Análise Psicológica (2001), 4 (XIX): 559-566

The great importance of the distinction between declarative and procedural knowledge

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1. INTRODUCTION

All humans are born with adaptive forms for relevant functions. This is something endowed by nature. The distinction between declarative knowledge and procedural knowledge is so important because it is the most fundamental. Also it is so important because the forms each of the two types of knowledge representation takes «are related to how that knowledge is to function» (Gagné, Yekovich & Yekovich, [Gagné et al. for short hereinafter], 1993, p. 57).

Specifically, there are two ways of representing declarative knowledge which is static: a) basic units and b) schemas. There is one way of representing procedural knowledge which is dynamic: productions (Gagné et al.). Declarative knowledge has something to do with facts like proposition (arguments and relation), images, and sequences. Procedural knowledge has something to do with motor skills, cognitive skills and cognitive strategies. As evidence shows, the two forms of knowledge tend to be more distinct than interdependent (Gagné et al.). The distinction between the two enables us to understand much more clearly the nature of knowledge representation, its varieties and their functions. These have their own characteristics each adapting themselves uniquely, if not exclusively, to particular relevant functions. How to make the best out of our teaching and learning is the biggest concern of our educators. For teachers working within educational and training institutes, the remarkable implications of this distinction lies in that it brings deeper insight into mental processes, mental strategies, problem-solving, instructional effectiveness, etc. It provides us with the potential to analyze the workings of the human information processing system, so as to help decide what to teach and how to teach, in an attempt to improve human learning more effectively and efficiently in a well-organized way, or to put it bluntly, to optimize the results of teaching and learning.

2. THE DISTINCTION HELPS ENHANCE TEACHERS' AWARENESS OF THE TEACHING METHODS TO BE ADOPTED

To start with, as put by Gagné et al., one important reason for varying one's teaching methods (including the motivation and background of the students) «is the type of knowledge repre-

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sentation that is the focus of a particular segment of instruction» (Gagné et al., ibid., p. 60). As is defined by them, Declarative knowledge is «knowing that *something is the case*» (ibid.), namely, «knowledge of facts, theories, events, and objects» (ibid.). And procedural knowledge is «knowing *how to do something* which include motor skills, cognitive skills and cognitive strategies» (ibid.). This tells us that to acquire more effectively and efficiently a certain type of knowledge or skills in a way that fits in line with the forms for functions created by nature, we ought to become aware of what sort that type of knowledge or skills into. Namely, is it something belonging to that knowing something is the case or that knowing how to do something? In this sense, the right teaching methods to take will vary, depending on what the teacher's primary goal is, and influenced by the right identification of the type of knowledge a given to-learn-knowledge belongs to. Thus whether or not the type of knowledge for a given subject is right identified does weigh a lot. If it is correct, a right teaching method or strategy may well follow up and much effort can he saved with a better learning result. Or else, the opposite will be bound to come along. This also accounts partly for the reason why the distinction between the two types of knowledge is so important.

When in a particularly given teaching context, should a teacher keep consciously in mind 'Is the type of knowledge to be instructed to the students something concerning facts, theories, events and objects? Or is it something regarding motor skills, cognitive skillls and cognitive strategies? For example, in a language teaching situation where and when you are going to have students learn conununication skills and practice some specific language points, then one should create some situational or semi-authentic simulated contexts in which students can be so arranged in pairs or groups for discussions about something. Through interactions and with repeated errors or inadequate expressions, students may come to be able to use the language correctly and freely step by step. With this primary goal in mind, one may come to see that these skills demand procedural knowledge and decide that it is appropriate to use cognitive skills and cognitive strategies as these may turn out to be more effective and efficient for teaching this type of knowledge.

Conversely, if one wants to have students get some brief understanding of Chinese history, then, perhaps it is more proper, after twenty hours' lecturing to them, for example, to brush up consolidate what they have learned by asking them relevant questions by comparison about the time, places and big events concerning productive level of those major dynasties, etc. It is not appropriate to get them involved in a trip to a place where one of the dynasties was established to make investigations into detailed data on scientific findings as indicators of the productive level at that time (e.g. calculate, or verify some statistics in astronaut research). This demands more of declarative knowledge than procedural knowledge because it is something static that just wants students to know that something is the case instead of something dynamic which requires students to know how to do something (i.e. to experience some practical skills like problem-solving, etc.). It is not necessary, nor is it worthwhile since you do not have enough time and energy for that and it is not your major concern, although admittedly, contact with elaborate experiences (e.g. study trips) can make declarative acquisition more efficient, i.e. it is 'easier' to learn of things when you have prior meaningful connection to them available via past experience. The effort could be saved for something else.

It is the distinction between declarative knowledge and procedural knowledge that matters greatly because it guides us in the more proper direction of teaching and learning, which is less time-consuming and more effective and efficient.

The distinction also implies that it is something instructive for many curriculum decisions and instructional decisions in the domain of education. As far as recently, by some cognitive theorists, it has been admitted as a fact that education decisions in the areas of curriculum and instruction have not been coordinated well enough (Gagné et al.). Why so? Part of the reason is that, in terms of problem-solving, people do not integrate well the understanding of how different types of knowledge are acquired and how knowledge functions. It is however, distinction between the two types that makes clear the three-point characterization of expertise (or knowledge possessed by domain experts), namely automatic basic skills and domain specific strategies (These two forms fall into the type of procedural know-

ledge) and conceptual understanding of a domain (This is declarative knowledge). This characterization «ties together ideas about how knowledge functions in problem-solving with how different varieties of knowledge are learned» (Gagné et al., ibid, p. 208). This is something significant as this characterization helps understand how knowledge functions and how different types of knowledge are acquired. In this sense, this distinction is so important because «if our understanding of these two areas can be coordinated, then it is likely that educational decisions in the areas of curriculum and instruction will be more coordinated and complementary as well» (Gagné et al., ibid.). In other words, traditionally, these two areas of understanding relatively have been standing in isolation, or at least, not so close in association with each other, to say nothing of knitting well in integration. Now, the distinction enables us to see the great importance of the integration of the two, which will be bound to improve the quality of educational decisions in the areas of curriculum and instruction.

In terms of facilitating students' acquisition of cognitive skills, we may take, for instance, instructional support for learning automated basic skills. As put by Gagné et al., «we who are engaged as teachers, can do three things to make easier or faster the process of proceduralization and automaticity, or to make it more likely to occur» (Cagné et al., ibid. p. 187). That is to help students automate prerequisite procedures or subskills, to help them compose small procedures into larger procedures and to help them proceduralize their skills «so that they can exploit the goal-subgoal structure of the procedure without thinking about it» (Gagné et al., ibid.). If this is done, hopefully, students may be enabled to make rapid progress with relatively less effort. They stressed that «proceduralization is particularly desirable when the goal is an automated basic skill» (Gagné et al., ibid.)

3. BRING MORE POSITIVE FACTORS OF EACH OF THE TWO TYPES OF KNOWLEDGE INTO FULL PLAY

Images

The distinction between the two reveals a tendency that in terms of acquisition of declarative knowledge, specifically, we may come to see that imagery instruction is to be greatly encouraged, as «Asking students to think of images of what they are studying enhances recall» (Gagné et al., p. 141). Statistics do show the advantages of this. According to an experiment conducted by Kulhavy and Swenson in 1975 with 128 fifth and sixth graders (See Gagné et al., ibid., pp. 141-142), the outcomes turned out to be that «the students who received imagery instructions performed better especially on the paraphrase items» (ibid., 141) and «it appears that imagery instructions helped students form a more meaningful representation» (ibid.). The following is a rather strong piece of evidence: (adapted from Kulhavy & Swenson, 1975, cited in Gagné et al., ibid., p. 142).

There were 128 fifth and sixth graders in the experiment who read a twenty-paragraph passage called «The Island of Ako and Its People». In the passage there was a question after each, paragraph which asked the student to use information in the paragraph just read. Those questions were either verbatim from the passage or paraphrases of passage words. Some students were asked to form mental images of the activities in the paragraph studied before answering the questions given while other students were just asked to study the passage and questions for a test. And the results go as in the Table 1.

As shown in Table 1, in the group that received immediate test, instructions for verbatim turned out to be 11.06 (without use of image) versus 12.95 (with image), and instructions for paraphrase turned out to be 10.89 (without use of image) versus 14.23 (with image) respectively; and in the group that received no immediate test, instructions for paraphrase turned out to be 8.94 versus 8.01 (without use of image), and 8.04 versus 10.93 (with use of image). The above indicators demonstrate a significant difference between the students who received instructions with use of image and the students who received instructions without use of image. As we can see, in the group that had immediate test, the percentage of instructions for verbatim with use of image (12.95) is higher than that of instructions for verbatim without image (11.06) by 1.89. The percentage of instructions for paraphrase with use of image (14.23) is much higher

TABLE 1
Effects of imagery instructions on learning

	INSTRUCTIONS			
	NO IMAGE		IMAGE	
	verbatim	paraphrase	verbatim	paraphrase
Received immediate test	11.06	10.89	12.95	14.23
No immediate test	8.94	8.04	8.01	10.93

than that of instructions for paraphrase without use of image (10.89) by 3.24. In the group that did not have immediate test, the percentage of instructions for verbatim with use of image (8.01) is lower than that of instructions for paraphrase without image (9.94) by 0.93. But the percentage of instructions for paraphrase with use of image (10.93) is higher than that of instructions without use of image (9.04) by 2.89. This experiment shows that it «appears that the imagery instructions helped students form a more meaningful representation» (Gagné et al., ibid., p. 142), especially on the paraphrase items, and to quite some extent, demonstrates that 'a picture is worth a thousand words' as someone put it. This is one of those desirable ways we can adopt to increase students' use of elaboration and organization processes so as to make things easier. It is important since it leaves students a deeper impression by helping students visualize what is to be learned so as to facilitate the learning processes.

Take interpreting for example, sometimes when a speaker speaks continuously for about one or two minutes, it really makes it very hard for an interpreter to put what has been said into another language. It does overload the brain with so much information to memorize and organize, doesn't it? And yet, a well-trained interpreter does manage to complete the tough task, rarely missing anything. The key point lies in that when transforming the language, very often, the interpreter visualizes the meaning of what the speaker says. The skilled interpreter may report that: there appears, in front of him/her, one picture after another, just like films passing by rapidly. It is the meaning, rather than the actual sentences which string up the meaning, that is the most important. By visualizing the information or message, the brain can manage, to so arrange itself that it stores the information or message much more rapidly into the working memory (WM) and processes it much faster and more effectively and efficiently by retrieving from long memory (LM) prior knowledge or «sets, of organized and interlinked mental schemas» (Yates & Chandler, 1994, p. 2) for its equivalent meaning, sentence patterns, and organization of it in another language. That is to say, those well-organized and arranged pictures or images, are then transformed or represented with their right meaning in another language. Strategically, being able to distinguish between the two types of knowledge equips us with the knowledge and advantage, that use of images will facilitate effectively the storage of information in WM since it is a space-saving device. This is particularly vital for WM as WM is a 'bottleneck' in human processing system. By using imagery, you can store more quickly and more information in this capacity-limited section.

Why can the skilled interpreter manage to get the job done so quickly and effectively? He or she, as a matter of fact, does it with the help of images. This is more effective and efficient, which makes him/her more competent though the reason behind it concerning how the mechanisms work is yet to be known.

With this message, we may be enlightened somewhat that in teaching interpreting, a teacher may preferable teach students to use images for effective memory of information.

A message from modifiability of knowledge

between the two types of knowledge. The difference in terms of modifiability of knowledge between declarative knowledge and procedural knowledge also, leads us to see the importance of the distinction between the two. According to Gagné et al., basic units of declarative knowledge are learned relatively quickly and also can be modified quickly. In contrast to this, procedural knowledge can only be acquired slowly, but once automated it is very hard to modify.

The important implication of this for teachers is that when giving students knowledge of procedural type, we should be very cautious. In reality, we often come up against something, which, due to improper guidance, results in a bad habit. And we do find it hard to rid those students of it. For instance, as far as phonetics teaching is concerned, it is deemed pretty necessary to get language-learning students a qualified teacher with right pronunciation. Otherwise, the bad effect on them from a teacher with poor pronunciation could be enormously disastrous. There can be little chance for remedy.

Once I met a student who always pronounced her English words with a '-t' at the end of each. Later I came to understand that she had learned her English from one of her friends. And she picked up this bad habit from her friend. She also knew that she had developed such a bad habit but she found it hard to eliminate it. This is a case in point which shows that theoretically speaking, «Once a set of productions have been built by the memory system, it is difficult to modify» (Gagné et al., p. 111). When it comes to the acquisition of procedural knowledge, like mastering the pronunciation of a new language, we should make sure that a good example is followed. If a bad habit or ill tendency is taking shape, we should not leave it alone. Instead, we must stop it as soon as possible since «With respect to procedural knowledge, it is only easy to modify productions in the early stages of acquisition» (ibid.). 'Never leave today's work for tomorrow' is a piece of good advice to go by. If it is developed further, it is even worse because according to Gagné et al., «once a procedure becomes automated, it is virtually impossible to change» (ibid.). This, by comparison, is widely distinct from learning basic units of declarative knowledge which, including propositional information, images, and temporal strings, «can be added, reorganized, and corrected much difficulty» (ibid.).

The Great Importance of Automaticity

With the distinction between the two cleared up, we are in a better position to treat different subjects with discrimination and thus optimizing the learning result.

In terms of acquisition of procedural knowledge, we, as teachers, can promote students' learning quality by making use of its characteristics. Specifically, the distinction between the two types of knowledge gives us a message that to acquire a practical skill with a minimum effort and time, it is highly recommended that «the mastery of any skill... depends on the ability to perform it unconsciously with speed and accuracy while consciously carrying on other brain functions» (Bloom, 1986, pp. 70-77), meaning to get that skill automated.

Automaticity, as «the hands and feet of genius» (ibid.) has been highly evaluated and ought to be greatly encouraged. Though we have to pay dear for that, it is worth doing. According to Bloom, time and overlearning «is necessary to develop automoticity in the many subskills required to reach top-level performance in a talent field» (Bloom, pp. 43-47). This is so because «once a skill has been developed to a high level of automoticity, it requires frequent use hut very little special practice to maintain at that level» (ibid.) and as evidence shows «automatic functions can simultaneously serve higher functions» (ibid.). It seems that nature has endowed as with something special – we are able to perform a lot of skills at a tremendously fast rate with great accuracy, something that is beyond attainment if performed under conscious control. There is however a condition: we should keep on practing until we have reached a high level of automaticity. It is only then that we can perform a skill unconsciously with great speed and accuracy. At this stage, the goal-directed processes are «intentional but effortless mental processes» (Bargh, 1999, p. 463).

What is even more wonderful is that at this stage, the speed and accuracy is much better than are done, consciously.

«Many writers have pointed out how im-

> possible it would be to function effectively if conscious, controlled and aware mental processing had to deal with every aspect of life, from perceptual comprehension of the environment (both physical and social) to choosing and guiding every action and response to the environment...» (Bargh, 1999, p. 464)

Bargh thought quite highly of this phenomenon:

> «Just as automatic mechanical devices free us from having to attend to and intervene in order for the desired effect to occur, automatic mental processes free one's limited conscious attentional capacity – from tasks in which they are no longer needed.» (ibid., 1999, p. 464)

This is particularly significant in those occupational training domains where highly skilled manipulation is required for a variety of jobs. Enlightened by this, when making our educational policies and teaching plans, we should encourage and guide students to strive to reach that level of automaticity since they can benefit a lot from it and save a lot of energy and effort in their future work. For one thing, to keep the skill at that level, you need little special practice (Gagné et al.). For another, when he or she has reached a high level of automaticity, he or she will have little loss of the skill acquired if he or she does not practice it for a long lime – one year or two, for instance (Bloom). Isn't overlearning of a skill worth the effort that goes into it? The answer could be 'yes'. The length of automated procedures is possibly the lifetime. We now know that elderly people can still ride bikes after not being on one for 40-50 years. Just after a few minutes 'trying' it all comes back.

One can never overemphasize the importance of this. It appears that it is somewhere between unconsciousness and consciousness that is the best state (automaticity) in which skills can be acquired much more easily and put to more ideal functions. It is the time when people are doing the highly-skilled jobs but their attention is directed elsewhere. Why so? Still little is known. But at least people have so far come to understand that humans are born with this potential and once it is activated and appropriately further developed, it can enormously enhance learning results. «If one compares the efficiency of a process when it is done with conscious attention versus when it is done automatically, there is little doubt that the economy of effort is far greater when done automatically» (Bloom, 1986, pp. 70-77). This point is made clear all the more by the words from Whitehead «Civilization advances by extending the number of operations which we can perform without thinking about them» (Whitehead, 1911, cited by Bloom & Chartrand, 1999: 464). «Or at least, one third less effort thin regular thinking» (Gilbert, 1989, p. 193, cited by Bargh & Chartrand, 1999, p. 476).

Though a lot more about the cognitive process is yet to be known, it appears that human beings are born with such ability that once skills have become automated, tasks demanding the performance of the skills are done much faster and better under unconscious control than, when done consciously. The former is the state to be desired and thus striven for because is worth doing. Enlightened by this, teachers may come to see the importance of training students towards this goal. This is greatly significant for teachers, who, during their long teaching career, do try, in someway or other, to optimize teaching and learning outcomes by guiding students onto the right track of moving towards automaticity. This reveals that it is quite necessary for them to emphasize in teaching, the great importance of practice, practice, and practice until the procedural knowledge (motor skill or cognitive skills) becomes automated. Although you may have to spend about 10 years on extended intense practice (Gagné et al., Ericsson & Lehmann, 1996) to obtain automaticity in certain expertise because it causes physiological, anatomical and even neurological adaptations in the body (It does take time!), it should be highly recommended and encouraged.

A Message from Memory Expertise

People with amazingly good memories certainly are those others admire greatly at. How to enhance the capacity of memories is quite a central topic on teachers' teaching agenda. Often in terms of language learning, we hear people say 'A good memory is half the battle'. This seems true to quite some extent. Being able to

distinguish between the two types of knowledge will help to make our memory-training more oriented, more efficient and more 'on the right track'.

Each of the three memories, as we have been told by Gagné et al. (1993), has features of its own. The first one, the immediate memory, though brief, is quite capacious. Therefore, when it comes to something that demands quick memory, we know that theoretically, the amount of information could be large if it is to be stored in the immediate memory.

The second one, the working memory (WM), is not only brief but also limited as far as its store is concerned. Then a message from the above two could be drawn that if we want to obtain as more brief information as possible, we ought to manage to get it at the first stage (immediate memory). Do seize the chance and not let the incoming information move onto the second stage (WM). Otherwise, we may not be able to store much information as working memory (WM), in light of what has been revealed by Gagné et al. (1993), is the «bottleneck» of human processing system, quite limited in terms of duration and capacity. Theoretically speaking, this seems to be what nature demands us to do cognitively though the mystery is yet to be known.

The third one: long-term memory (LTM) can be for spacious and permanent store but a bit slow. Thus it may work well with information that is of large amount but demands long-term and slow memory. This memory is particularly good for use when combined or interacted with elaboration. As concluded by Carroll (1999), when new information comes in via the process of elaboration, it becomes related more organically to information already stored in permanent (long-term) memory (meaning activating the old information), this LTM plays a part in enriching memory representation of the new information.

The implication of these three is also significant. As teachers who try to facilitate this cognitive process of students, we should be well aware of these and teach students to select them differentially. This can be tailored, depending on their objectives. Thus, students can be made more competent in their choice of strategies in memorizing things so as to produce better learning results.

4. MORE POTENTIAL HUMAN RESOURCES REMAIN TO BE TAPPED

This distinction leads us to understand as well the great importance of automoticity which reveals a fact that «we are able to do very different processes at the same time» (Bloom) like in the example that people can think of something else while walking. Thus, we may take a farther step. With some more similar but more advanced training, is it possible that we do two or three different things at the same time? E.g. One talks to somebody else while his/her left hand is writing Chinese but his/her right hand is writing English? Get something creative out of people's cognitive process? Once I was told that there was a girl who could, while talking to somebody else, use her left and right hands at the same time, write down separately two same English words. Can that be further developed? Can we challenge what seems to be the extremes of humans' physical and cognitive ability? If the answer is 'yes', there will be great leap forward in the «tapping up» of humans' ability and resources. Actually in practice, most people who develop expertise de so in only one area of fife. Sometimes it is just because the sheer level of time/energy/effort needed to develop and sometimes the skills. However cognitive theory indicates that we all can develop skills, given sufficient time and motivation. This suggests that there lies a broader prospective before us for development in the research into this field.

5. CONCLUSION

The distinction between the two types of knowledge is crucial for us to understand the mental cognitive processes. It helps make things much easier for teachers to become competent in choosing the right teaching methods and strategies to help facilitate more effectively students' mastery of knowledge and skills as per what we are endowed with by nature. It may even further help get more out of human resources. In this sense, it may help create a brighter future. To quite some extent, it is the awareness of this distinction that leads to and accounts for a large part of those successful teachers in their choices of teaching methods or strategies. Psychologi-

cally, different subjects require different types of knowledge that would optimize the relevant learning and teaching outcomes. Better results can be obtained with less effort. Otherwise we may find ourselves 'stranded' in the situation of a 'square peg in a round hote'. That means we do not make full use of what we human being are endowed with by nature. Being able to distinguish between the two types of knowledge will shed fight on how to use effort and time wisely with much more achivement to be made but much less time and effort to be spent.

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ABSTRACT

So far as we know, apparently the declarative knowledge interacts and combines with the procedural knowledge. But seen from a cognitively psychological point of view, it seems important, as this paper claims, to make a distinction between these two aspects of knowledge. The implication of this distinction for teachers or educators lies in that it helps make clear what human beings are endowed with, how differently they function, and how to adapt human beings more adequately to what are offered with, in an attempt to help students optimize or maximize their learning results. According to the points suggested by this paper, being able to distinguish between the two types of knowledge can enhance teacher's awareness of the teaching methods to be adopted, bring into full play more positive factors of each of the two types of knowledge, and may reveal some more human potential resources to be tapped.