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Enhancing Classroom Learning through Cognitive Psychology: Six Practical Recommendations

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Abstract: Classroom teaching and learning involve not only the delivery of knowledge but also the effectiveness of the instructional approach. While educational practitioners often focus on what to teach, it is equally important to examine how teaching and learning are conducted. Incorporating principles from cognitive psychology into classroom instruction could help teachers enhance their pedagogical effectiveness and improve students' learning outcomes. This paper reviews important empirical findings that apply cognitive psychology to real-world educational settings. Based on these findings, six evidence-based recommendations are proposed and analyzed. These recommendations address aspects such as cognitive load management, long-term memory retrieval, multimodal learning, simulation-based activities, the use of conceptual models, and metacognitive processes. Together, they aim to offer practical guidance for educators aiming to improve students' learning outcomes through cognitively informed teaching practices.

1. Introduction

It is meaningful to see through the lens of cognitive psychology and make recommendations on how to improve students' school educational outcomes since students' learning and study in school involve lots of brain activity like perception, memorization and reasoning, which are important areas to study in cognitive psychology. In this paper, the following six recommendations for teachers to implement in their teaching curriculum are discussed in detail: teaching essential information only through one modality and avoid presenting redundant information through other modalities, giving students tests and exams more frequently, finding video games relevant to their teaching contents for students to play before formal class sessions, adding simulation activities when teaching about reading comprehension tasks, assisting novice students learning explanative science materials by providing them with conceptual models before or within lessons, and adding a session in class for students to "self-explain" the knowledge just taught.

2. Avoiding extraneous cognitive loads

The first recommendation is that it would be helpful for teachers to teach essential information only through one modality and avoid presenting redundant information through other modalities like presenting redundant text information on PPT when talking about it. Teachers should try to reduce students' extraneous cognitive loads imposed by redundancy effects so students could keep their total cognitive loads below the needed processing capacity of learning.

One supportive study is from Kalyuga, Chandler, and Sweller [1]. They asked 34 people to learn from a computer-based program about some scientific knowledge named the Fusion Diagram. 12 people were assigned to learn with visual animation and visual plus concurrent audio text (group one); 11 people learned with visual animation and visual text only (group two); 11 other people learned with visual animation and audio text only (group three). After two phases of learning, all three groups were tested on their learning outcomes. The result showed that group three greatly outperformed group one, indicating that eliminating redundancy of information is an effective instruction method.

Bobis, Sweller and Cooper have similar findings [2]. They asked 30 fourth graders to learn a geometric task by constructing certain shape with paper disc. Half of them learned with diagram format instruction while the other half learned with the same instruction plus redundant written instruction. Result showed that more children from the diagram-only group completed the task, meaning that the redundant instruction impeded children's learning.

Study from Mayber, Herser, and Lonn also shows the effectiveness of excluding redundancy instruction [3]. 78 college students were asked to learn from a multimedia presentation about formation of lightning. Besides the animation, 19 students learned with added text narration; 16 students learned with both added text narration and entertaining but irrelevant information; 21 students learned with added entertaining information; and 22 students learned with animation only. The results from the afterwards tests showed that students learned with animation only had the best retention of the knowledge. The result also indidcated that adding on-screen texts or entertaining information is harmful.

In practical teaching scenarios, teachers should try to keep their PowerPoint slides short and concise by not including narrative text that they are going to say when the slides are presented. This is to avoid redundancy effects and better enable students to keep a manageable cognitive load while processing information. A good way to avoid redundancy is to only have graphical and diagram information on screen, but not on-screen narrations that are concurrent with audio information.

3. Increasing testing frequencies

Another way teachers could use to enhance students' learning outcomes is giving them difficult tests and exams more frequently. Students are likely to forget about some knowledge as time goes by because their ability to retrieve related memory declines. Teachers could use tests and exams to both help students strengthen their long-term memory retrieval and elaborate on their learned knowledge.

One supporting example is from Hogan and Kintsch's study [4]. In one experiment they conducted, 64 college students were asked to learn 40 words. The first group learned through three study trials and one free-recall test, while the second group learned through one study trial and three free-recall tests. Results from the final recall and recognition tests conducted two days later showed that, although studying and testing are equally effective for recognition tasks, testing would be more effective than studying for memory retrieval tasks.

Thompson, Wenger and Bartling conducted a similar but modified research [5]. In addition to the design of the two groups in Hogan and Kintsch's study [4], they added a third experimental group in which students had an extra trial to study those words they failed to recall from previous recall tests. Results from their two-day after final recall test showed that the third group outperformed the other two groups and the second group outperformed the first group. In general, their study revealed that testing has a positive effect on later memory retrieval but not on immediate memory retrieval.

Roediger and Karpicke's study yields similar findings [6]. In one experiment, 180 college students were assigned to three groups to study some passages. The first group studied the passage four times; the second group studied three times and took one free recall test; the third group studied only once but took three consecutive recall tests. Five-minutes later and one-week later final tests were given to all three groups. The results showed that more retrieval tests are associated with better recall in the one-week-after test, but poorer recall in the five-minutes-after tests.

As found in all three studies, testing is particularly effective for delayed—but not immediate—recall tasks. Therefore, in practice, in addition to midterms and final exams, teachers might consider giving frequent tests on material taught at least several days earlier. These tests can be free-recall tasks, and no feedback is necessary, as demonstrated in the three studies above.

4. Incorporating video and computer games

The third suggestion advocates that teachers incorporate video games relevant to their teaching content for students to play before formal lessons, as a way to better prepare them for the deeper learning to come. This recommendation is from grounded cognition's perspective that teachers should try to activate students' multi-modal learning by helping them build more perceptual simulation experiences which benefits their future formal learning.

One supporting study is from Hammer and Black [7]. They recruited expert players from a historical game *Civilization* and some other expert players from a non-historical game *Sim City.* They did a pretest and found that the two groups of players had similar levels of knowledge on historical contents related to *Civilization.* After having both groups read the history content from a difficult college textbook, the posttest showed that the *Civilization* group gained significantly more from the reading than their counterparts did, suggesting that playing video games before formal learning can facilitate deeper future learning of relevant content.

Black and McClintock's study also shows the usefulness of video games [8]. They assigned sixth-grade students to learn ancient Roman and Greek history. One group learned by first participating in the simulation game *Archaeotype* and then receiving help from teachers, while the other group learned with teachers' help only. Students then worked in pairs and developed reports and explanations, which were used to assess their learning outcomes. The results showed that the group played the game scored ten more percent more than the other group, acknowledging the effectiveness of video games.

Han and Black found that forced-feedback video games could further improve students' future learning outcomes [9]. They asked 220 fifth grade students to learn about some physics knowledge about gear movements. The first group learned using video and paper-based instruction along with a force-feedback simulation game; the second group received the same instruction but used a simulation game without force feedback; the third group learned without any simulation game. Students' learning outcomes from posttests showed that the simulation game is helpful for enhancing students' future learning and using force feedback games could further improve their performance.

The usefulness of video games, especially ones with force feedback, could be incorporated into classroom learning in many ways. For example, an astronomy teacher who is going to teach about stars in the galaxy could find a force feedback simulation game which involves some knowledge like colors, shapes and locations of the stars for the students to play several days before the formal class. Playing the game provides students with some prior perceptual experience about the stars and it enables students to draw inferences from both game playing and class learning afterwards, which could lead to deeper learning outcomes. Force-feedback video games are the most effective option to choose, but if teachers cannot find any, video games without force feedback can also be effective.

5. Adding simulation activities

The fourth recommendation is that teachers should help primary school-aged children enhance their comprehension of reading and listening texts by incorporating simulation activities—such as having students manipulate text-related objects—into the classroom. This recommendation is rooted in the indexical hypothesis, stating from a standpoint of embodied cognition that meaningful comprehension requires simulation of the reading content [10]. In order to achieve such goals, one needs to “index words to the objects and actions those words represent” [10].

One supportive study was from Bender and Levin [11]. They randomly assigned 96 children into four experimental groups to listen to a 20-sentence story. The first group viewed a picture while listening to each sentence, the second group imagined a picture while listening to each sentence, the third group listened to each sentence twice and the last group only listened once. 20 questions designed to measure students' ability of recalling information of the story were asked. The result showed that the first group recalled significantly greater amount of information than all other groups did.

Another supportive study was from Rubman and Waters [12]. 192 third grade and sixth grade students were asked to find inconsistencies in given stories and were tested on their recall of stories. They were assigned to two different conditions: read and constructed storyboard representations of the story or read the story twice. Results showed that the storyboard group detected more inconsistencies and recalled greater amount of stories.

The study by Glenberg, Gutierrez, Levin, Japuntich, and Kaschak also confirm the effectiveness of “indexing” [10]. They assigned second-grade children to three groups: the first group read a text, observed a related scenario, and manipulated scenario-related toys; the second group read the text and observed the scenario; and the third group only read the text. Students were then assessed on their free recall and cued recall of the information. Results showed that first group students remembered more sentences for both types of recall than the other two groups could.

But it should be noted that this recommendation may only be applicable to lower grade students and it may only be effective on descriptive reading or listening tasks, as the above three supporting studies show. One way teacher could implement this recommendation is incorporating similar activities in the above three studies into their teaching. For example, elementary school teachers could help students index by asking them to play out or draw out scenes when teaching a story-based reading comprehension task.

6. Providing conceptual models

The fifth recommendation involves assisting novice students in learning explanatory science materials by providing them with conceptual models before or during lessons. Conceptual models are not abstract schemas. They often represent real-world systems and movements of interacting parts. They lay out important actions and causal relations of a system, which could help novice students to understand and build mental models.

In one study by Mayer, Dyck, and Cook, students were divided into two groups and were asked to read a passage related to density [13]. The experimental group read a model sheet before the lecture while the control group did not. This study showed that the experimental group had 144% better recall of conceptual information and 43% better ability to solve related but transferred problems.

In a similar study, students were divided into two groups and were asked to listen to a lecture about how radar works [14]. The experimental group had one minute to exam a model sheet before the lecture while the control group did not. This study showed that the experimental group had 54% better recall of conceptual information and 83% better ability to solve related but transferred problems.

Assisting students with conceptual models during lecture is also proved to be effective. In another study by Bromage and Mayer [15], students were divided into two groups and were asked to read a passage about using 35mm camera. The two groups read different versions of the passage. To be more specific, the experimental group read the one including a conceptual model and the control group read the one without any conceptual model. This study showed that the experimental group performed 29% better in solving related problems compared to the control group.

The usefulness of conceptual models could be applied many ways. For example, in a first year university engineering class where the professor is going to talk about the law of motion, he or she could distribute conceptual model sheets to students before the lecture begins. The conceptual model serves as a useful tool to help students understand the definition of motion, the factors that cause motion, and other related information. In this way, students are believed to be better prepared for the lecture and more capable of understanding and retaining the content. However, the usefulness of conceptual models may be limited. They tend to benefit only novice learners with little prior knowledge of the material. In addition, to be effective, conceptual models must be provided before or during the lesson. Moreover, their benefits may be confined to scientific or systematically organized knowledge only.

7. Encouraging students' self-explanation

The final recommendation suggests adding a session in class for students to "self-explain" the material just taught. "Self-explaining" improve students' learning outcomes because it is a metacognition process which helps students to monitor their own thinking and identify gaps in their understanding. In this "thinking about thinking" process, students are also able to construct new knowledge and integrate them with old knowledge.

One supportive study is from Chi [16]. In this study, eight college students who studied some introductory physics text were asked to voluntarily explain on their understanding of reading materials from three examples. The study correlated the amount of students' self-explaining to their performances on related problems solved. Findings showed that students who were more successful at solving related problems were those who generated larger amount of self-explanations.

A similar study by Lavancher, Chiu, De Leeuw, and Chi proved the positive effect of self-explanation on learning declarative knowledge [17]. 24 eighth graders first had a pretest on some circulatory system knowledge. Then they were given a related text and a follow-up posttest. Fourteen students learned by reading each line of the text and self-explaining; the other ten students learned by reading the text twice. Results showed that students who learned with self-explanation learned more (32%) from pretest to posttest than the other group did (22%).

Nathan, Mertz, and Ryan also had similar findings [18]. In their study, 32 college students were first given a pretest. They then either studied worked-out solution examples or generated their own solutions to the problems. Half of them were asked to read and self-explain worked-out solutions or self-generated solutions while the other half read solutions twice. Results from delayed posttests showed that self-explanation yields 20% greater improvement for low cognitive load tasks but not for high cognitive load tasks.

Self-explanation is effective, but it has limitations as well. It is useful for learning problem-solving skills and declarative knowledge that impose a low cognitive load. For example, a math teacher could ask students to self-explain an intermediate level worked example so students could monitor their understanding and improve their learning outcomes. However, when a problem is too difficult to even consider, students may not have sufficient cognitive resources to engage in self-explanation. Therefore, this method may not be applicable in such situations.

8. Conclusion

Incorporating principles from cognitive psychology into real-world classroom teaching and learning can be highly beneficial for educational practitioners. This paper presents six recommendations, most of which are applicable to both K–12 and college education, with only one specifically limited to primary school settings. However, although these recommendations are generally widely applicable, it is important to consider their practicality for specific populations. When necessary, the recommendations should be appropriately adapted before implementation.

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