Cognitive Load

A Learning-Teaching Perspective

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Cognitive Load: A Learning-Teaching Perspective

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Cognitive Learning Strategies For Effective Science Learning

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Ms. M. Vijayalaksmi**

Introduction

Learning is a never-ending and life long process. Learning is considered as the collection of experiences. Learning is referred to as a relatively permanent change in behaviour which results from experience or practice. Learning is the process of connecting the symbols in a meaningful and memorable way.

Science learning is a systematic process which consists of activities such as observing, comparing, classifying, measuring, predicting, communicating,

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inferring, etc. Science learning provides opportunities for the learners to think meaningfully, creatively and innovatively, acquire knowledge, ask questions, describe objects, etc. Science learning engages the learners in joyful hands-on activities and makes them explore new things.

Cognition is the mental action or process of acquiring knowledge and understanding through thought, experience and the senses. Example for cognition is learning. Cognition and learning are central concepts in educational psychology (Greeno, Collins and Resnick, 1996). Mental processes include perception, attention, memory, thinking, reasoning, problem solving, decision making, etc. Mental processes facilitate symbol connection.

Cognitive learning makes the learners use their brain for better understanding of the learning, thinking, perceiving, remembering and problem-solving processes. The Cognitive learning process uses existing knowledge and discovers new knowledge. Learners organize these knowledge and experiences in their mind and retain them for a long time. Learned information can be stored in long-term memory and recalled easily by adopting certain strategies. They are called Cognitive learning strategies. Cognitive learning strategies are spaced practice, interleaving, retrieval practice, elaboration, concrete examples and dual coding. These strategies encode the information efficiently in the brain, store in the long-term memory and retrieve the information from the memory easily whenever it is necessary.

This paper attempts to explain the six cognitive learning strategies that are used for effective science learning.

Need of the Study

Developing scientific skills, knowledge, attitudes, values, etc., understanding the scientific information clearly and precisely and remembering the learned facts for a long time are considered more important in this 21st century. To create an effective, unforgettable scientific learning, it is essential to have a suitable learning strategy which will provide better understanding and easy remembrance. The learned information should be encoded, stored and retrieved easily from the long-term memory. Cognitive learning strategies encode the learned information correctly in the brain, retain in a long-term memory and recall and recognize the information easily and accurately. So, cognitive learning strategies are used for effective Science learning.

Objectives of the Study

- To explain the term Cognition
- To elucidate the concept of Cognitive learning
- To describe about the Cognitive learning strategies
- To understand about the practice of Cognitive learning strategies for science learning
- To list out the benefits of the practice of Cognitive learning strategies for science learning

Cognitive Learning Strategies For Effective Science Learning

Cognitive learning strategies such as spaced practice, interleaving, retrieval practice, elaboration, concrete examples and dual coding are explained and applied in science learning for better results in the learning process.

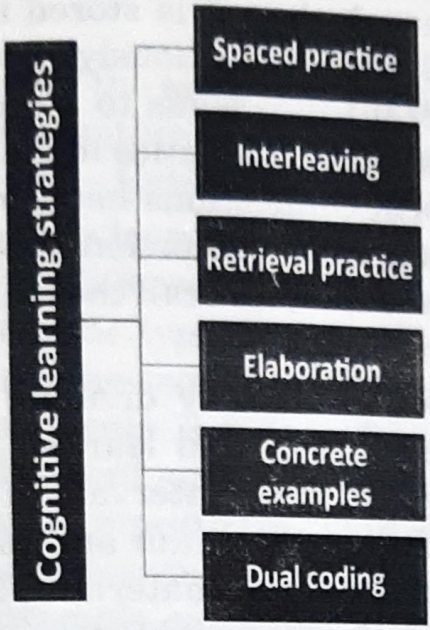

Figure 1: Cognitive Learning Strategies

Spaced Practice

"Spaced practice(also known as Distributed practice)is a learning procedure in which practice periods for a particular task are separated by lengthy rest periods or lengthy periods of practicing different activities or studying other material, rather than occurring close together in time" – APA Dictionary of Psychology.

Spaced practice is a study technique where the learners review the learning material repeated at specific time intervals. This technique helps the learner to retain the learned material for a long time in the memory. Kang (2016) revealed that the benefits of spaced practice to learning are arguably one of the strongest contributions that cognitive psychology has made to education.

The learned material may be forgotten, if the learner does not recall or review again. If the learner

restudies the learning material again and again at a specific time interval, then it is stored in a long-term memory. Restudying continuously with a specific time gap for several times leads to a reduction in the forgetting process. Spaced practice makes the minds of the learners to form connections between the learned ideas and concepts. This connection supports to build upon knowledge and aids to recall the learned material easily.

Spaced practice is done by dividing the learning material into small pieces and learned correctly and repeatedly at regular time intervals. This will lead to accurate encoding in the brain and to increase the retention rate of the learned material. This also helps the learner to learn the material better and to achieve good results in exams. Rawson and Dunlosky (2011) opined that the student has to practice recalling the concepts to an initial criterion of 3 correct recalls and then to relearn them 3 times at widely spaced intervals.

For example, spaced practice is done in a science topic – vegetative propagation. This topic must be divided into small pieces such as vegetative propagation, its types, cutting, budding, fragmentation and spore formation. Then the learner is allowed to learn the topic with examples correctly and precisely. The learner must relearn the topic several times with a specific time interval. Learning schedule might consist of the topic cutting on Monday, budding on Wednesday, fragmentation on Friday and spore formation on Sunday. Relearning or reviewing the topic helps the learner to remember the topic for a long time and build the knowledge upon it. It reduces the forgetting process also.

Interleaving

The meaning of the term interleave is "to put layers or flat pieces of something between layers or flat pieces of something else" – Cambridge Dictionary.

Interleaving is a learning technique which involves a sequence of a different set of tasks or examples, rather than the same type of task followed for multiple times. Next time, the sequence of the tasks is shuffled. That is, each sequence is followed immediately by an example of a different sequence rather than the same sequence example repeatedly. This occurs due to the shuffling or randomisation of the order or sequence of the tasks. For example, presenting the botany students with an example of a reticulate venation, then an example of parallel venation, then another reticulate venation, and so on.

Interleaving improves the learner's brain to differentiate the two concepts and strengthens the associations of the memory. Interleaving facilitates the learners to retain the newly learned information for a long time and develop the new skills in various fields. Eglington and Kang (2017) demonstrate that interleaved presentation can improve learning of educationally relevant categories, even when coupled with pedagogical techniques that emphasize the diagnostic features of each category.

Interleaving practice helps to learn two or more related concepts at a time. If the learner practices a single concept repeatedly there is a chance to get bored quickly. Interleaving practice gives a good solution for this problem. By practicing interleaving methods, the learner can easily learn two or more concepts by mixing the concepts or alternation of concepts. This helps the learners to categorise the learned concepts

and gain the ability to discriminate the concepts. This type of learning retains a long time in the memory and is stored in long term memory.

For example, interleaving practice is explained with the science topic – Acids, Bases and Salts. The topic is divided into three small pieces such as Acids, Bases and Salts and presented with examples to the learners in a sequence. Next time, the sequence of the topics is shuffled and presented to the learners. That is, first presenting the examples of acids, then examples of salts, then examples of bases, again examples of salts, and so on. This type of learning helps the learners to understand and differentiate the acids, bases and salts and to categorise them separately. Also improves the learner's knowledge level of the concepts and retention rate, which then aids to store in long term memory.

Retrieval Practice

Retrieval refers to the process of getting something back from somewhere. Synonym for retrieval is recall or remember or revive.

Retrieval practice is a strategy in which the learned information is recalled and brought back to the mind and enhances and boosts the learning process. The practice of recalling the information from the stored information or memory is called Retrieval practice. After learning a concept, this process is done purposely to the learner in order to examine what he knows about that particular concept. Retrieval practice improves the power of the memory and decreases the forgetting process. Retrieval practice helps to store the information in a long-term memory. Roediger and Butler (2011) stated that the power of retrieval practice in consolidating memories has important implications for both the study of memory and its application to

educational practice.

Retrieval practice is done by giving worksheets, asking questions, examining the performance, conducting quizzes, etc. Known information is easily recalled or remembered rather than the unknown information. Sometimes the learner feels quite easy to remember or recall the information. This shows that the information is familiar and stored well in the memory. If the learner felt some difficulty in recalling the information, it represents that the concept is unfamiliar and not stored properly in memory.

Types of retrieval are recall, recognition and relearning. Recall is the act of remembering the information without any cues. For example, remembering the home address. Recognition is the process of identifying the information with cues, which has previously been learned. For example, attending the multiple-choice question in the examination hall and recollecting the answer from the memory. Relearning is the process of learning the information which has already been learned. For example, mathematical formulas which are learned already in school days are learned again in college days.

For example, retrieval practice is explained with the science topic – Speed calculation. The average speed is calculated by the following formula - Speed = total distance covered divided by total time taken. By retrieving and using this formula, the learner can easily calculate the speed of a car, speed of a ball, speed of a snail, speed of a human etc. Here, memory cues assist the learner to recognize the formula for speed calculation. Thus, the retrieval practice helps to store recalled material in a long-term memory of the learner. Retrieval practice is an effective tool to promote conceptual learning about science (Karpicke

and Blunt, 2011).

Elaboration

Elaboration is the process of explaining a concept or fact in a detailed manner. Elaboration means giving additional information to the already learned concept or fact.

"Elaboration is the process of interpreting information to be remembered or of relating it to other material already known and in memory" – APA Dictionary of Psychology.

Elaboration is used to explain the ideas, concepts, theories, principles, etc. with more information. And this tries to connect among the ideas of present learning and also connects the learning material with learner's experiences, memories and present life situations. For example, addition, subtraction, multiplication and division are explained to the learners with a lot of examples and tries to make connections with their experiences, memories and day-to-day life activities also. Elaboration learning technique helps to recall the information from memory. So, it is also called a memory aid technique. Elaboration theory helps to ensure that the learner is always aware of the context and importance of the different ideas that are being taught (Reigeluth and Stein, 1983).

There are different types of elaboration techniques. They are mnemonics, rewriting, note-making, comparisons and self-questioning. Mnemonics helps to retain the information in the memory. Mnemonic types are keywords, chains, rhyme, acronyms, word and picture, sequence, gestures, words to numbers and word parts. Rewriting is the process of writing the learned material in your own words such as paraphrasing and summarizing. Note-making is a

process of writing down the notes in their own words which the learner heard or read. Different types of note-making are outlining, mapping, charting, sentence method and Cornell method. Comparisons is the process of providing connections between the known images, ideas, etc. Self-questioning is the process of asking questions with the help of 5 Ws – What, When, Where, Who, Why and 1 H – How. These elaboration techniques make the brain of the learner to work well and assist for better learning.

For example, elaboration technique is explained with the science topic – Respiration. Respiration process is learned in a detailed manner by describing the process of aerobic and anaerobic respiration, breathing, inhalation, exhalation, breathing rate, mechanism of breathing, etc. To learn this topic, different techniques of elaboration are adopted. So, this technique helps to retain the learned material in a long-term memory of the learner. Mayer (1980) suggest that elaboration techniques can be applied to "real-world" materials and can result in more integrated, broader learning outcomes.

Concrete Examples

Concrete examples are real or definite examples which are existing and can be sensed through sense organs. An abstract concept can be explained with the help of concrete examples. Concrete examples in learning helps the learners to understand the concepts easily and supports them to remember and store in a long-term memory. For example, to understand about the different textures such as rough, smooth, hard, soft, solid, liquid, lumpy, gritty, etc. the learners must collect different real and relevant materials and must feel the different textures from different things. This

type of learning helps the learners to remember for a long time in their memory. De Bock et. al. (2011)stated that students who learned from concrete examples transferred their knowledge into a similar concrete context.

Concrete examples are considered as a supplement or supporting information for the abstract ideas and concepts. Concrete examples are used for the contents which are more conceptual in nature and support understanding the ideas very easily. Concrete examples are in the form of text, image, audio, video, etc. These examples assist in understanding the concepts which do not physically exist. These supplement materials are easily remembered and retained in the memory for a long time. For example, to learn about the function of the human heart, the learners can learn from the text, images, audio (lub and dub sound of heartbeat), video, etc. which are relevant to the topic.

For example, Concrete examples are explained with the Science topic – Sexual reproduction in plants. In class, after the teacher explains about Sexual reproduction in plants, learners must be allowed to search and collect the different flowers which their teacher mentions in the class. And also, to find out the reproductive parts in the flowers such as filament, anther, ovary, ovule, style, stigma, etc. They must find the relevant animated videos which explain about the self-pollination and cross-pollination in flowers and must watch it. They must also learn the Fertilisation process with the help of text sources and images. Learners must cross check with the teacher to confirm whether collected materials are correct or not. Then they must share their learning materials and examples with their friends. This type of learning helps the learners to understand the concept easily and clearly

and also to remember for a long duration.

Dual Coding

Dual coding technique is used to explain the concept clearly. Dual coding technique uses two types of codes. They are analogue codes (images) and symbolic codes (words). It consists of both visual and verbal information. Reed (2012) stated that there are two ways a person could expand on learned material – verbal associations and visual imagery. Sternberg (2016) opined that Dual coding theory is suggesting both visual and verbal information is used to represent information. Visual and verbal information helps the learners to remember the information easily which is stored in the long-term memory.

In dual coding technique, visuals such as diagrams, pictures, posters, infographics, timelines, icons, symbols, graphs, tables, etc. are used. This type of dual coding technique improves the learners recalling power. Clark and Paivio (1991) demonstrates in their research that concreteness, imagery, and verbal associative processes play major roles in various educational domains: the representation and comprehension of knowledge, learning and memory of school material, effective instruction, individual differences, achievement motivation and test anxiety, and the learning of motor skills.

Dual coding technique is more effective when the visuals are meaningful. The meaningful visual must consist of the following criteria. They are - visuals should be simple and easily understandable, visuals should be covered with white background, colours and patterns should be simple, visuals should be relevant to the verbal information, visuals should be decorated simply, etc. Effective visuals are retained in the

memory for a long time. This extends the learning time of the learners.

Dual coding technique is more suitable for learning science concepts. According to the saying "A picture is worth more than a thousand words", dual coding explains the scientific concepts more clearly and precisely than a verbal mode of teaching. Visuals are more memorable than verbal explanations. Clark and Paivio (1991) also stated that DCT also has important implications for the science and practice of educational psychology — specifically, for educational research and teacher education.

For example, Dual coding technique is explained with the science topic – Circulatory System. To explain the circulatory system in humans, dual coding technique is used. Circulatory system is explained with the help of visuals under the headings such as types of blood, blood vessels, arteries and veins, double circulation, section of the heart, circulation of blood, etc. Visualizing these perfect visual representations along with appropriate verbal information makes the learners understand the concept easily and properly. These visuals increase the learning time and remembering power among the learners. This information is stored in a long-term memory of the learners.

Benefits of Cognitive Learning Strategies

Cognitive learning strategies help to learn science effectively and efficiently. Cognitive learning strategies integrate new ideas with the already known concepts and organize them into a new mental representation. This will be stored in a long-term memory and recalled easily later. It encourages to find relationships, similarities and dissimilarities of the ideas and helps for better understanding of the ideas. While

learning new concepts, cognitive learning strategies improve the learner's retention rate of information and minimizes the cognitive load. Learning of Science through cognitive strategies enhances the learning process, promotes the comprehension level, encourages confidence level, supports for better understanding of the scientific concepts, improves the problem solving and decision-making skills, helps to learn the new facts quickly, fosters creativity and innovation, assists to form concept formation, boosts to think abstractly and reasonably, encourages to find solutions effectively, etc.

Conclusion

The ultimate goal of science learning is to remember for a long-term and to use it for day-to-day life and future activities. Cognitive learning strategies fulfil this goal. Science learning through cognitive learning strategies provides a deep understanding, accurate encoding in the memory, storage in the long-term memory and easy retrieval process.

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