KNOWING, UNDERSTANDING, AND BELIEVING

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1. Learning and Knowing How

"Learning" in the ordinary sense simply implies the acquisition of knowledge, or the change in the state of knowledge. However, psychologists have been afraid of being asked by sceptics, "How do you know that your subject has changed his or her state of knowledge?" Their avowed answer follows: "From the subject's behavior may we infer his or her state of knowledge." Thus Bower and Hilgard (1981) define:

> "Learning refers to the change in a subject's behavior or behavior potential to a given situation brought about by ......" (p.11)

However, if we stick with our ordinary notion of learning, then "X learned" simply implies that X has come to know something.

But then we must face with a fundamental problem in epistemology on the distinction between knowing how and knowing that. This distinction has been introduced by Winograd (1975), and Rumelhart and Norman (1981) in relation to the controversy on the representation of knowledge, i.e., procedural vs. declarative representations. However, the original distinction between knowing how and knowing that was on the nature of knowledge itself, rather than on its representation (Ryle, 1949). In other words, if we focus upon the kind of knowledge characterized by the subject's performance approaching to a certain criterion, then we are primarily concerned with subject's knowing how, rather than knowing that. On the other hand, if we focus upon the other kind of knowledge characterized by the subject's belief in the truth of a proposition, then we are concerned with his knowing that.

Although Ryle originary made the basic distinction, he was primarily concerned with knowing how. He specified the subject's intellectual disposition by his potential tendency of behavior to act properly and correctly under the given situation, not as a result of simple habit, but as a result of deliberate consideration. Thus the state of subject's knowledge that traditional psychologists have been concerned with seems to correspond to Ryle's definition of "knowing how" exclusively.

2. Understanding and Knowing That

The nature of "knowing that" has been extensively analyzed by Scheffler (1965). According to Scheffler, X knows that Q if and only if

(1) Belief condition; X believes that Q,
(2) Evidence condition; X has adequate evidence that Q,
(3) Truth condition; Q.

(Here, the third condition is purely epistemological, and will not be discussed in the present paper.)

Petrie (1965), independently of Scheffler's work, reached at almost the same conclusion in his analysis of "learning with understanding," to be distinguished from rote learning. He asked the question, "What is to learn a fact or a methodology with understanding?" Then he proposed first on learning proposition P with understanding such as: X learned with understanding that P if and only if

(P1) X has come to believe through experience that P,
(P2) X has good (justifying) reasons for believing that P,
(P3) P (the truth condition).

Then he examined if there is any sense in saying, "X learned methodology M with understanding." Obviously, there seems to be some factual learning about M, such as learning that the rules and principles underlying M are indeed valid and appropriate to attain a goal under given circumstances. In order to allege learning of M with understanding, learning of the principles seems to be requisite.

In addition to the learning of principles for M, Petrie requires that the reasons for believing these methodological principles should include not only inductive evidence that they do work, but also that they are only heuristic, i.e., there may be the better way to attain the same goal. The reason for this comes from the fact that methodology must always be improving.

Petrie's suggestions may be further elaborated as follows: If X learned M with understanding,

(M1) X has come to believe through experience that the basic procedures of M are appropriate under the given circumstance,

(M2) X has good (justifying) reasons for believing the appropriateness of the procedures,

(M3) X is trying to discover the better procedures by improving M.

Although conditions M1-M3 are necessary for learning M with understanding, they are by no means sufficient. It still remains true that one could learn all the facts about M without becoming an expert on M, that is, without learning how. In order to become a real expert, one must acquire the automatization of component skills to act smoothly. Although such automatization may occur without understanding, its formation helps people to obtain the deeper understanding ofthe basic principles than non-automatized learning of the principles, because of the proper encoding of chunks and the organization of the entire task. Moreover, the formation of automatization strenthens the understanding, because one would realize the appropreateness of the procedures together with the points to improve, through the excercise of the present methodology. Cross-cultural studies on cognition revealed that people's performances on reasoning and problem-solving are quite "domain specific," which may be interpreted as the outcome of such interactive effects between automatization and understanding (Cole and Scribner, 1974).

Recently, a number of authors (Anderson, et al., 1981; Greeno, 1980; Simon, 1980) attempted to clarify the concept of understanding in "meaningful" (instead of "rote") learning within the information-processing framework. They regard understanding as the proper use of higher order schema, representing the conceptual meaning in declarative form, from which necessary procedures are derived to solve seemingly different, but conceptually the same problems. VanLehn and Brown (1980) proposed a model called "planning nets" for the knowledge about the purposes of every component of procedural skills, reflecting teleologic semantics. The concept of understanding in these and other studies in cognitive science clearly indicates the importance of Condition M2, the process of having good (justifying) reasons for the parts of procedural skills.

Condition M3, invention of new strategy through experience, has been extensively observed for learning arithmetics (Resnick, 1980). The process has been simulated by ACT production system (Anderson, et al., 1981). Adaptive production system (Anzai and Simon, 1979) also deals with natural development of skills through experience. Thus we may conclude that Conditions M2 and M3 are properly taken to account in cognitive science. Then, what about Condition M1?

Unfortunately, belief condition of "knowing" has been virtually ignored in the past studies on cognition (except for beliefs in interpersonal relations or political judgments, simulated by Colby, 1973, or Abelson, 1973). The condition is missing in the discussion of procedural knowledge, as well as semantic knowledge.

The treatment of semantic knowledge in cognitive science seems to have been close to Hartland-Swann's (1954) interpretation of "knowing that." He claimed that Ryle's "knowing that" should be interpreted as another kind of "knowing how," that is, "knowing how to answer correctly to the expected questions." This proposal was immediately criticized by Ammerman (1956) asking, "How do you know that your answer is indeed 'correct'?" One can produce "correct answers" without knowing their truthfulness.

3. When and How People Are Convinced

We all know that the results of logical reasoning, mathematical deduction, and statistical inference do not always convince ourselves. Tversky and Kahnemann (1974) demonstrated a variety of our "heuristic biases" in probabilistic judgments, differred from those prescribed by probability theory, i.e., availability, imaginability, and representativeness. Here, we may extend their notions to people's strategies to convince themselves or others of the truth of logical conclusion, physical descriptions, causal attribution, and the validities of procedural skills. We are easily convinced by being shown a "good example" (availability). An elaborated episode which stimulates our imagination often makes a plausible explanation (imaginability). We often cite proverbs and old sayings, insisting on the similarity to the "typical case" (representativeness). Obviously, we should not use these biased tendencies to believe, for convincing children of false propositions. However, some of them may be quite helpful in our classroom instruction to explain new subject matter, which is quite unfamiliar at the moment, but is to be examined rationally later. In classroom, however, experienced teachers adopt various strategies to convince children of the truth and validity of principles in subject matters. "Decomposition Strategy" breakes down the problem into familiar, manipulable, subproblems. "Reduction Strategy" reduces the problem into a simple case. "Transformation Strategy" transforms the problem into different views, keeping the essential part the same.

We are investigating why and how these strategies work (or do not work) in a variety of learning, convincing children the reality and truthfulness of the knowledge.

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