. The affective engagement, interest and attitude of students are important for meaningful reading because it reflects students' motivation to fulfil the task (List & Alexander, 2019). When students are not interested in the topic and experience a negative attitude towards the assignment, they may be less motivated to persist in fulfilling the task. Measurement of interest and attitude might therefore be important for future research, in order to compare if highly motivated students benefited more from processing texts graphically than students who are less motivated.

Limitations and Strengths of Current Study

Possible influence on the results in this study may be the increased cognitive load that students experienced as a result of generating a concept map. In the current study, students did not require a specific amount of experience with making a concept map, which means that it might have been the first time that students made a concept map. Chang et al. (2002) found in their study that students experienced higher cognitive load when they had to create a concept map from scratch without scaffolding. In the current study students received some practical explanation about the tool that they had to use in the ILS. However, the students did not receive guiding on how to exactly construct a concept map and what content should be

incorporated, this might be one of the reasons for the task being too demanding. The students might have used a high level of attention to construct the skeleton of the concept map resulting in only a few resources being left for meaningful comprehension. Thus, the influence of cognitive load might be an explanation for the low benefits of the graphical strategy in this study and this influence should be taken into account when further research is conducted. An example for future research might be a training that provides students with guidance on how to select appropriate key words for the concept map. However, there is little chance that the chosen topic of the experiment caused cognitive overload. The texts students read were adapted from an existing textbook which guaranteed that the chosen topic fitted well with the current knowledge level of the students and prevented for too complex word use.

It was not possible to monitor the behaviour of the students during the experiment. It is not clear how dedicated and serious the students participated and carried out the task. After the analysis of results, it appeared that not all students generated a concept map using their own words and that some questions of the test were not answered. After contact with the teacher of the students, it appeared that these incomplete products and tests might be the result of difficulties with working at home. This appearance gave reason for eliminating these students from the study. For further research, it would help to increase the sample size for finding usable results.

Despite the exclusion of students due to the online character of the experiment, the online character made it possible to continue the study. The current developments showed us that online education can be used at all times when a device and internet access are available. Furthermore, the development towards more digital tools in education is corresponding to the character of the experiment. The anticipation on this development with the use of an ILS is a

representation of the reality and might be a good training for the students. Unless the results of the study, this experiment shows that online concept mapping can still be carried out.

Implications for Future Research

The current study focussed on the benefits of using a graphical strategy, in comparison to a non-graphical processing strategy for multiple- text integration and comprehension. There was no clear answer whether the use of a graphical processing strategy improved the integration and comprehension of multiple texts. Unambiguous and in line with previous research is the result that students face difficulty with integrating multiple texts, indicated by the absence of multiple-text-links. Further research might focus on textual and personal characteristics in order to increase integration and comprehension and to diminish the difficulty that students experience.

Textual characteristics might be of interest through the contribution of these characteristics to students' integration and comprehension. Rouet (2006) found that textual characteristics such as genre or word use able students to differentiate the sources which makes it possible to determine the contribution of the document to the overall representation of the topic. In the current study, textual characteristics were identical for the texts. The texts were all written in the same style and had the same genre. For further research, the use of sources that variate more in textual characteristics in combination with processing the information graphically may be of interest in order to investigate whether students benefit in this situation from graphical processing. Such studies might offer new insights into constructing appropriate educational assignments that include graphical processing.

Additionally, students with prior knowledge might have been able to create a concept map with less need for reading to write down information about climate change (Britt et al., 2018). Influence of this appearance might have limited the measuring of the effects from the graphical processing strategy. For further research, prior knowledge can be taken into account

in order to investigate whether this helps students to process information graphically. It might be possible that when students already possess some knowledge, they are better able to select and determine what knowledge is fitting into the concept map (Britt et al., 2018).

Furthermore, Chang et al. (2012) found in their study that scaffolding when constructing a concept map increased the positive effect of using a concept map to process information for assignments containing one text. In the current study no scaffolding was provided. However, it might be of interest to study what the effect of scaffolding is when students generate a concept map with guidance when the assignment includes multiple texts. By exploring possible benefits of scaffolding, boundary conditions for successful multiple-text integration can be established.

Conclusion

It has been argued that learning from multiple texts is difficult for students due to unsuccessful integration of the texts (Beker et al., 2019). In the current study, there was aimed to investigate whether a graphical strategy might increase students' successful integration of multiple texts in order to improve comprehension. There is aimed to answer the question '*'What is the effect of using concept maps on multiple-text integration and comprehension compared to a not-graphical strategy?''*. In this study, there was no increase or decrease found in students' integration or comprehension of multiple texts as a result of processing information graphically. However, the results of the current study confirm what previous studies on multiple- text use found, students participating in the current study showed as well problems concerning integrating and comprehending the information originating from multiple texts. In this study, there was investigated if graphical processing might benefit students with integrating and comprehending information of multiple texts. Results showed no effect of concept mapping being more beneficial over summarizing. Possible other factors were identified which might have interrupted the effect of graphical processing. Motivation

and cognitive load were marked as possible influences which might have hampered integration and comprehension.

However, the results of the current study provided a first step towards gaining more insight into using a concept map as a graphical, instructional processing strategy. It can be used as starting point in revealing other factors that might facilitate learning from multiple texts when information is processed graphically. Hence research is still needed in order to investigate what is needed to support students in optimally using graphical processing strategies in order to meaningfully learn from multiple texts.

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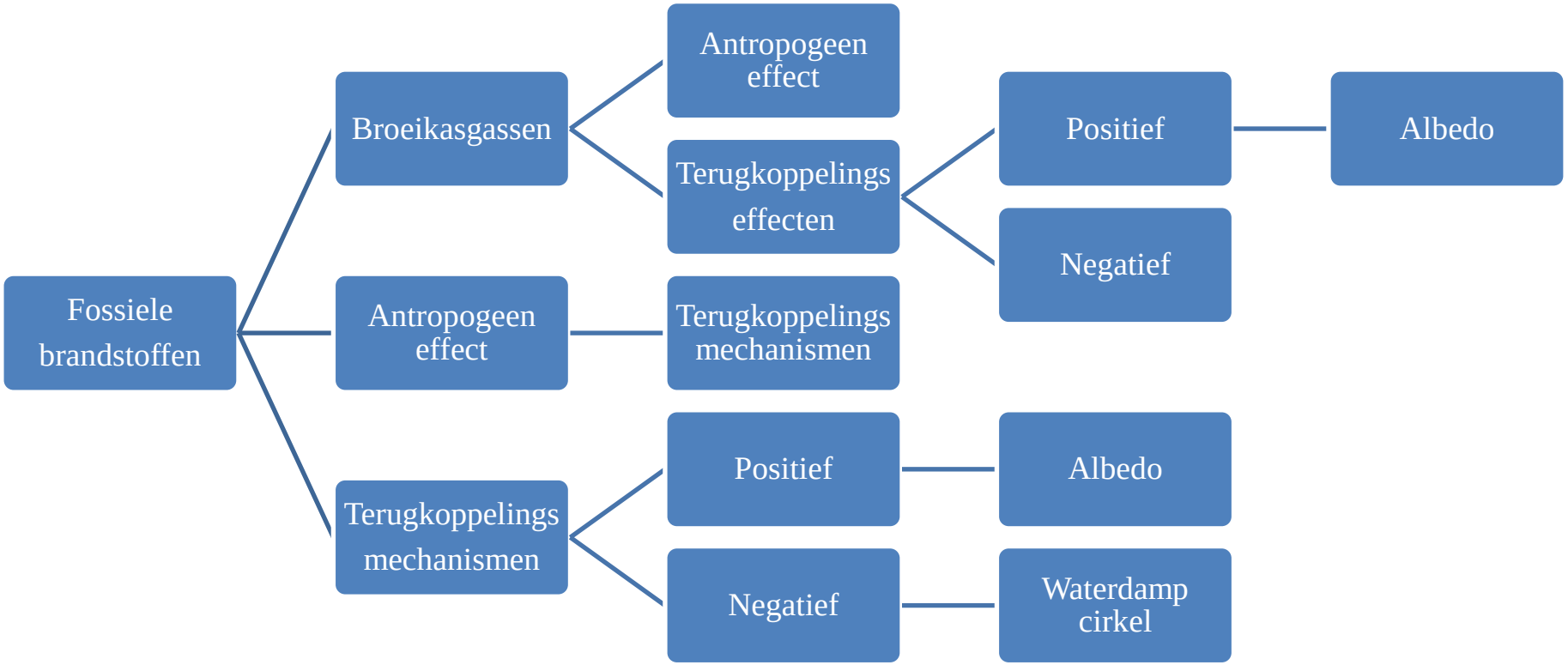
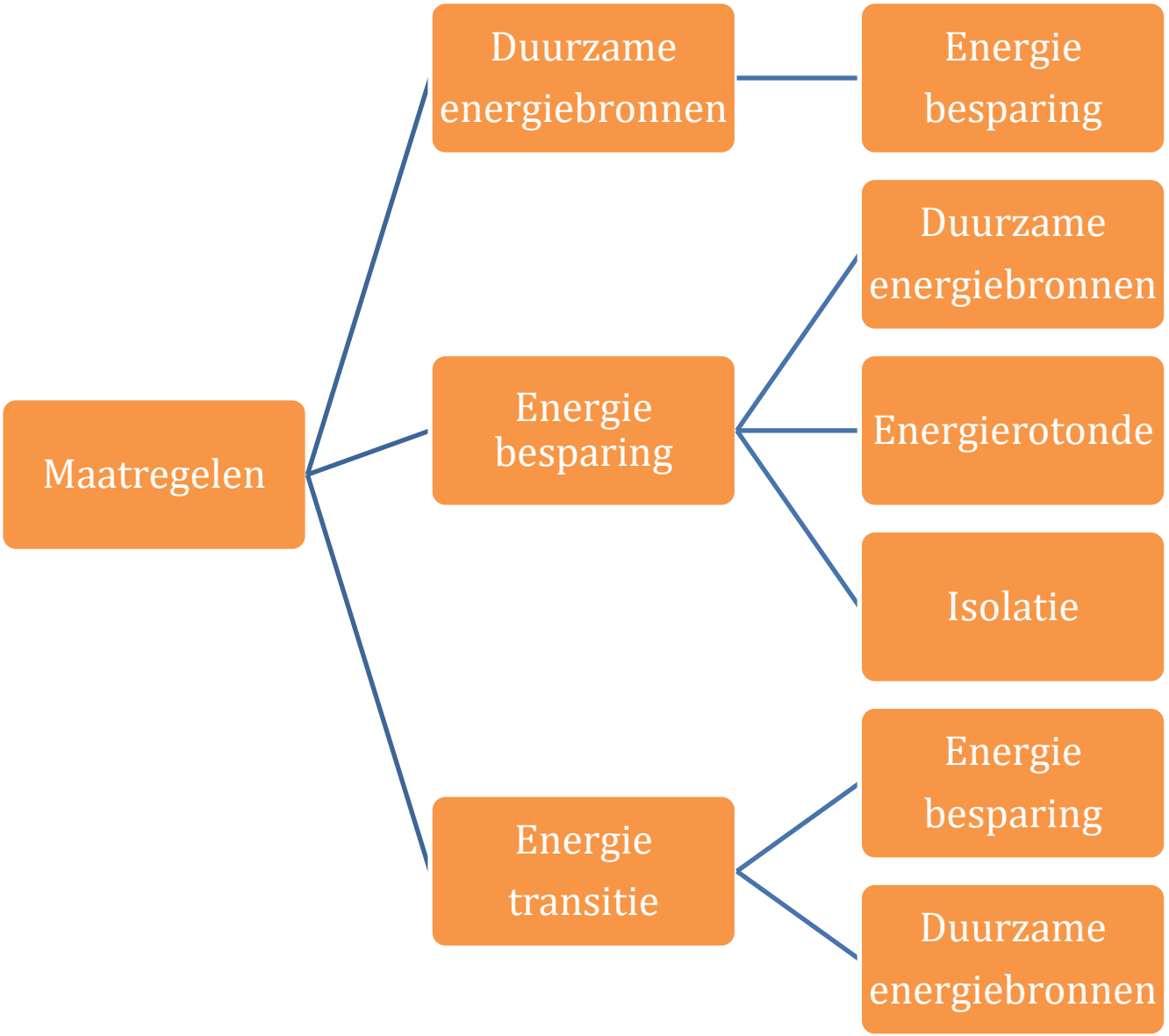
Appendix A – Definition Schemes

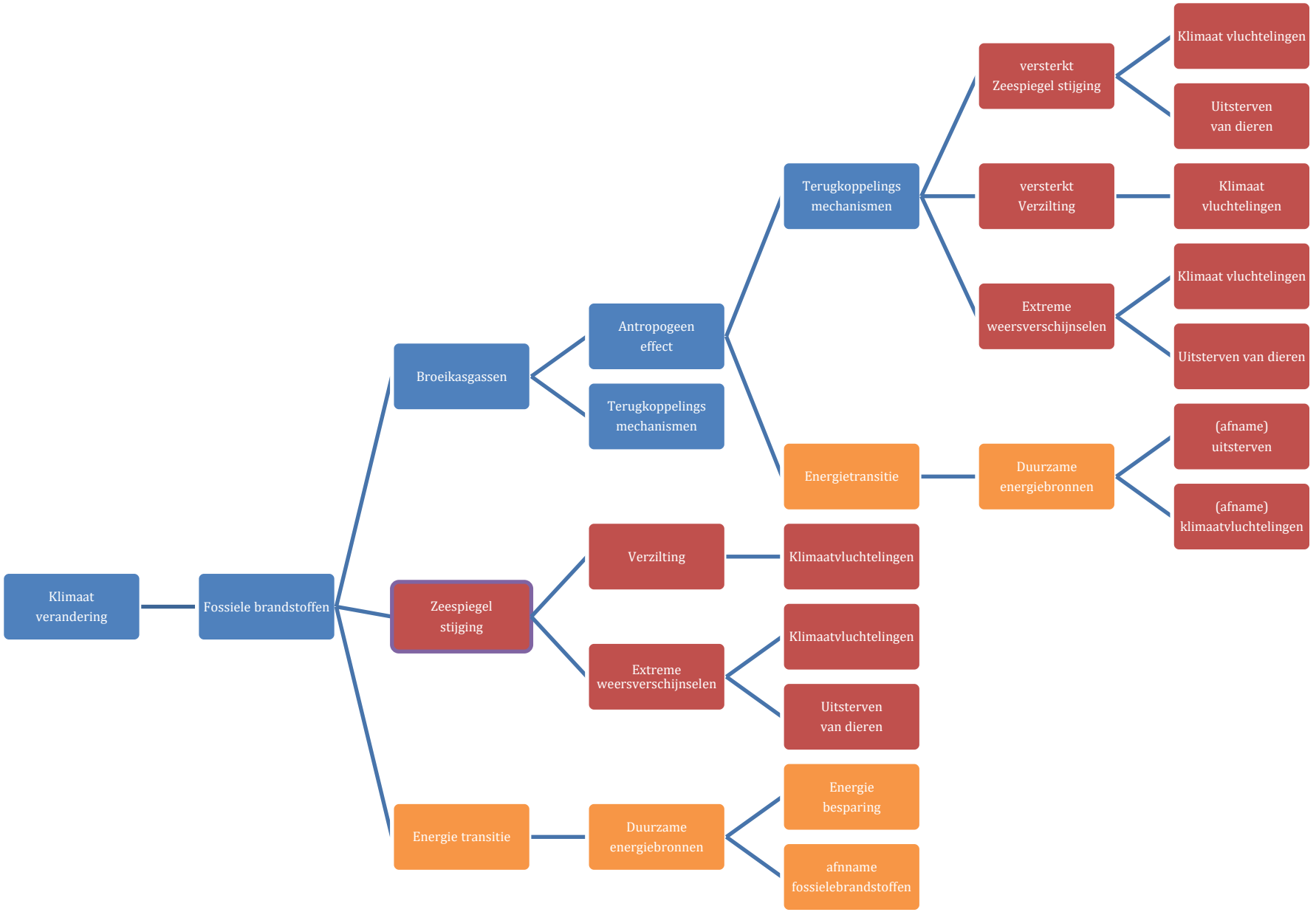
Text 1



Text 2


Opwarming
Zeespiegelstijging
Verzilting
Klimaatvluchtelingen
Klimaatvluchtelingen
Uitsterven van dieren
Extreme weersverschijnselen
Klimaatvluchtelingen
Uitsterven van dieren


Maatregelen
Duurzame energiebronnen
Energie besparing
Energie besparing
Duurzame energiebronnen
Energierotonde
Isolatie
Energie transitie
Energie besparing
Duurzame energiebronnen


Klimaat verandering
Fossiele brandstoffen
Broeikasgassen
Antropogeen effect
Terugkoppelings mechanismen
Terugkoppelings mechanismen
versterkt Zeespiegel stijging
Klimaat vluchtelingen
Uitsterven van dieren
versterkt Verzilting
Klimaat vluchtelingen
Extreme weersverschijnselen
Klimaat vluchtelingen
Uitsterven van dieren
Energietransitie
Duurzame energiebronnen
(afname) uitsterven
(afname) klimaatvluchtelingen
Zeespiegel stijging
Verzilting
Klimaatvluchtelingen
Extreme weersverschijnselen
Klimaatvluchtelingen
Uitsterven van dieren
Energie transitie
Duurzame energiebronnen
Energie besparing
afnname fossielebrandstoffen