ENHANCING NINTH GRADE STUDENTS' PERFORMANCE IN CHEMISTRY THROUGH COGNITIVE STRATEGY

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ABSTRACT
The present study is aimed to investigate how ninth grade students performing academically in the periodic classification of chemistry were affected by their cognitive strategy (mnemonics). For direct investigation, research hypotheses were developed. Pre-test-post-test, randomized, quasi-experimental design was employed in the investigation. For the study, 76 secondary school students from the public higher school in the Salem Education District, Tamilnadu State, were recruited. While the control group received regular instruction, the treatment group's students learned periodic classification utilizing a cognitive strategy. Using Cronbach's alpha approach, the reliability of the chemistry achievement test was calculated and came out to be 0.89. The experimental and control students received the same courses for two (2) weeks. In order to determine how the treatment affected students' performance, data were gathered using a chemistry achievement test. A 0.05 significance level paired sample t-test was used to analyze the data. Results showed that the treatment group taught using mnemonic aids (Cognitive Strategy), performed better on average than their control counterparts, who were trained using the conventional approach. Teachers should use mnemonic devices to help students remember chemistry concepts, as this will facilitate more flexible learning.
Keywords: Chemistry, Cognitive Strategies, Memory, Mnemonics, and Periodic Table.

Background of the Study

Learning the name of an object in the sense of an imprint is completely different from learning the meaning of that name. This last expression implies the attainment of a concept, described previously. Teachers familiarize themselves with the difference between "knowing the name of something" and "knowing the meaning of that name". The student knows a label when he can simply provide the name of a particular object. To know this object as a concept, it must be able to identify examples and non-examples used to denote and delimit classes. The name of a concept is often learned when the concept itself is learned or just before that time (Toit , Kotze, 2009; Al Ghraibeh, 2012). While the task of learning names can be easy for one or two objects at a time, the difficulty increases rapidly when learning different names for many objects or names for many objects at the same time. Such a situation arises during learning when students are asked to name a group of plants, a group of leaves, or all members of the president's cabinet (Lah, 2018). It is fair to say that students who participate in such tasks will memorize names, but this does no harm, and students generally enjoy doing it. In any case, learning labels is a very useful activity. Among other uses, it establishes the basis for communication between learners and teachers or between learners and textbooks.

The teacher's problem in science instruction is to provide tangible examples to explain things that pupils cannot see in order to ensure that they fully understand abstract concepts. Students' ability to accurately portray relationships between abstract notions in symbols, formulas, and graphs appears to depend on their ability to establish links between actual events and abstract phenomena (Johnstone, 2000). Recurrent priming and the creation of connections between tangible circumstances and abstract concepts appear to be crucial in helping students develop their problem-solving skills in science. To use chemistry education as an example, pupils are already familiar with the concept of burning when they cook potatoes without adding any water. This prior understanding could serve as a basis for explaining what transpires during heating (ignoring oxygen): sugar can transform into carbon and tar, among other things. Teachers can help students understand how real-world experiences relate to classroom science instruction and coach them through logical procedures to develop an understanding of and resolve issues relating to the origin of oil. Teachers must encourage the creation of solid connections between knowledge of specific circumstances and abstract concepts when scientific information is delivered over more extended periods of time. Science teachers need to be aware of memorizing techniques that help students efficiently reproduce connections between applicable basic principles and situational knowledge if they are to support students in their learning. The capacity of students to recall this type of "declarative knowledge" not only aids in their comprehension of previously covered content. It might improve students' ability to comprehend the nature of science-related issues.

As issues in science are studied for a longer period of time, teachers must promote and strengthen the connections between understanding concrete situations and abstract ideas. (Walsh, 2022). Teachers must be knowledgeable about teaching strategies that enable students to successfully reconstruct the relationship between pertinent principles and situational information if they are to support students in their learning. A student's ability to understand new and relevant learning material is called declarative knowledge (Schacter, 2007). This makes recall easier. This can improve students' ability to analyse the nature of scientific problems. Over the past few decades, the applications of memory-enhancing strategies have been studied with different grades of students who frequently experience academic failure. These types of strategies have been very effective in improving memory for selected content. The learning of content can often be aided by the use of mnemonic techniques, most of which have been known for many years. This strategy often yields significant improvements in paired associate learning.

Concept of Mnemonics

The fundamental ideas were devised by Greek philosophers over a thousand years ago, and they are still used today in a variety of methods, from easiest acronyms to advanced methods that allow individuals to recall certain concepts and numerals by encoding them into special phrases and words. Modern memory research (Scruggs , Mastropieri, 2000; Bakken , Simpson, 2011; Pals, 2018) has amply demonstrated the effectiveness of mnemonic aids as learning aids in a variety of circumstances, including the memorization of lists of names and things. Previous research (Lubin , Polloway, 2016) believed that these techniques improved memory by taking advantage of natural mnemonic processes such as semantic mapping, visualization, detail coding, and organization. Other studies (Tullis , Qiu, 2021) have provided detailed explanations of the mnemonic technique, its underlying mechanism, and how to use it effectively in a learning context.

There are many different kinds of mnemonic techniques that teachers might implement in their classes. They include verbal mnemonics, visual mnemonics, physical response mnemonics, spatial mnemonics, and linguistic mnemonics. Linguistic mnemonics are peg word and keyword techniques that include associating brand-new ideas with well-known words and/or expressions to aid with memory. Spatial mnemonic is a position and fingering method that involves connecting a new concept with a commonplace, a familiar pattern, and fingers to help remember the concept. A visual mnemonic technique that uses symbolic or pictographic symbols to make connections with concepts. Physical mnemonic is the use of body parts to aid in memory, through movement or physical sensations. Speech methods are used as grouping, semantic organization, or narrative to help students remember concepts.

The important distinction is the difference between single-use and repeated-use mnemonics. Thus, a single-use mnemonic helps to remember a specific event (e.g. the acronym VIBGYOR for remembering the seven colours of the rainbow), while a repeated-use mnemonic is a cue to store different information on different instances (e.g. method of loci and learn a mind map of types of matter). Another division is between organizational and coding mnemonics. Organizational mnemonics provide a structure for unorganized concepts, such as the example above, providing learners with a retrieval plan to memorize all necessary items. While mnemonic encoding involves re-encoding information into a more understandable format.

Mnemonics as a Cognitive Strategy

The connection between working memory and long-term memory mediates the capacity to store and access memory. Working memory is the short-term holding of information that has recently been retrieved or perceived. Although it can be remembered for a long time by using it repeatedly or by using repeatedly effective tactics, it is transient. Although many different factors are associated with memory, declarative memories work best when using mnemonics with memory and active recall. The use of such rehearsal techniques is inevitable when designing learning and teaching methods to retain long-term memory. According to Chun and Turk-Browne (2007), working memory is not considered independent storage. Instead, it is thought to be the manifestation of memories that are sent from long-term memory to other sections of the brain.

Does Mnemonics Go Beyond Rote Memorization?

Mnemonics have been criticised for just serving to improve memorising and failing to support higher-order cognitive abilities like understanding and knowledge transfer. These criticisms can be addressed with two categories of research outputs. First, according to a number of studies (Azmi, Najmi, and Rouyan, 2016; Samuel, 2017; Fasih, Izadpanah, and Shahnavaz, 2018; Pal & Banik, 2014), mnemonics were created solely to improve recall, not to support higher order learning. Although many educators anticipate that their pupils will have a critical, inquisitive, appreciative, and in-depth comprehension of the subject matter. Second, a limited number of studies (Tullis & Qiu, 2021) have argued that memorization can directly support higher learning. For instance, research by Pals (2018) demonstrated that memory performance was enhanced on a vertical connection between the groups receiving treatment compared to the non-treated group.

Objectives of the Study

1. To compare the mean pre-test scores of control and treatment groups.
2. To compare the mean post-test scores of control and treatment groups.

Hypotheses of the Study

H1: There will be a significant difference between the pre-test means of the control group and the treatment group for the periodic table in chemistry.
H2: There will be a significant difference between the post-test means of the control group and the treatment group for the periodic table in chemistry.

Materials and Methods

Based on the objectives of the study, a quasi-experimental quantitative research approach was used. The experimental subjects were divided into two homogenous groups at random: control and treatment. For the study, 36 male and 36 female ninth-graders from a public higher secondary school in Salem, India, were chosen as participants. The G. C. Ahuja group test of IQ was used to confirm the participants' uniformity. The students in the intact classes were then split into a treatment group and a control group based on how well they performed on the intelligence test.

Instrumentation and Experimental Procedure

The techniques and instruments that followed were used to accomplish the study's objectives:

G. C. Ahuja Group Test of Intelligence – the test was devised to meet the pressing demand for a group and was developed by Ahuja (2009) and standardized by establishing reliability (Reliability Coefficient; test-retest method – 0.84 ± 021 and split-half method – 0.974 ± .003) and validity (item and empirical validity). The test is designed to evaluate students' general mental abilities who are between the ages of 13 and 17 and are enrolled in classes VIII through XI.

Pre-test - Before treatment, an 18-item chemistry achievement test (combination of multiple choice, blank-filling, and true/false) was developed by the investigator as a pre-test to ensure the attainment of the periodic classication in chemistry. A pilot group was subjected to the examination. Using Cronbach's alpha formula, the test's reliability was calculated to be 0.89. The general usability of the chemistry achievement test was confirmed by an item analysis. The item analysis shows that all questions of the test had an item difficulty between 0.300-70 and the item discrimination index between 0.30-40

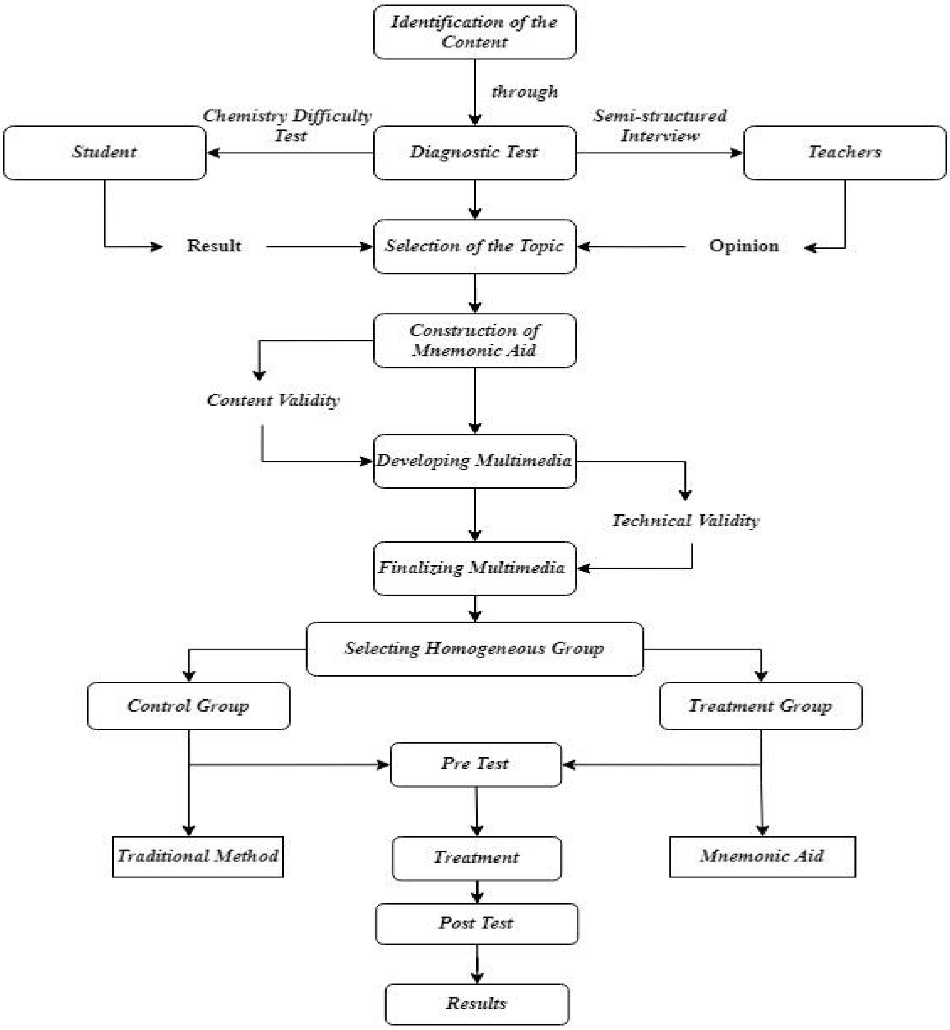

Figure 1. Experimental Procedure of the Study (Devendiran & Hema, 2020)

Item no.	p	r	Item no.	p	r
1	.50	.63	10	.54	.72
2	.36	.54	11	.50	.45
3	.40	.63	12	.50	.45
4	.59	.45	13	.59	.45
5	.54	.36	14	.68	.36
6	.63	.36	15	.40	.45
7	.59	.45	16	.50	.45
8	.46	.36	17	.54	.36
9	.54	.72	18	.40	.34

Table 1. The item difficulty index (p) and the item discrimination index (r) values of the test items

Mnemonic Aid - There are 118 elements in the periodic table. Mnemonic aid is considered essential for all these as it is a bit difficult to remember them easily. In this study, mnemonic aid has been constructed for all the seven series in the periodic table in ascending order of atomic number. A total of 6 sets including two sets for f-block elements were constructed and given to the students. Among these, set 3 (with atomic numbers 51-57 & 72-80) is arranged to remember the elements from back to first, i.e., arranged in order from atomic number 80 to 51. These mnemonics are in story type so they are easy to remember. Also, to improve memory, mnemonics are interspersed with atomic numbers for certain elements at approximately appropriate places which are given for easy understanding and remembering of the elements. For example, in a set - I, the names of the elements from hydrogen to Zinc (atomic number 1- 30) have been constructed as mnemonics as,

> *"Hi (Hydrogen – H)! Hello (Helium – He)! Lithish (Lithium – Li), BBC (Beryllium, Boron & Carbon – Be, B &C) ……."*

In f-block elements, following mnemonics is been developed for the actinides (atomic number 90-103),

"Thora (Thorium - Th), Protogenia (Protactinium - Pa), Uranus (Uranium - U) Neptune (Neptunium – Np) and Pluto (Plutonium – Pu)……….."

Apart from this, separate mnemonics have been created for each of the 18 groups of the elements in the periodic table and the atomic numbers of the elements are included in them. Specifically, for d-block elements (four rows) have been constructed by separate mnemonic For example, the second row of the d block elements are arranged as follows

> *"Yudhika (Yttrium - Y) Zara (Zirconium - Zr) Nia (Niobium - Nb) and Molyb (Molybdenum - Mo) all went to Deccan (Technetium - Tc) theatre………………..*

The mnemonics thus developed were presented to the pedagogical and subject experts and their opinions were sought. The final form was developed with some changes suggested by them. These mnemonics were converted into a video with suitable animations and then technical and content validity were done. It was used for experimental study after carried some changes suggested by the experts. The length of this video package is 00.27.07 hrs. It is also provided to the students as a basic mp4 le to support all devices.

Ethical Procedure and Treatment - The permission of the Chief Educational Officer was sought after ensuring that the school selected for the experiment has the necessary facilities. After getting permission from the authorities the selected students were clearly instructed about the aim of the study. And also assured that all the details collected while experimenting would be kept confidential. We also sought the willingness of students to participate in the study. After all the students in the class agreed to participate as volunteers they were divided into two groups administering an Intelligence Test. It was found that both groups contained about equal amounts of boys and girls. While the students in the control group were taught using conventional methods, the students in the experimental group were taught utilizing mnemonic aids. The class met for 70 minutes each session, four times per week. Within the allotted time for the study, all of the content was taught. The present stage of the study lasted two weeks and involved eight class hours.

Post-test - At the end of the experiment, the chemistry achievement post-test was administered to the two groups to compare their learning achievement.

Results of the Study

Hypothesis- 1: There will be a significant difference between the pre-test means of the control group and the treatment group for the periodic table in chemistry.

Group	Test	N	Mean	Standard Deviation	Mean Difference	t-value	p-value
Control Group	Pre test	36	18.89	4.7	0.08	0.069	.946
Treatment Group		36	18.81	4.9			

Table 2. Paired t-test of pre-test scores

As is seen in Table 2, the pre-test on the achievement of control and treatment groups was compared. In the result of paired t-test, the difference between the achievement of the groups is considered statistically not significant (t=0.069; p=.946). Therefore the two groups do not differ significantly in their Achievement of periodic classication in chemistry. So it is inferred that before the treatment the two groups were more or less the same performance.

Hypothesis- 2: There will be a significant difference between the post-test means of the control group and the treatment group for the periodic table in chemistry.

Group	Test	N	Mean	Standard Deviation	Mean Difference	t-value	p-value
Control Group	Post test	36	54.75	10.12	14.86	5.85	.000
Treatment Group		36	69.61	10.37			

Table 3. Paired t-test of post test scores

As is seen in Table 3, the post-test on the achievement of control and treatment groups was compared. In the result of paired t-test, the difference between the achievement of the groups is considered statistically significant (t=5.85; p=.000). The said difference occurred in favour of the students in the treatment group.

Discussion

The results of this study have demonstrated that mnemonics are more successful at raising students' proficiency in chemistry-related material. The findings showed that mnemonic help outperformed conventional teaching methods in terms of the mean scores. The study proved the value and tremendous impact that mnemonics had on students' achievement, particularly with regard to the periodic table of elements. Because mnemonics effectively create a cognitive architecture for students to remember factual knowledge. Additionally, it would help pupils who might have trouble remembering things in their minds. Additionally, it affects how students perceive new knowledge and determine whether kinds of facts are important or not. Based on the results, it has been suggested that teachers use mnemonic techniques in their instruction to increase students' positive attitudes towards chemistry, and that they train the students to create their own mnemonics. Additionally, it aids in the conceptualization and perception of complex problems. As a result, it encourages creativity, making it possible to develop answers to any given challenge. Research done earlier in the field has shown mnemonics as an important memory enhancement strategy. It is evidenced by the research studies conducted by Akinsola and Odeyemi (2014), Maghy (2015), Anandhi and Raja (2015), and Cecilia, Joseph & Joy (2017) which showed a significant effect of mnemonic aid on academic achievement of various subjects. According to the American psychology students evaluated by Richmond (2011), the results showed that the students who used the mnemonic strategy performed better than their peers in terms of immediate recall, delayed recall, and higher order thinking. Anandhi and Raja (2015) studied that teaching with the mnemonic technique was more effective than the conventional method for teaching science and mnemonic techniques helped in the retention of learned materials. The results of this study can be seen as supporting the studies of Amoli & Karbalaei and Holden. Amoli & Karbalaei (2012) report that learners can improve their ability to remember new concepts over the long term if they use different memorization strategies, such as visual methods containing pictures. Similar studies that support student academic progress and retention were carried out in Nigeria (Adepoju, 2014; Cecilia, Joseph & Joy, 2017; Ntibi & Neji, 2018). Mnemonics is a useful teaching tool for chemistry since they motivate pupils to study the subject. Furthermore, Holden (1999) expressed that learners have to imagine a scene or an image through the mental image that has a strong connection with the concept or things related to them to remember. Students can retain ideas more quickly by exchanging and discussing visual experiences of concepts with one another.

Conclusion

Cognitive strategies boost self-assurance and give students an extensive understanding of chemistry principles and the rationale behind many things. Learners can deepen their understanding of existing ideas and knowledge through cognitive learning. Because of this, when a student acquires something novel, it is added to what they already know and their knowledge is thereby improved. Instead of rote memorising, the technique promotes immersive learning and understanding of new ideas and information. It supports the use of problem-solving techniques in pertinent circumstances and aids in their promotion.

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