Prerequisites For Understanding: Implications For The Design Of Instructional Strategies & Materials

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Many times instructional materials and strategies fail or are only partially successful because of misunderstanding about the nature of comprehension. In this paper we will examine some of the factors involved in comprehension and see how these factors are related to the design of instructional materials. Although the points I intend to make are true of comprehensions in general, this paper will focus upon the understanding of language.

Typically understanding what another person says seems to be a smooth effortless, automatic process. People speak and we just know what they mean. Partly as a result of this ease of understanding words we are led to false conclusions about the way that words work in allowing us to understand other people and written messages. It seems natural to assume that we learn words and their meanings, and that when we later hear the words their meanings are evoked. Understanding, then, is just being aware of the meanings of words. Words function in language, the story goes, as symbols or representations of meanings. The word is heard or seen, its meaning is evoked, and understanding occurs.

As we shall see, this set of assumptions about the way words work is inaccurate and can be detrimental in the development of instructional materials. Words do not function as referents of objects or meanings, rather, words act as cues on the basis of which we construct meaningful interpretations of messages or interactions. For example, the words "How are you?" can mean a wide variety of things depending upon how they are said and the context in which they occur. Frequently, we assume *"how are you"* is not really a question in need of an answer, but a form of greeting that can vary from friendly to cold politeness. In the situations where it is infact a question it can have many meanings such as "Are you feeling better now" if you have been sick or "Can you continue" if we are doing something difficult, or a complaint if I haven't heard from you in a long time. In each case the meaning of the phrase is inferred on the basis of the listeners knowledge about what is happening between the speaker and himself and how this might relate to other interactions, or special knowledge he has about himself, the speaker or their relationship. The words do not evoke a given set of meanings, rather they act as cues to possible meanings. If you play the game of changing contexts, changing relations between people, and changing the demands of the situation, you can create a seemingly endless set of meanings for the phrase "how are you." How can this be so? How can words work if the possible meanings they have can be such a long list? How does the head keep a record of so many possible meanings for the thousands and thousands of words we know? The answer, as we shall see, is that the meanings are not stored. Rather, the meanings are created in the different situations. Words act as cues for this creation, they do not stand for a list of meanings which are evoked as the words are experienced.

Read the following words slowly with the knowledge that you will be asked to remember them in a few minutes: pillow, spread, bed, rug, slippers, yawn, book, pajamas, dresser, light, robe, awake, alarm, sheet, blanket. Now write down as many of the words as you can remember. About 30% of my students who hear or read this list later remember the word sleep. Sleep, however, was not in the list of words. This is not a surprising result if we assume that the words led people to imagine or construct in their mind a situation or series of events that would occur in a bedroom. Many of these constructions could involve sleeping, or falling asleep, or waking up. If the act of sleeping was a part of the construction then it makes sense to remember or think you heard the word sleep. The words acted as cues on the basis of which you created possible or likely mental constructions. What you tend to remember is the construction, i.e., what your head builds, not just a copy of the list of words. Consider now what it means to have understood those words. The understanding was an active process, the creation of mental events. It is this active building of mental events which characterizes comprehension. What we understand depends upon the events we construct and what we learn is contained in these mental constructions.

Similarly, when we listen to people talk or when we read sentences and paragraphs we are rarely able to recall the exact words that were used. What we are usually very good at remembering is the meaning of what was read or said. In a cleverly designed series of experiments, Sachs (1966 & 1967) presented short stories to subjects. She stopped the story and presented new sentences to the subjects asking them if they were identical to sentences in the story or changed in any way. The subjects were unable to consistently detect changes in the form of the sentences. However, any change that effected the meaning of the sentences was detected 80% to 90% of the time.

For example, consider the following five sentences actually used by Sachs.

BASE (unchanged): A wealthy manufacturer, Matthew Boulton, sought out the young inventor.

SEMANTIC CHANGE: The young inventor sought out a wealthy manufacturer, Matthew Boulton.

ACTIVE TO PASSIVE CHANGE: The young inventor was sought out by a wealthy manufacturer, Matthew Boulton.

FORMAL CHANGE: A wealthy manufacturer, Matthew Boulton, sought the young inventor out.

LEXICAL CHANGE: A rich manufacturer, Matthew Boulton, sought out the young inventor.

The "base" sentence was in the original story. If forty seconds or more had passed since the subject heard the base sentence the passive/active, formal, and lexical changes were not detected at a level different from chance. In contrast, the semantic change was consistently detected as different. Sachs' subjects had knowledge of the meaning of the passages, but they had little knowledge of the exact words in the sentences or the form of the sentences. Much as they did with the word list you heard, these words also acted as cues for the mental constructions. Consequently, sentences which were consistent with the constructions of Sach's subjects were not detected as changed. Clearly, when we listen to or read words we do not learn copies of the words or sentences themselves, rather we learn the meanings that we construct.

Studies such as the Sachs' studies illustrate that the words somehow act as the basis for mental construction and that what we know or remember are these constructions. It is not the case that we remember sentences and repeat them back again so we can remember what they meant. We remember our constructed meanings and evaluate consequent events in terms of these constructions. The meaning that sentences have for us are the mental constructions we create when we experience the words.

Bransford, Barclay, and Franks (1972) discuss a series of experiments which investigate the nature of these constructions. Consider the sentence "Three turtles were sitting on a log when a fish swam beneath them". Subjects who heard this sentence later believed that they had heard sentences which said the fish swam under the log. The event of the fish swimming under the log is implied in the original sentence and would therefore, be in our mental constructions about the sentence. It is important to note, however, that the event is not described in the sentence or contained in the meaning of the words in the sentence. The event of the fish swimming under the log is implied given what we know about turtles, water, logs, and fish and how these objects can interact. It is not contained in the meanings of the words. If we have the appropriate knowledge we can use the words as cues to build a mental construction. What is contained in these constructions goes beyond the meanings of the word used.

In a related experiment Johnson, Bransford, and Solomon (reported in Bransford and McCarrell, 1975) found that after hearing the following sentences "John was trying to fix the birdhouse. He was pounding the nail when his father came out to watch him and help him do the work." Subjects frequently believed that they had heard a sentence containing the word hammer. Again, note, that hammer is implied only if you have the appropriate knowledge. In other times or cultures, "rock" could have been implied by a similar sentence. Hammer is implied for us because of our knowledge about tools, birdhouses, etc., and it is not in the meaning of the words in the sentence.

To review, understanding is not an awareness of given meanings which we store and bring to mind when the word is experienced. Rather, words act as cues allowing us to create semantic constructions on the basis of knowledge we have about the words, the situation, the objects involved, and the possible interaction of these factors with each other. As the above examples have shown the content of the construction is more than what is contained in the meanings of words. The content of the construction depends upon what the listener contributes, it is not predetermined by meanings which are evoked when the words are heard.

To this point we have discussed evidence suggesting that words act as cues to allow us to build mental constructions. Now I would like to turn to a consideration of the factors necessary for this construction to occur. John Bransford and his colleagues have conducted a series of experiments investigating some of the limitations upon people's ability to understand and recall verbal material. Consider the sentences "The trip was not delayed because the bottle shattered. The haystack was important because the cloth ripped. The note was sour because the seam was split." At first, these sentences sound like nonsense and are difficult to remember even a few seconds after they are heard. McCarrell, Bransford, and Johnson, reported in Bransford & McCarrell, (1975), that subjects were extremely poor at recalling sentences such as these and found them exceedingly difficult to understand. However, the same sentences were not difficult to remember or understand when preceeded with appropriate context cues: (christening a ship) The trip was not delayed because the bottle shattered. (parachutist) The haystack was important because the cloth ripped. (accordian) The note was sour because the seam was split. When the sentence occurs in a context that provides the listener enough information to create a semantic construction, understanding and memory are easy. When the conditions are such that the necessary information is not present, exactly the same words seem terribly difficult to understand and remember. If understanding was simply a matter of having words evoke meanings, the sentences would be equally understandable with and without the contextual cues.

The contextual cues are effective only if we have appropriate knowledge. It is possible for someone to know the meaning of the words in the sentences and not have knowledge of christenings. In that case the meanings of the words would not be a sufficient condition for understanding the sentence even if the contextual cue (christening) was present. Understanding entails the successful creation of semantic constructions. If we are unable to build these constructions understanding does not occur. Relevant background knowledge is required to build the constructions. Knowledge of the words in the sentences is no guarantee that the sentence can be understood by the listener.

Finally, consider the following paragraph.

"The procedure is actually quite simple. First you arrange things in different groups. Of course one pile may be sufficient depending on how much there is to do. If you have to go somewhere else due to lack of facilities that is the next step, otherwise you are pretty well set. It is important not to over do things. That is, it is better to do too few things at once than too many. In the short run this may not seem important but complications can easily arise. A mistake can be expensive as well. At first the whole procedure will seem complicated. Soon, however, it will become just another facet of life. It is difficult to foresee any end to the necessity for this task in the immediate future, but then one never can tell. After the procedure is completed one arranges the materials into different groups again. Then they can be put into their appropriate places. Eventually they will be used once more and the whole cycle will then have to be repeated. However, that is a part of life."

This paragraph was used in an experiment conducted by Bransford and Johnson (1974). Subjects showed poor comprehension and very little ability to recall the words in the paragraph. The problem in understanding this paragraph is not a problem of word meanings. We all know all of the words in the paragraph. The difficulty in understanding this sentence is a problem of creating a semantic construction which fits the paragraph. Read the paragraph again with the knowledge that it is about the task of washing clothes. Now the same words can provide you with a completely different experience. Notice how you are constructing situations, objects, and relations in your mind. For example, what is the mistake that could be costly? This demonstration shows that the meaning of the words, the meaning of the sentences, and the meaning of the paragraph depend upon the listener being able to construct a semantic interpretation. When the listener fails at this task, the prose seems to have no meaning. It is not sufficient for understanding that we have relevant knowledge. All of us have enough knowledge about washing clothes to understand what the paragraph is about if we know what part of our knowledge is relevant to understanding the paragraph.

Implications for Instructional Design

In the first part of this paper we saw that to understand, a listener has to actually build semantic constructions. When we interferred with this building even simple facts were not grasped or remembered. Instructional materials will fail if they do not lead the learner to build relevant semantic representations. To build these representations the listener must have the necessary background knowledge. Unless you had knowledge of christenings you could not build an appropriate representation for "The trip was not delayed because the bottle shattered." Similarly, unless you had knowledge of parking laws and penalties you could not understand, "The car was gone because he didn't have change." In addition to needing appropriate background knowledge, the listener must know what aspect of his knowledge is relevant to the problem at hand. In the washing clothes example we all have the background knowledge necessary to build the appropriate constructions. However, we are not aware of what parts of our knowledge were relevant.

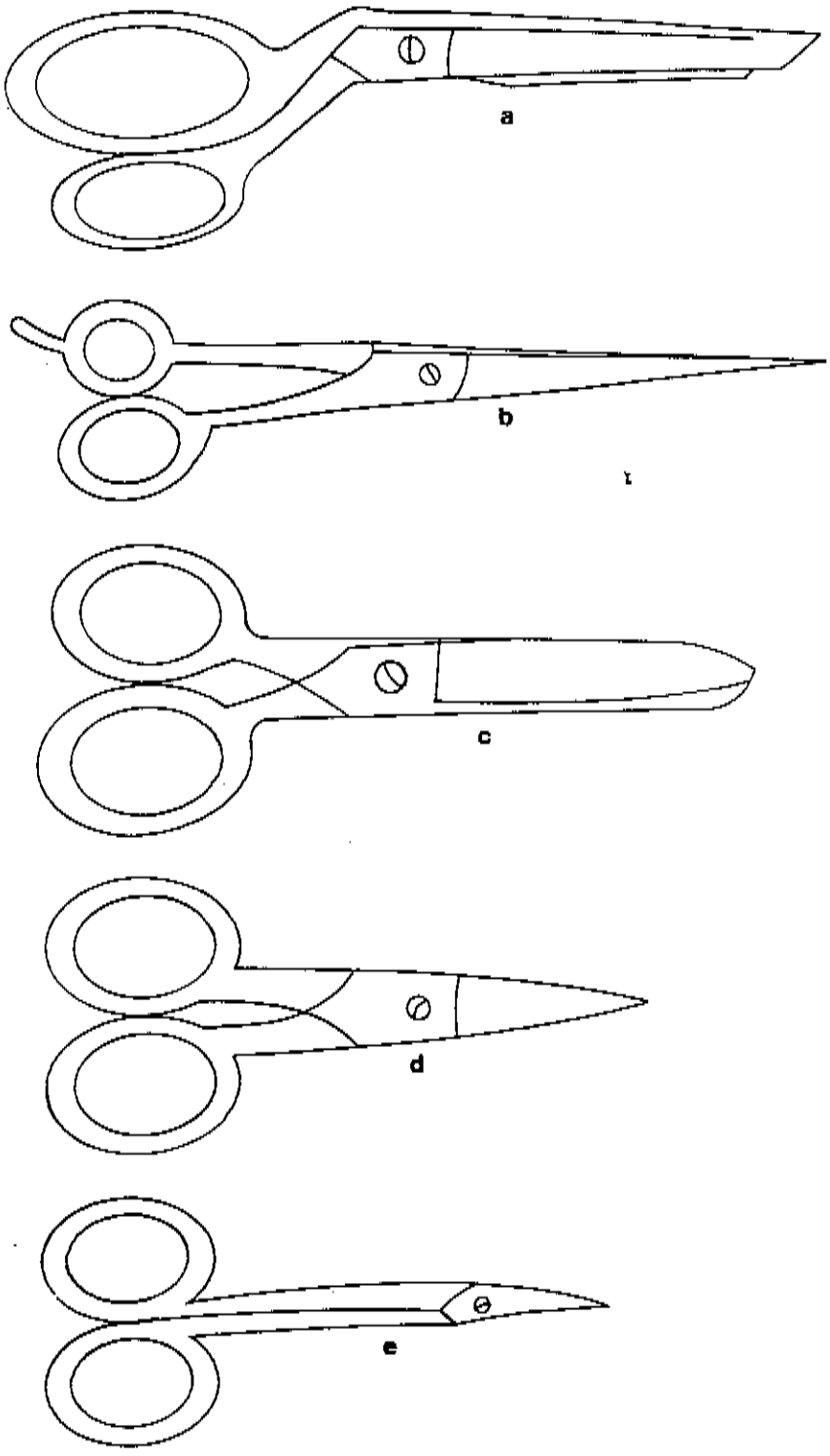

FIGURE 1

Consider the instructions for filling out your income tax forms. These instructions work, in that, if you follow them carefully you will be able to complete the task. However, following the steps in the instructions does not give you much information about what you are doing or why. The steps involved in doing a task need not give you any understanding about what you have done. It is important to keep the differences clear between instructions on how to do a task, such as assembling a toy or piece of furniture, and instructions which allow you to understand what is involved in the solution of a problem or similar problems.

Consider the scissors in figure 1. (This figure is taken from Bransford and McCarrell, 1975). Suppose you are assigned the task of developing instructional materials to teach people to correctly identify each of the five types. One procedure would be to develop criteria or defining characteristics which when mastered would allow the learner to correctly identify each type of scissors. Typically, characteristics such as: size of blades, size of handle, shape of blade, shape of handle, shape of blade tips, and weight, might be used. The learner would then be required to learn the six defining characteristics of each type. Once the characteristics of each type had been acquired the learner would have a foolproof set of procedures for identifying the five types of scissors.

What is wrong with such a set of procedures. It is clear that this system once learned would in fact allow the successful identification of the scissors. There are, however, a number of problems with such a set of procedures. It is clear that this system once learned would in fact allow the successful identification of the scissors. There are, however, a number of problems with such a set of procedures. First, the task of memorizing the six characteristics of each type seems complicated and difficult. Five characteristics for each type must be memorized. This means six for each of five scissors types, i.e., 30 items to be memorized. The real problem, however, is that most of us do not have background knowledge that relates to the criteria we have selected. We are hard pressed to build semantic constructions based upon size of handles, size of blades, etc.

These characteristics seem artificial in that it is difficult to organize them or group them in terms of things we already know. Even when memorized the list of characteristics has little relation to other experiences or situations we might encounter. They are simply a set of unrelated facts which don't make sense in terms of the rest of our knowledge of the world. In such a list, facts are easily forgotten and confused with each other. Another way to say all of this is that the learner cannot understand the scissor types. He is left with the tedious task of memorizing the six defining characteristics of each of the five types of scissors.

An alternative would be to develop instructional materials which would lead the learner to use his existing knowledge to build constructions concerning the five types of scissors and their relations to each other. For example, we could develop materials leading the learner to infer or discover the relation of the structure and function of the scissors. The heavy scissors with the lower blade flush to a surface and an unusually large finger hole are for cutting cloth. They are heavy for cutting heavy material, the blade and handle are designed to allow them to slide along a flat surface as you cut, and the large finger hole allows more fingers and therefore stronger pressure to the cutting blades. Now look at the other types: which might be safe for small children? How would large finger holes be helpful to children? Which scissors would be good for cutting hair? Why? Now the learning of the different types seems sensible, easy, and straight forward. This is because we have selected criteria that are appropriate to our background knowledge. We all have knowledge about material, about what is necessary for something to slide along a flat surface, how pointed tips could be harmful to children, etc. Your existing knowledge is useful and you know which parts of your knowledge are relevant. Now, the task seems so easy as to be almost automatic. But if you look carefully, you will see your head at work building constructions which entail the relations that make sense of structure and function. The understanding is not automatic, and is only possible because of the existing knowledge you have. If you were from another culture and did not have the relevant knowledge you would once again be in the position of memorizing unrelated facts.

So much of what we teach people is learned as isolated facts that don't relate to the rest of their knowledge. I have interviewed children who had recently finished a 6th grade science curriculum. When asked about cells, they seemed to have learned a considerable amount. They knew about cell walls, cell nuclei, and the division of cells. However, when asked about where cells were, and what things had cells, they looked at me with a blank stare. "Do you have cells in your body? Do plants have cells?" They didn't know the answers to these questions and had not even considered them before they were asked. Clearly, they had no idea which part of their knowledge was relevant to the information they had been learning about cells. They had not used relevant aspects of their existing knowledge to build constructions about cells. They had memorized facts which were meaningless and irrelevant to them. The second set of characteristics we discussed is easy to make sense out of in terms of familiar objects and events in the world. Sharp points could be dangerous to children so the children's scissors have blunt tips. Small children are not well coordinated so the finger holes are large. Similarly, it is easy to imagine the importance of thin sharp blades for cutting hair. If the blades were dull they might pull the hair, if the blades were thick it might be difficult to cut the hair close to the ears. The building of these constructions is not difficult and seems sensible and natural. We have relevant background knowledge, and we are aware of what part of our knowledge is relevant. Now the task of building semantic constructions is once again easy and almost automatic.

We have seen that (1) understanding is a problem solving type of activity which entails constructing semantic interpretations. (2) To be successful at this task the listener must have appropriate background knowledge and (3) must know what aspects of his knowledge are relevant to the task of understanding. Knowing the meanings of the words is not a sufficient basis of understanding. The problem is not simply a vocabulary problem. Rather, the problem of understanding is one of providing sufficient conditions for the construction of semantic representations. To be successful, instructional strategies and materials must lead the learner to use her knowledge to develop these mental constructions.

Finally, consider the following definition of "constitution" which is typical of that found in eighth grade social studies texts. A constitution tells what a government can do; what the parts of the government are, and what work each part will do. An eighth grader can memorize this definition without too much trouble and read a chapter on constitutional government. Having completed these two tasks, the student could appear to understand the term constitution. However, it is unlikely that the semantic constructions necessary for understanding were actually built by the students. The definition does not provide cues which lead the student to use his existing knowledge to create relevant semantic constructions. The words "tells what a government can do" do not automatically bring examples or instances of events

covered by the constitution to mind. To understand, however, the student must in fact create mentally or deal with such instances. The meaning for the student is not in the words, but in the semantic construction he builds. Consequently, the students can learn the definition, read a chapter on history, pass related tests, and still have almost no knowledge of what a constitution is that is relevant outside the classroom. If asked about the following situation, most students would have difficulty seeing its relevance of the constitution. Suppose you got a job after school and then discovered that an older person who had worked there just as long as you and was doing exactly the same job, was getting twice as much as you. Can the employer do this? Is it legal? How could you find out? Learning the definition itself does not lead to the creation of the semantic constructions necessary for understanding.

An alternative instructional strategy to learning the definition, reading a chapter, and taking a test, is to design materials which lead the student to use his knowledge to create related semantic construction. For instance, the student might be directed to existing knowledge he has of rules in games, clubs, family situations, etc., as a source of relevant knowledge. What if the pitcher on the other team wants to stand five feet in front of the mound? Is it fair? How do we decide? This knowledge forms a basis upon which to create semantic constructions about the constitution and its functions.

Students could then be lead to build such constructions in many different ways such as: (1) considering interesting or relevant examples of individual, group, or governmental rights, (2) actually participating in the formation of a set of club rules or classroom rules, (3) or hypothetically solving important personal or group problems in terms of a state or city constitution. The list of possible alternative strategies is endless. What is important is that they lead the student to create the semantic constructions necessary for comprehension. They are not organized simply in terms of the subject matter, rather, they take into account the students existing knowledge and his task of creating semantic constructions. (For a more in depth account of the nature of comprehension and implications for instruction see Wilson, in press; and Shaw and Wilson, 1976).

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