

Comprehensive review of mnemonic devices and their applications: State of the art

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Abstract: Mnemonic devices can be defined as learning strategies which can often enhance the learning process and later the recall of information. On the other hand, mnemonic systems are special techniques or strategies consciously used to improve memory, they help employ information already stored in long-term memory in order to make memorisation an easier task. There is no doubt that mnemonic techniques are one of the most important methods and methodologies used in education. However, nowadays these methods seem to be unremembered and seldom used by teachers or students. There is a deficit in the actual reviews on this subject. In this article we review mnemonic methods from the point of view of teaching and learning science subjects. This article is the first work in literature that refers to and emphasises various and complex aspects of mnemonic devices applications in didactic practice like science learning and teaching, helping students with disabilities and behaviour problems and second language acquisition.

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Introduction

The word “mnemonics” is derived from the $\mu\eta\eta\mu\omicron\nu\iota\kappa\acute{o}\varsigma$ (mnēmonikos), meaning “of memory”, or “relating to memory” and is connected with Mnemosyne – the Greek titan, goddess of memory that represented memory (“remembrance”) in Greek mythology.¹

The idea of mnemonics is application in developing better ways to take in (encode) information, so that it is much easier to remember (retrieve)² it. Therefore, mnemonic devices can be defined as systematic procedures for intensification of memory. Hence, mnemonic devices ought to be understood as learning strategies which can often enhance the learning and later the recall of information.³ The main idea in mnemonic strategies is to find a connection between a new piece of information

and the one that students have already locked in long-term memory. If the connection the students make is strong enough, the memory will last for a very long time, because of the fact that the mnemonic strategy carefully links it to things that are very familiar according to these procedures and they can be powerfully effective.² What is more, further mnemonic devices can be incorporated for the things that require recall. These strategies are also a useful way of improving memory in students who exhibit difficulty with remembering things. Although the mnemonic devices are not an educational panacea, they can play an important part in improving memory for learning or teaching processes.

There are various types of mnemonic methods described, yet a suitable classification and nomenclature system of those methods are lacking. Because of this problem it is very important to note the basic distinction between mnemonics that primarily involve organising operations and those that primarily involve encoding operations. An organising operation is one that associates or relates in memory units of information that at first appear unrelated.³ Furthermore, an encoding operation transforms a unit of information into some other form that can be fit into some organisational scheme. Mnemonic devices have been differently classified by different authors, e.g. Thompson in 1987⁴ arranges mnemonic strategies into five classes: linguistics, spatial, visual, physical response and verbal methods. On the other hand, Oxford in 1990⁵ identifies four major strategies: namely, creating mental linkage, applying images and sounds, reviewing well, and employing action. In turn, Baddeley in 1999⁶ described that mnemonic devices can be classified into visual imagery strategies and verbal strategies.

Methods

The primary aim of this article was to review the articles related to mnemonic devices and its applications in learning and teaching of science subjects, teaching of students with disabilities and behaviour problems, and in second language acquisition.

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The classification method used in this study was the method adopted by Bellezza in 1981³ (Fig. 1), which seems to be more comprehensive in our opinion.

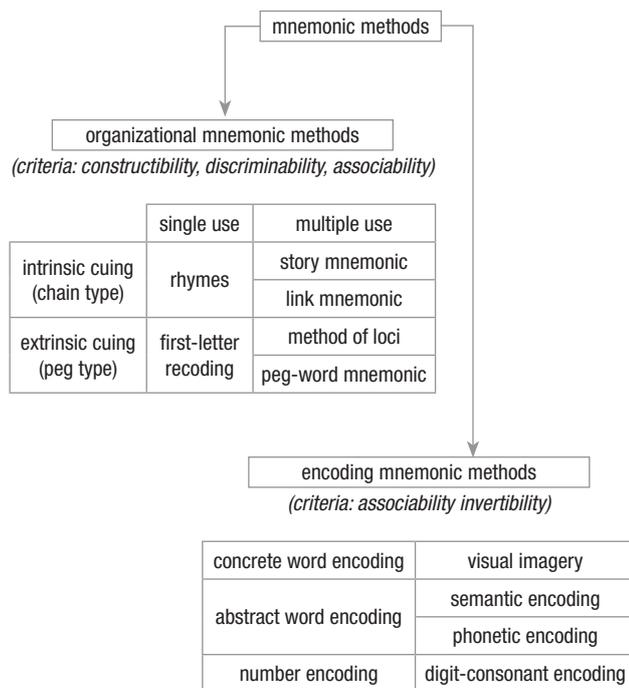


Fig. 1: Classification of mnemonic methods – based on.^{3,7}

We reviewed the theoretical and empirical literature on mnemonics as memorised tools, published over the past half century, primarily focusing on research in pedagogical and educational journals. We examined articles related to the mnemonic methods and methodologies according to: 1) Mnemonic methods as didactic tools (9 articles); 2) Application of mnemonic devices in learning and teaching of science subjects (30 articles); 3) Application of mnemonic methods in teaching students with disabilities and behaviour problems (9 articles); 4) Application of mnemonics devices in second language acquisition (7 articles). For our studies we applied Google Scholar due to the fact that it has been well received among the research community. Moreover, Google Scholar offers free,

universal, and easy access to scientific literature coupled with the perception that it covers the social sciences and the humanities better than other traditional multidisciplinary databases.⁸

Results and Discussion

Mnemonic methods as didactic tools

It must be emphasised that the mnemonic methods are not a general teaching method or a curricular approach.² The idea of mnemonic strategies is so specific that they are intended to be used to enhance the recall of the components of any lesson for which memory is needed. From the didactic point of view, mnemonic strategies are memory strategies and not comprehension strategies.² As was mentioned earlier, many articles provide evidence that the application of a mnemonic method by students or pupils increases their results in comprehension tests.^{9,10} This situation occurs because they are able to remember more and it can be applied in comprehension tests. For example, Chase and Ericsson in 1981 and 1982 described that regular college students can attain world-class memory performance after extensive practice and proposed skilled-memory theory as an account for how ordinary people can acquire exceptional memory.^{11,12} On the other hand, due to the exceptional memory performance, Wilding and Valentine (1997) reported that the skilled-memory theory did indeed account for truly exceptional memory performance involving specific types of materials, such as digits.¹³ Moreover, these authors also proposed evidence for the existence of naturally superior memory, whereby some people's memory for specific materials had never been truly exceptional, but consistently well above average for several different materials tested. Besides, these subjects reported that they did not use mnemonic encoding strategies.¹³ Based on this observation, it can be ascertained that mnemonic strategies are not comprehension strategies, but only memory strategies/methods.¹⁴

Application of mnemonic devices in learning and teaching of science subjects

Approaches to the science of learning are very different. Mnemonic strategies can be incorporated into the elements that require recall.¹⁵ Educationally, mnemonic methods can have a significant impact on studying or teaching important information, and can improve recall and boost the student's self-confidence which in the scientific field is important because of the fact that the ability of recalling new pieces of information is often more difficult due to the unfamiliarity with the content.¹⁶ Mnemonic procedures and materials are valuable in classroom teaching, but the question is how effective self-initiated mnemonic strategies can be for all learners.¹⁷

Mastropieri and Scruggs in 1998² have found that mnemonic strategies can be used to enhance science learning when the curriculum involves a handbook / lecture format or when the curriculum involves a hands-on, inquiry learning format. Even though these approaches to science learning are very different from each other, mnemonic strategies can still be incorporated for the elements that require recall.

In science courses (Chemistry, Biology, Physics and also Mathematics) there are many examples of mnemonic devices, but describing these examples is beyond the scope of this review. A list of selected popular examples of mnemonic devices in science courses is presented in Table I.

Table I: Examples of mnemonic devices applications in teaching and learning science.

Science Subject	Example	Source(s)
Chemistry	Monosacharides	18, 19, 20
	Thermodynamic functions	21, 22, 23
	Gas laws	24, 25
	Indicator Colours	26, 27
	Mole and Molarity	28
	Electronic configurations of atoms	29, 30, 31

Science Subject	Example	Source(s)
Biology	Vertebrates: Fish, Amphibians, Reptiles, Mammals, And Birds	2, 32
	The Krebs cycle	33, 34, 35
	The Calvin Cycle	36
	The order of taxa in biology	37, 38
Physics	Colour coding on electronic resistors	39, 40
	The colors of visible light (colours of the rainbow)	41, 42
	Speed of light in metres per second	43
	Maxwell relations in thermodynamics	44
	Metric prefixes	45
Mathematics	Pi number	3, 46
	Correct order of operations of an algebra	47
	Number for sequences	48
	Trigonometry	49, 50

Application of mnemonic methods in teaching students with disabilities and behaviour problems

There is no doubt that mnemonic strategies organise and integrate the transformation of information which is difficult to remember into something that is more meaningful for individuals to recall at a later date by using associations between the new item of information and the one previously learned in long term memory.^{16,51,52,53} Mnemonic strategy instructions for students with learning disabilities and other mild disabilities have been studied experimentally for almost 20 years.⁵⁴ Students with learning disabilities and other special needs may be at particular risk of failing at school. As was described by Mastropieri *et. al.* in 1998² teachers should teach students how to remember as well as what to remember. This can be done by a variety of strategies, but most useful ones were: the keyword method, the pegword method, and letter strategies. Systematic instruction makes use of mnemonic methods not only for remembering important information, but also for systematic instruction in the independent use of mnemonic strategies. They can be important factors in determining school success for students with learning and memory problems.

What is more, students with learning disabilities have been taught to successfully generate mnemonic strategies independently. Research findings indicate that they learn more content in shorter instructional time periods when mnemonic strategies are developed and presented by teachers.⁵⁵ This does not indicate that teachers should not encourage students to develop strategies independently, however, it does imply that teachers should think carefully about the allocated time for specified subject areas and content to be covered. Hence, if there is sufficient time for students to learn to develop and generate their own strategies, teachers should encourage them to do so⁵⁶. This clearly shows that once mnemonic materials have been developed they can be used time and again.²⁸

Application of mnemonic devices in second language learning

Interestingly enough, the effective use of encoding technique, which relies on phonetic encoding, can be frequently found in teaching foreign language vocabulary.^{57,58,59} This example of use despite appearing to be strange and difficult at first sight, is indeed very easy. In this approach a foreign word is presented and its English translation must be remembered. The English word, the “keyword,” that sounds like some part of the foreign word to be learned is found. This is possible, when the phonetic encoding of the stimulus unit occurs. The next step is forming the mental image of the keyword interacting with the English translation of the foreign word. Hence, the correlation between the foreign word and its English equivalent can be based on two associations: 1) phonetic (acoustic) and 2) visual imagery.³

The application of mnemonic studies in second language learning by the means of phonetic (acoustic) association was first described by Atkinson in 1975.⁵⁹ He proposed linking acoustic mnemonic to imagery mnemonic in order to help students to learn Russian. The students were given an English word that had a similar pronunciation to the Russian word. Then,

students were told to imagine that word interacting with the true definition of the word. Not only did this spark interest in mnemonics as an aid to teaching language, due to his successful results, but also his final remarks in the paper, where he stated that this technique might be very useful for these students who find language learning especially challenging, led to a whole new application of mnemonics.^{60,61}

While mnemonic devices are characterised by numerous advantages, there are some disadvantages. The advantages and disadvantages of mnemonic methods are presented in Table II.

Table II: Advantages and disadvantages of mnemonic strategies.

Advantages	Disadvantages
<ul style="list-style-type: none"> • Procedures for intensification of memory; • Extremely effective in helping people to remember things; • Own prepared mnemonics by students outperform the results in comparison to students in free-study conditions; • Often enables information to be better retained in memory; • Memory strategies; • Is not as dependent as a memory schema 	<ul style="list-style-type: none"> • Are not comprehension strategies; • Low or lack connection between the conceptual content and the material being learned; • Students' performances may be lower than when teachers supply the strategies; • Are focussed only on certain aspects of their operation; • Are not teaching and learning methods

Conclusion

This review has looked at various perspectives of the value of mnemonic devices. From a cognitive perspective, mnemonic strategies are effective because they form an effective acoustic-imaginal link between the stimulus and response.

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