Review of Graphic Organizer Research

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Introduction

Regarding how text comprehension can be enhanced, researchers and instructors have a variety of views (Dole, Duffy, Roehler, and Pearson, 1991). Among these various perspectives, research has consistently found that helping readers comprehend the main ideas of a text is one of the most important goals of reading instruction (Cunningham and Moore, 1986). Currently, there exist several methods for improving main idea comprehension.

Among these methodologies, there is one effective way for main idea comprehension, which is called the *graphic organizers*. Graphic organizers can be defined as diagrammatic and pictorial overviews of the argument (Waller and Whalley, 1987). One of the roles which graphic organizers are expected to play is to show the relationship between superordinate (more important) and subordinate (less important) information in a passage (Alvermann, 1981). We would review the graphic organizer research in the following sections in this paper. In section 1, the researches concerned with text comprehension were reviewed. In section 2, a variety of graphic aids, including graphic organizers, whose purposes are to facilitate text comprehension were introduced. In section 3, we reviewed recent research concerning graphic aids, including graphic organizers, in terms of for whom, when, and why graphic aids would be effective in facilitating text comprehension. In section 4, some limitations of graphic organizer research were pointed out.

1. Text comprehension

Reading a text is one of the daily activities. We read many texts such as newspapers, magazines, textbooks, or manuals. For a high school student, who is assigned to recite a passage of a famous novel from memory in a class, the purpose of reading the novel is to remember what is written in the novel. By contrast, for those who want to use a new MD player, their purpose of reading its user's manual is not to remember verbatim text, but to learn how to use it from the manual. The former type of reading activity is called *learning text*, and the latter is called *learning from text* (Kintsch, 1988, 1994).

1.1 Learning text and learning from text

Remembering a text is one thing and learning from it is another. By remembering a text, one is expected to reproduce it in some form such as verbatim, complete or its gist (Kintsch, 1994). Learning from a text means that one can apply the information or knowledge gained through reading text to another situation, whose purpose is not just for reproduction (Kintsch, 1994).

1.2 Propositional textbase, and situational model

Related to the level of readers' understanding texts, Kintsch's (1988) model suggests two different levels of mental representation. One is called textbase. The textbase is constructed by the elements and relations that are directly derived from text itself (McNamara and Kintsch, 1996). The reader is expected to have syntactic and semantic knowledge in order to construct textbase. At this level of representation, the interconnection is not solid and even incoherent. To make the interconnection of textbase more coherent, the reader need integrate textbase with his/her prior knowledge. When the information provided by the text, a textbase is elaborated from prior knowledge and is integrated with it, the situation model is constructed (Kintsch, 1994). Situation model can be seen as a deeper level of understanding.

1.3 The mental representation which graphic aids are to help readers construct

As we mentioned above, in order to construct situation model, ample background knowledge is needed. In real life, however, we sometimes meet with texts whose contents are very unfamiliar to us. So, we need consider the way to fill in the gap between defective background knowledge in our mind and what is written as information in text. Therefore, if we utilize graphics as an aid for text comprehension, graphic aids are to help readers construct situation model, not textbase. A number of research concerned with graphic aids claimed that graphic aids can help readers construct situation model (Glenberg and Langston, 1992; Guri-Rosenblit, 1989; Gyselinck and Tardieu, 1999; Mayer, 1989; Robinson and Schraw, 1994; Winn, 1987; Winn and Schill, 1991).

2. Graphics as aids for facilitating text comprehension

We sometimes have such experiences as the widely used proverb indicate: "A picture is worth thousand words." By seeing a diagram displayed next to a text, we sometimes can grasp the outline without thoroughly reading the text. In this section, some types of graphic aids were introduced, and above all, two types of graphic aids were featured.

2.1 Functions

According to Levin, Anglin, and Carney (1987), there are five main functions of graphic aids. These

functions are *representation, organization, interpretation, transformation,* and *decoration.* Although Levin, Anglin, and Carney (1987) proposed these five main functions, there are some criticism on their classification scheme (Gyselinck and Tardieu, 1999).

Representation : When graphics repeat the content of the text or overlap with the most part of the text, they serve a representation function.

Organization : When graphics provide the text with greater coherence, they serve a organization function.

Interpretation : When graphics provide the text, whose content is too abstract to comprehend, with concrete instances, they serve a interpretation function.

Transformation : When graphics show a way to memorize critical information in the text in a more memorable form, they serve a transformational function.

Decoration : When graphics are not directly related with the text, they serve a decoration function. They don't support or supplement critical text information, but rather they are selected to make a book look more attractive.

Levin, Anglin, and Carney (1987) claimed that it was very important to distinguish the functions between the pictures whose purpose is to make the content more concrete (representational pictures), and the pictures whose purpose is to make the text content more comprehensible or more coherent (organizational pictures). In the following subsections, the studies concerned with these two functions, representation and organization, were reviewed.

2.2 Graphic representations

Graphics representing the text content can be broadly divided into the following two types: graphics which represent mechanics and procedures.

Mechanics

There are a variety of mechanics used as materials to investigate the facilitative effect of graphics, such as a pulley system (Hegarty and Just, 1993), a tire pump (Mayer, 1997), a hydraulic drum brake (Mayer, 1989), or human respiratory system (Mayer and Sims, 1994). In the study of Mayer (1989), participants with little prior knowledge about car mechanics was instructed to read a text about vehicle braking systems that either contained labeled illustrations of systems, illustrations without labels, labels without illustrations, or no labeled illustrations. The participants who read passages that contained labeled illustrations of braking systems recalled more explanative than nonexplanative information as compared to control groups, and outperformed control groups on problem solving transfer but not on verbatim recognition. In this experiment, the graphics of vehicle braking systems were used as aids for text comprehension.

Procedures

Glenberg and Langston (1992) investigated the role of graphics in the processing of texts describing four-step procedure for writing a paper. Texts explicitly stated the two middle steps to be performed simultaneously, but the text describes the four steps successively because of its linearity. The participants received texts either with graphics that highlighted the simultaneity of the two middle steps or without graphics. The participants who read the text with graphics were more accurate at verifying the sequence of steps than those who received the text without such graphics.

2.3 Graphic organizers

While the function of graphics which represent the content of texts is to illustrate simple relationships among variables (Winn, 1987), the function of graphic organizers is to graphically organize the relationships among variables described in text (Dunston and Ridgeway, 1990). Graphic organizer, originally called structured overview, was developed from Ausubel's (1968) cognitive theory. As instructors and researchers tried to apply structured overviews in order to form a hierarchically organized visual display of information, they adapted the use of structured overviews for prereading, during-reading, and postreading tasks, and the term, structured overview, was replaced with the term, graphic organizer (Merkley and Jefferies, 2001; Robinson, 1998). Graphic organizers are thought to include such graphics as concept maps, flow diagrams, tree diagrams or matrices.

Guri-Rozenblit (1989) investigated the impact of a tree diagram on the comprehension of main ideas in a social science text of about 3,500 words. The text was prepared in four versions, with and without a tree diagram, and with and without additional verbal explanation. The results showed that participants who received the tree diagram outperformed the participants who received the original or the elaborated text without tree diagram on recall of the relations between various elements in the text.

3. Review of recent graphics research

The recent researches conducted on the two types of graphic functions, graphic representations and graphic organizers, were reviewed in terms of for whom, how, and why graphics are effective in facilitating text comprehension. Although the main purpose of this paper is to review the research concerned with graphic organizers, it would be wise to include the review of graphic representations studies because there are a number of factors that graphic representations and graphic organizers have in common.

3.1 For whom graphics are effective in facilitating text comprehension

McNamara, Kintsch, Songer, and Kintsch (1996) suggested that readers with little knowledge about the domain of the text benefit from a coherent text, whereas readers with ample knowledge benefit from a

minimally coherent text. Similar to this findings, facilitative effect of graphics are variable depending on the characteristics of the readers. Some studies investigated the interaction of the effect of graphic aids and the spatial ability of readers, and they showed the readers with high spatial abilities benefit from graphics more than with low spatial abilities (Mayer and Sims, 1994; Hegarty and Just, 1993). Other studies investigated the interaction of graphic aids and background knowledge (Gyselinck, 1995; Hegarty and Just, 1993; Mayer, 1989), and their results showed low prior knowledge readers benefit from graphic aids more than high prior knowledge readers.

3.2 When graphics are effective in facilitating text comprehension

Mayer and Anderson (1991) investigated the effect of graphics representing the system of a bicycle pump. In one group the graphics were presented after (successive group) or during (concurrent group) a verbal description. Results showed that the concurrent group outperformed the successive group on transfer questions. This study was conducted to examine the effect of graphic representation. However, concerning graphic organizers, evidence suggests that presenting graphic organizers after reading text is more effective than presenting them either before or concurrently (Moore and Readence, 1984). Robinson and Schraw (1994), for example, presented the graphic organizer after reading in their experiment.

3.3 Why graphics are effective in facilitating text comprehension

There are a variety of explanations as to why graphic aids facilitate readers to comprehend text. They are dual-code theory, selective attention, computational efficacy, visual argument, and access structure. Most of these explanations are based on psychological or physiological experiments.

Dual-code theory

Paivio (1986) suggested the notion that the information referenced in a graphic is dually encoded in both verbal and nonverbal memory. A verbal system and a nonverbal system are independent although they are interconnected. Graphic information is automatically stored both in the nonverbal system and in the verbal system, whereas the reverse would not be as systematic. As a result, graphics would be encoded as such by the reader who would benefit from two memory traces, which are a verbal form and a nonverbal form.

Selective attention

Since graphics repeat important text information, it is natural that readers generally recall more of that information when they read a text with graphics than without them, and readers can pay attention to certain text information which has selected out by the author because of its importance (Robinson, 1998).

Computational efficacy

According to Larkin and Simon (1987), the information presented as text, a linear search begins. When the first relevant element concerning the concept is found and processed, it has to be stored in memory and then the search continues for the next relevant element. This search, find, and process in working memory continue until the last element is found and processed. The reader loses a great deal of cognitive resources, and as a result it is likely that a reading error will happen. By contrast with this linear processing, when searching information in a graphic, once the first relevant element is found, the next element will be found next to it or near it. This advantage reduces the amount of search and also the working memory burden to determine the relation, since both two elements concerning the concept can be viewed simultaneously. In this way, fewer cognitive resources make text comprehension greatly facilitated.

Visual argument

Visual argument involves conveying ideas through a visual and spatial arrangement of information rather than through written linear text, and because readers can see, not read, ideas, they are relieved from the burden of understanding complex relations described in the linear cobwebs of text (Waller, 1981). As an example of this effect, it is often easier to draw a map giving directions than to describe verbally the route to follow (Winn, 1987).

Access structure

Different from linear text, graphics can be accessed from top to bottom, from bottom to top, from left to right, or from right to left. Readers can alter their reading strategies more effectively to match their purposes (Waller and Whalley, 1987). In the case of matrix, for example, the information in the matrix can be accessed and processed not only in column but also in row.

4. Limitations of previous research

So far, the studies conducted to examine facilitative effects of graphics, especially graphic representations and graphic organizers, have been reviewed. In this section, some limitations of these researches are pointed out.

4.1 Graphics constructed by readers themselves vs. those constructed by researchers

Traditional approach often employed in graphics research is to investigate simply whether graphics are effective or not (Mayer, 1993). According to Mayer (1993), the research questions derived from this approach are: Do high prior knowledge readers remember more from graphics than low prior knowledge readers? Do readers who received a text with graphics recall more that readers who received the text alone?

In the research which adapted this approach, the graphics are generated by the researchers or experts, and presented with a text. It is natural that the graphics are produced by the researchers, since their interest is not in the process, but in the outcome. However, this approach cannot reveal the underlying mechanisms in which graphics yield facilitative effect. In order to investigate the mechanisms, more research should be conducted on process. In the study of Moore and Scevak (1997), for example, they investigated the strategies employed by the readers while they integrate the information in a graphic and in a text, using think-aloud protocol analysis.

4.2 Limitations concerning dependent measure

Another limitation concerned with the graphic research is that the researchers use only free recall and counting the total number of idea units to investigate facilitative effects of graphic organizers while graphic organizers are not meant to store or remember concepts (Robinson, 1998). As we mentioned in the first section of this paper, the graphics seem to have the most beneficial effect when graphics help readers construct not textbase, but situation models, so dependent variables should be such tasks as bridging inference questions (Robinson and Schraw, 1994; Glenberg and Langston, 1992), problem-solving tasks (Mannes and Kintsch, 1987; Mayer, 1989), keyword sorting tasks (McNamara and Kintsch, 1996; McNamara, Kintsch, Songer, and Kintsch, 1996).

4.3 Limited investigations of graphic elements

As for the graphics which represent the content described in the text, the format of graphics will not be variable whoever draw them. The picture of tire pump (Mayer and Sims, 1994) is always the picture of tire pump whoever draw that picture. However, as for the graphics which organize elements in text, not only verbal items but also visual elements or spatial configurations will be to a great extent variable. Therefore, the functions of those visual elements and spatial configuration should be investigated. Waller (1981) presented a kind of syntax for diagrams. In his study, he suggests that boxes play a role of nouns, arrows function as verbs, and labels or captions are adjectives or adverbs. However, there have been no studies which examined these functions empirically.

5. Conclusion

There are two main research schools whose common research interest is in graphics: one is from the perspective of cognitive psychology, and the other is from the perspective of education. The notion of situation model derived from cognitive psychology, and it is safe to say that situation model is not well applied to or adopted by educational research. In the field of cognitive psychology, where independent variables have to be well controlled, there are few researches which dealt with graphic organizers, partly

because graphic organizers have a number of potential independent variables about their visual elements such as formats, configurations, arrows, or boxes. In fact, the term, graphic organizers, has not yet been well defined. Moore and Readence (1984) claim that graphic organizers don't include mapping and flow-charting, whereas Hall and Strangman (2004) introduce descriptive or thematic map and series of events chain as graphic organizers.

In conclusion, we should note the following points: 1) The facilitative effects should be examined in the frame of the situation model, 2) The internal as well as external process while utilizing and generating graphics should be explored, 3) The functions of graphic elements constituting graphic organizers should be experimentally investigated.

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