MAPPING SOME DESIGN CONSIDERATIONS FOR LEARNING FROM TEXTS

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Abstract. Text study involves following a sequence of steps that assist in managing the complex process, applying various cognitive and metacognitive strategies, and constructing intermediate external representations. A procedure is proposed for constructing a sequence of external representations, based on a text to be studied, to aid the comprehension processes. These representations include a marked phrase list selected from the source text, a question list, descriptive and organizing concept maps, sentence and text summaries, and a model map reflecting a desired end for the comprehension process. Design considerations for producing technological tools for these tasks are discussed.

1   Introduction

Our concern is the process of learning from texts and how this process can be aided by using tools, such as Graphic Organizers (GOs), including concept maps. First, we briefly review and categorize the abundance of methods, techniques, or strategies (our preferred term) for comprehending texts that were introduced and applied at all grade levels with students of all ranks, including underachievers, developing students, and students with learning disabilities (e.g., Block and Pressley, 2002). Then, we will describe and demonstrate the use of these tools in the application of one reading comprehension strategy. Finally, we shall list several considerations of designing comprehension tools.

The term Strategy refers to a plan of action designed to achieve a particular goal, in our case the goal is learning and understanding a particular text or texts, so that we can answer questions about them or apply our understanding in new contexts, such as in writing an essay or in other tasks that utilizes our new knowledge. We broadly categorize this multitude into three complementing approaches: (1) managing and sequencing the reading process, (2) applying a single or a compendium of cognitive and metacognitive strategies, and (3) constructing external representations during the learning process.

One approach is to manage the process of reading and studying in general, a "do this and then do that" strategy. Some of us are familiar with the SQ4R reading strategy, an acronym which stands for: Survey in order to get the general idea of the content, structure, organization, and plan of the text; Develop Questions that provide a purpose for reading (this also activates prior knowledge); Read each section of the text to answer questions that were developed in the previous step; Recite - write summary answers to questions that were previously developed; Review outlines and previously generated notes and summaries to be able to retell what was read; And Reflect by linking together the information from the entire text and critically thinking about it (Richardson & Morgan, 1997). SQ4R was emanated from SQ3R (omit the Reflect), which dates back to Robinson (1946) that perhaps dared not use "reflection" in the heights of the Behaviorism. A myriad of other related cousins exists: PQRST (Preview, Question, Read, Summary, Test), SRR (Survey, Read, Review), PQ4R (Preview, Question, Read, Review, Recite, and Rewrite), REAP (Read to discover the author's ideas; Encode into your own language; Annotate your interpretation of the author's ideas; Ponder whether the text information is significant), and more distant relatives such as the KWL (what I Know, what I Want to learn, and what I did Learn) introduces by Ogle (1986), which emphasizes cognitive and meta-cognitive knowledge management. These strategies are designed for learning expository materials. Some, e.g., SQ3R, were introduced for remedial college reading, and later adapted for earlier grade levels, and some, e.g., KWL, were designed for primary grade instruction. To summarize, the various formulas act like external regulation schemes, similar to the concept of

an external Locus of Control (Rotter, 1966).

The second, strategy approach is to apply a particular activity or set of activities at certain points throughout the study process. A list of such strategies includes predicting, questioning (generation and answering), seeking clarifications, creating mental imagery, associating to ideas in the text, summarization, identifying text structure, looking for patterns and principles in ideas presented in a text, backward reasoning, interpreting ideas in the text, negotiating interpretations with others, activating prior knowledge, identifying word meanings, graphic organizers, and comprehension monitoring (National Reading Panel, 2000; Pressley, 2002; Trabasso and Bouchard, 2002). Several classifications are in place here. We listed single strategies but as the process of reading is a complex one, different phases of the process may benefit from different strategies. For example, activating prior knowledge is best suited at the point prior to reading a text segment rather than after reading it. The KWL does just that. It proposes application of an ordered set of strategies: prior knowledge, setting reading goal, and monitoring comprehension. So strategies can be combined as in the case of KWL above or in applying Reciprocal Teaching (Palincsar and Brown, 1984) that include prediction, question generation, summarization, and seeking clarification. Reciprocal Teaching, as its name suggests, is applied in a cooperative setting, where a small group of students jointly learn a text. Another classification is to cognitive and metacognitive strategies. KWL can be considered a metacognitive strategy that regulates the sequence of applying strategies and monitors outcomes. It does not tell us what to do when we actually read, except keeping in mind KWL, so at breakpoints we can apply it. So is RT where the group monitors the application and the interim generated mental products that are expressed in the students' discourse. A third classification is the nature of the mental products of applying strategies. It can just be a flitting or a more articulated thought that is echoed in working memory when we individually study a text. Or, it is also partially or elaborately verbally expressed during a group discourse. In both cases there are no external lasting traces, unless the individual or the group produces external representations of mental dialogues. Those can be in a form of verbal products such as summaries and written notes. Or, the external representations can be partially graphical as we underline, list our notes, or produce various graphic organizers, such as concept maps, flow diagrams, trees, or tables (see classification schemes in Horne, 1998; Robinson, 1998; Winn, 1987; also see a table of visualization methods in http://www.visual-literacy.org/periodic_table/periodic_table.html).

This brings us to describe the third approach of strategically constructing external graphical representations of the text or texts that are studied. McAleese (1998) described the process of creating a concept map "to make sense of something that is knowable" (pp. 266-267) in the sense of Novak's work (Novak, 1998; Novak and Canãs, 2006). This is done within a virtual space that McAleese termed a knowledge arena. The knowledge arena consists of active internal mental (working memory) objects, external representations of the internal objects (the elements of a constructed concept map), and the dynamic interplay between the two conceptual structures. Internal objects are selected to be included in a developing concept map, so even if those objects are no longer active in working memory, they are still available for an easy map look-up and deliberation. Thus, the contents of working memory were selectively off loaded to the map. An extended concept of working memory includes the developing map (actually, parts of the map that the learner attends to) and the current active internal working memory set. Mapping construction facilitates application of several metacognitive strategies: monitoring the external construction vs. the contents of the internal working memory (self-regulation, self-confrontation and reflection in and on action) and it assists in managing cognitive load (Sweller, 1988). This is somewhat equivalent to the process of self-explanation, which is offered by Ainsworth and Loizou (2003) as one of the mechanisms underlying the function of diagrams in understanding a scientific text.

So far we have discussed the role of concept mapping in describing and elaborating a given state of knowledge. Now enters a complication: How to construct external representations when we study from a text in order to facilitate its understanding and gain new knowledge? The text is an external object presenting mainly verbal information linearly. The text's format evolved through thousands years, perhaps initially used to list properties or counts of goods and eventually depicted longer narratives that were first orally presented and so evolved other genres (Olson, 1994). Is the text format efficient? Well, we adapted over the generations. The textual format evolved and we developed strategies to cope with it. We also developed alternative presentation schemes that include visuals and graphic organizers of all sorts for general or specific purpose comprehension. But the basic format is still the verbal text and developing readers are still struggling to comprehend it and evolve to be literate. Graphic organizers aid learning from texts, as several syntheses of research indicated (Institute for the Advancement of Education Report, 2003; Gersten, Fuchs, Williams & Baker, 2001; Moore & Readence, 1984; National Reading Panel Report, 2000; Nesbit & Adesope, 2006). But how is it done? We resort to Kintsch's (1998) Construction-Integration model of compre-

hension. This model is based on two stages that describe the transformation of information into knowledge from a textual source. In the first, construction stage, the information is assembled from external sources –texts--or retrieved from the learner's knowledge-base, and is functionally interlinked (propositions network) in working memory. At this stage, there is no significant intentional filtering of the information, based on relevance and consistency. During the second, integration stage, the information details and the links between them are examined, and minor, inconsistent, or irrelevant information is filtered out (deleted or discarded). At this stage, intentional processes of information re-organization and generalization are at work, and macro-propositions are constructed and related to other macro- and micro-propositions. This process is iterative. When applied to texts, it uses natural text units, such as sentence and paragraph boundaries to mark pauses and shifts from construction to integration, as is evidenced in eye movement research (Just & Carpenter, 1980; Reichle et al, 2009). The Construction-Integration cycles describe formation and manipulation of mental entities-propositions-that form the represented meaning of a text. But the input to this process can come from additional external representations, such as maps or oral discussions, and the formed propositions may be translated to an activity such as marking the text, writing, or forming a concept map. In turn, those external traces constitute additional sources for deliberating the studied text. Such an elaborate activity should be controlled by management strategies and by the multitude of cognitive and metacognitive strategies that were mentioned above.

A construction sequence of external representations that is contiguous to SQ4R is outlined in Table 1. It consists of several generic representation formats: text, list, map and chart. In addition there are tools for editing each representation and tools for transforming one representation type into another type, similar to Conlon's (2008, 2009) and Kozminsky's (1992) proposals. In the following section we briefly present a simulated example of applying this procedure to a lengthy text. Then we discuss some design considerations for developing such tools.

2   Graphic organizers construction sequence: An example

We apply the construction sequence to an 1884 words New York Times article on global warming (Revkin, 2009), published shortly before the Copenhagen Talks and included a picture of a polar bear walking on melting ice. Upon encountering the title of the Source Text, our meager knowledge brought up Al Gore waving vigorously before a presentation of melting glaciers and recalling our warming summers. The global warming even won Gore a Noble peace prize. The first step will be to develop a Knowledge Map, using a tool like Cmap, but it will be very impoverished in this case. The second step will be to skim the article and produce a Marked-up Text, using tools available for example in word processors. We mark up headings, major phrases distinctively marking relations among phrases. From the text we extract the marked phrases and headings and produce a Phrase List (Table 2 for a fragment of the list). The list is about 580 words. It contains thirty entries, heading and selected unedited phrases. This list is further edited and reduced. It is used to develop a Question List. For example, one major question on the list is "Why the global warming issue is so complicated?" The Phrase and the Question lists can be used now to develop a Descriptive Concept Map. The phrases are extracted using an appropriate drag and drop tool to form nodes and relations in the map. Upon reading the text and consulting the trail of external representations, the descriptive map is transformed to an Organizing Map (see Figure 1). Headings or other structural clues in the source text or the other representations are specifically framed in the map, using rectangles. Content nodes are in ovals. The map is hierarchical and can "read" top to bottom, left to right, to follow the major rhetorical markers (Nathan and Kozminsky, 2004). This will be used to develop a Sentence Summary representation, using a sentence generation tool, such as in Conlon (2008). Each node is read with its adjacent nodes to form a potential sentence which can be edited by the student. The next step is to produce a Text Summary were all the sentences are coherently related (Table 3). The final step is to develop a Model Map presenting in a map format the understanding of the text and answering the major questions (see Figure 2), in this case, the complexity of the global warming issue.

As we skipped some of the details of the process because of space limitations, we should note several important points. When we skim read, for example some newspaper articles, we can skip much of the process. But deeper understanding requires a more tedious reading phase. In that case recall that we started with an 1880 words piece which amounts to close to 1000 basic and compound propositions. At the end of the process we had in the Model Map just eight nodes holding compound propositions and twelve relations among them, totaling about 20 propositions. This

drastic reduction was accomplished through application of several representation tools and the remaining Model Map represents generalizations about "the complex issue of global warming", which is referred by the rectangular node (proposition) in the map. Note that we have not linked this node to any of the other nodes. It is actually linked to all of them, representing a super-ordinate construct that subsumes all the others. Studying is mostly a bottom-up affair, unlike knowledge activation which is a top-down one. So mapping tools, primarily aimed at knowledge description, may encounter difficulties in study situations or in thinking exercises, that require abstractions (Hoz, 2009). Also, understanding is not just about the information given but also noting possibilities beyond the explicit description. In the Model Map, note that one relation is marked with a question mark ("Buildup of greenhouse effect leads to [???] a global economic slowdown"). The build up of the model let up to the expression of this possibility and its further deliberation. The external representations facilitated the construction of this relationship.

SQ4R Step	Activity	External Representations Construction and Tools
SURVEY Preview	Skim and scan the text, in order to get the general idea of the content, structure, organization, and plan of the text. Surveying the text gives the "big picture" - a framework of the main ideas, which will help to hold the details together later. Read the titles and subtitles, captions accompanying graphics, overviews and summaries.	Mark relevant headings and major content phrases in the **Source Text**. Color-distinguish between structural and content headings or phrases. Export **Marked-up Text** to **Phrase List**
QUESTION	Develop questions that provide a purpose for reading. This results in spontaneous attempts to answer the questions based on information already known (knowledge activation), and maintaining attention while later reading to find answers to questions. One method is. This will also activate prior knowledge.	Turn headings and phrases into questions. Develop a **Question List** based on the Phrase List and Marked-up Text and add partial answers based on knowledge. Edit and drag-and-drop phrases from the phrase and question list into a **Descriptive Concept Map**.
READ	Read through the sections of the text to answer questions that were developed in the previous step. Reread unfamiliar words to recover its meaning from the context. If it is still unclear, mark it down and look it up when you finish reading. Study graphics and adjust reading speed according to the passage difficulty.	Add nodes and relate between nodes in the Descriptive Map. Reorganize the map by differentially framing nodes that contain structural information to form an **Organizing Concept Map** or other schemes, like charts.
RECITE	Write summary answers to questions that were previously developed. Rephrase in once own words. If a question cannot be answered - a reread is in place, sometimes revising the questions.	Generate a **Sentence Summary** from the maps, focusing on answering previously asked questions, and then edit it to form a coherent **Text Summary**.
REVIEW	Study outlines and previously generated notes and summaries to be able to retell what was read. Recall main points and sub points in the read text and look for relationships within the content.	Edit if necessary the previously constructed external representations.
REFLECT	Linking together the information from the entire text and critically reflecting on it. This helps setting the new learned facts and arguments with already known information. Also reflection is on how to use this information and clarifies what else should be learned.	Develop a **Model Map** based on the Organizing Map and Sentence Summary.

Table 1. SQ4R study procedure, its expected activities, and external representations constructed during study

1. Global Warming
2. **Overview**
3. Global warming has become perhaps the most complicated issue facing world leaders
4. On the one hand, as an increasing body of science points to rising dangers from the ongoing buildup of human-related greenhouse gases.
5. On the other, the technological, economic and political issues have gotten no simpler, particularly in the face of a global economic slowdown.
6. through Dec. 18, 2009, President Obama and other leaders announced that no formal treaty could be produced anytime soon.
7. the leaders call for reductions in emissions and increased aid to help developing nations adapt to a changing climate and get access to non-polluting energy options.
8. This would in theory give the nations more time to work out the all-important details.
9. Negotiators would then seek a binding global agreement in 2010, complete with firm emission targets, enforcement mechanisms and specific dollar amounts to aid poorer nations.
10. At the heart of the debate is a momentous tussle between rich and poor countries over who steps up first and who pays most for changed energy menus.
11. **Background**
12. Scientists learned that humans can be a powerful influence on the climate
13. since 1950, the world's climate has been warming, primarily as a result of emissions from unfettered burning of fossil fuels and the razing of tropical forests.
14. Recent research has shown that methane, is a close second to carbon dioxide in impact on the atmosphere.
15. Scientists are struggling more than ever to disentangle how the heat building in the seas and atmosphere will affect the strength and number of tropical cyclones.

Table 2. Unedited fragment Phrase List extracted from the Global Warming article (Revkin, 2009) with three types of markings: structural heading (Bold, no background), content phrases (light background), and relationships among phrases (dark background)

3   Design considerations of Text Comprehension Tools

There are several design considerations for developing and applying a suite of tools for studying texts, based on generation of external representations, including graphical mapping capabilities: (1) As the sequence of steps for studying a text seems complex, the proposed tools should not add unnecessary external cognitive load to the comprehension processes. (2) The action sequences to apply the various tools should be perceived intuitively as part of what we naturally do when we study (e.g., marking), and add minimal tool learning overheads. (3) The tools should facilitate interactive processing, both bottom-up processing from text to knowledge representations and top-down processing from knowledge activation to the constraining the information lifted up from the text. (4) The tools should allow flexibility of transformations among the external representations they generate and ability to edit the contents of the representations. By flexibility, we mean an ability to move from any one external representation to any other. Learners tend to apply with experience a predefined sequence of operations. In fact, teaching and adopting strategies, such as SQ4R, is such a predefined sequence. While efficient at times and reducing cognitive overhead (i.e., what should I do next?), it does not allow for individual differences. An instructional module of the tools can provide information about various strategies, but also retain flexibility of action. (5) The tools should include options for generating automated views of the transformed external representations. (6) The tools should allow handling partial information. Actually a tool can technically handle large amounts of information. A text or spatial representations, such as maps, can be composed of many rolling pages, huge screens, or embedded objects. But the amount of information that we can attend to in an external representation is limited to several lines or a page view. So, transformations of partial representation to another (partial) representation should be allowed, for example, marking up only a selection of the phrases in the list tool for its transformation into a map tool.
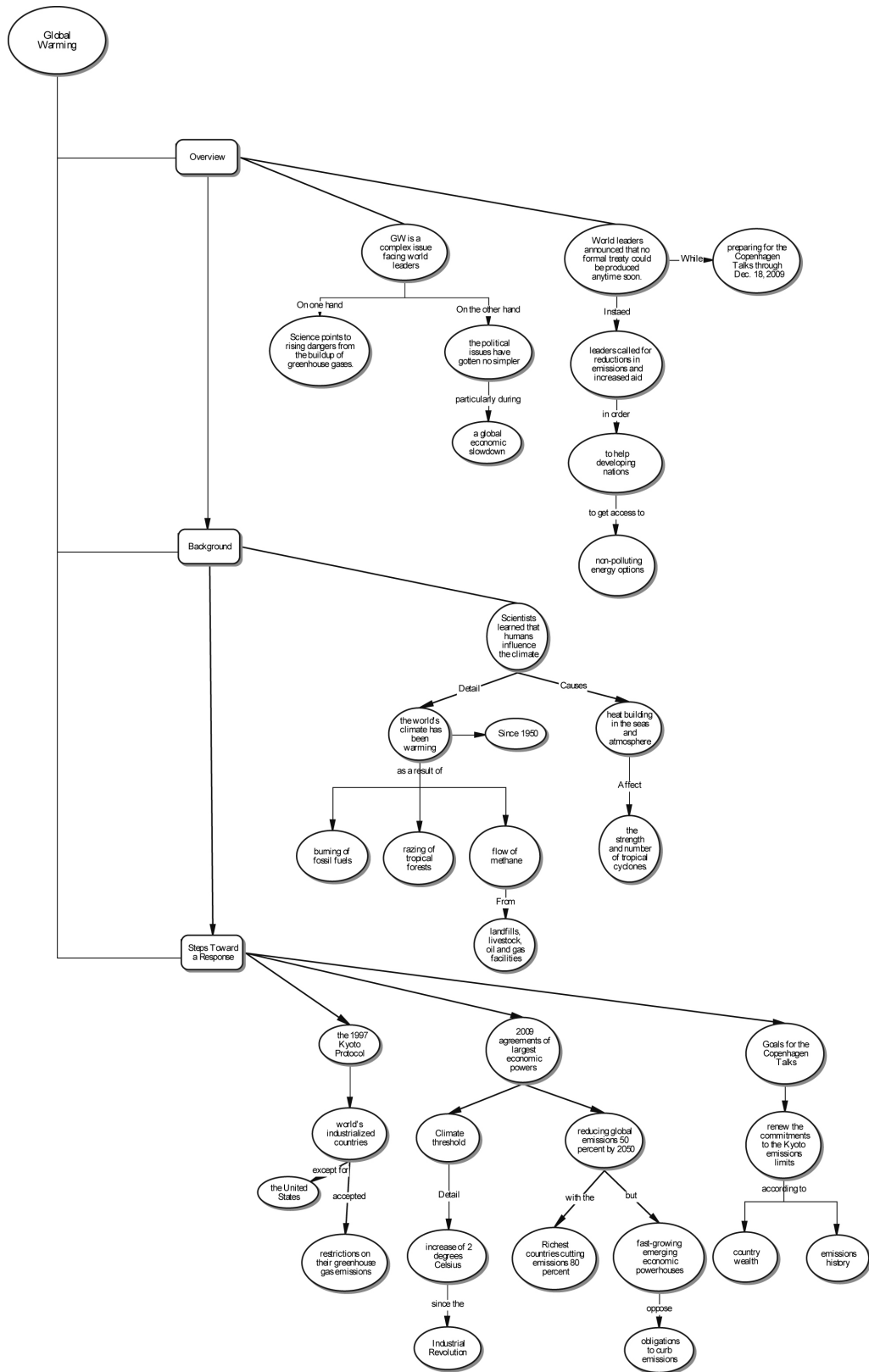
Figure 1. An Organizing Map for the Global Warming article (Revkin, 2009)

Global warming is a very complex issue, especially in the face of a global economy slowdown. Scientists claim that global warming is caused by increased build up of industrial gases that cause a greenhouse effect. World leaders can not agree on reducing emissions limits in the coming Copenhagen talks. On one hand there are the major industrial nations that produce most of the pollution but hold the majority of world wealth. On the other hand there are the fast-growing emerging economic powerhouses that don't want limits on their emissions that can effect their growth. This may result in just a minor achievement of renewing commitments to the Kyoto protocol.

Table 3. A Text Summary of the Global Warming article (Revkin, 2009)
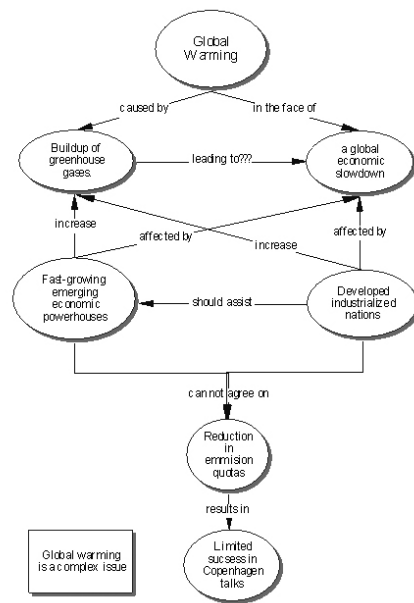
Figure 2. Model map of the global warming issue

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