

MNEMONIC TECHNIQUES AS AN EFFECTIVE LEARNING STRATEGY FOR NEUROANATOMY AMONG UNDERGRADUATE MEDICAL STUDENTS

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ABSTRACT

Background: Neuroanatomy is one of the fundamental sciences in medicine, which often leads to learning difficulties among medical students. These difficulties may even result in a phenomenon known as neurophobia, referring to the fear of understanding the field of neurology. One effective strategy to address learning difficulties in neuroanatomy is the use of mnemonic techniques, which function to enhance long-term memory retention through associative patterns.

Methods: This research used a quasi-experimental design with a nonequivalent control group. The sample comprised of 53 undergraduate medical students from batch 2023 at Universitas Udayana, divided into a control group (conventional method) and an experimental group (mnemonic technique).

Results: The mean N-Gain score of the experimental group (59.02%) was higher than that of the control group (40.69%), with t-test results showing a significant difference ($p = 0.004$). In addition, the questionnaire results revealed positive student responses toward the use of mnemonic techniques (Cronbach's Alpha = 0.893).

Conclusions: Mnemonic techniques have been shown to effectively enhance neuroanatomy learning results as well as enhancing the interest and motivation of medical students.

Keywords : Mnemonic techniques, neuroanatomy, medical student.

INTRODUCTION

Anatomy is a fundamental science that is crucial or very important for medical students to master, which is useful in practice in order to understand clinical complications related to diagnosis and treatment.¹ One branch of anatomy, which is neuroanatomy have a focus on the study of the structure and function of the brain, spinal cord, and the nervous system, including the central nervous system and peripheral nervous system.² Neuroanatomy can provide insight and understanding of brain function, the mechanisms of neurological disease, and the fundamentals behavior and cognition. In clinical practice, neuroanatomy also serves as a foundation for neurosurgery, neuropharmacology, neuroimaging, and other fields.³

Neuroanatomy is a complex and intricate studies, leading students to view it as a daunting prospect during their learning journey. Students have long struggled with neuroanatomy, as evidenced by the coining of the term neurophobia in 1994.⁴ Neurophobia is a phenomenon of fear or anxiety among medical

students and general practitioner regarding the field of neurology in clinical practice.^{5,6}

The overall learning of anatomy, including the sub-discipline of neuroanatomy, currently undertaken by students is generally conducted through in-class lectures, laboratory experiments, textbook reference, and in some cases, used case-based discussions.^{7,8} Curriculum reviewers and instructors continue to strive to address student's difficulties in learning neuroanatomy. Furthermore, intention and learning strategies area also crucial factors for optimal mastery of neuroanatomy. One popular learning method used to improve memory and conceptual understanding is the mnemonic technique.

Mnemonic techniques refer to strategies individuals use to enhance long-term memory retention through various methods, including music, names, expressions, models, images, spelling, and others. As a conventional or traditional method, mnemonics uses the principle of association by stimulating the memory to recall something or fact from connecting it to simpler or easier to remember data.⁹

In neuroanatomy learning, mnemonic techniques will make it easier for students to elaborate and remember complex topics over a long period of time.¹⁰ Mnemonic techniques have their own classifications, such as the grouping, rhyme, acrostics, and data association.¹¹ These mnemonic techniques can be freely selected as one of the most effective strategies for learning neuroanatomy by medical students. The author is interested in conducting an in-depth study of the influence mnemonic learning methods applied to neuroanatomy learning for medical students.

MATERIALS AND METHODS

This study was carried out using a quasi-experimental design using a non-equivalent control group design. The N-gain score test method was used to measure whether there was an improvement in student learning outcomes after being treated with mnemonic techniques as a learning strategy. This research took place from March and has received ethical approval with the number 1164/UN14.2.2.VII.14/LT/2025. The sample in this study came from 53 fifth-semester undergraduate medical students of Udayana University, consisting of 26 control group students and 27 treatment group students. The dependent variable in this study was the neuroanatomy learning outcome test score, the independent variable was the mnemonic technique, and the control variables in this study were age and gender.

This study used instruments in the form of neuroanatomy modules and mnemonic techniques as learning instruments and research instruments in the form of pre-tests, post-tests, and observation questionnaires on the influence of mnemonic techniques to determine the effect of

providing mnemonic techniques in neuroanatomy learning. The types of mnemonic techniques used in the neuroanatomy module include acronyms, acrostics, chunking, and rhymes. The pre-test and posttest instruments consisted of 30 questions to determine the results of student knowledge related to the use of mnemonic learning models regarding neuroanatomy material according to the learning process that has been given. The research instrument device have fulfilled the requirements for a good test by conducting several tests, including validity test, reliability test, and test of the level of difficulty. This research was conducted by conducting a pre-test, then providing neuroanatomy material, and continued with a posttest, then several questions were given in the form of an observation questionnaire.

Data processing was performed using a computer program (software), namely the Statistical Product and Service Solutions (SPSS) application version 26.0 for Windows. Univariate analysis was performed for the results of the N-Gain score test with normality and homogeneity tests and then bivariate analysis was performed using the Independent Sample T-test method with the assumption of equal variances not assumed or also called Welch's t-test. In addition, the completion of the observation questionnaire on the influence of the mnemonic technique was carried out quantitative descriptive analysis and reliability testing.

RESULTS

This study involved 53 samples who were assigned to two groups, there are a control group and a treatment group. The sample distribution according to age and gender for each group can be seen in **Table 1**.

Table 1. Sample Demographic Characteristics

Age (years)	Male (n)	Female (n)	Total (n)	Presented (%)
<20	4	6	10	18,9
20	12	21	33	62,2
>20	3	7	10	18,9
Total	19	34	53	100

In addition, this study showed that the control group had a higher average pre-test score than the treatment group. Meanwhile, the post-test results revealed a significant

difference between the two groups, with the treatment group having a higher average score than the control group. These results are presented in **Table 2**.

Table 2. Distribution of Pre-test and Post-test Results

Group	Average Value ($\bar{x}$)	
	Pre-test	Post-test
Control	55.86	75.09
Treatment	48.36	80.21

The participants' pre-test and post-test results were subsequently evaluated using the Normalized Gain Test. This test aims to determine the effectiveness of the

mnemonic method used as a learning strategy for neuroanatomy material by calculating the magnitude of the

increase in scores achieved compared to the maximum possible increase as can be seen in **Table 3**.

Table 3. N-Gain Score Test Analysis Results

Group	Mean	SD	Minimum	Maximum
Control	40.69	22.33	0	87.45
Treatment	59.02	21.49	16.5	92.27

Based on the results of the N-Gain test analysis, the control group showed an average improvement in learning outcomes of 40.69% with a standard deviation of 22.33. Meanwhile, in the treatment class, the average N-Gain test score was 59.02% with a standard deviation of 21.49. If categorized based on Hake's (1999) criteria, the average of both classes is included in the medium category ($0.3 < g < 0.7$) with the results in the treatment class having a higher average value.

Next, a normality test was performed on the N-Gain value of each individual in both groups, followed by a

homogeneity test on N-Gain variances of the control group and treatment groups. The purpose of normality test was to verify that the basic assumptions of parametric analysis were satisfied, ensuring that the resulting estimates and statistical inferences are methodologically valid. Meanwhile, the homogeneity test functions to ensure whether the variances between data groups were equal or homogeneous conditions.

Table 4. Normality Test Results

Group Data	Sig
Control	0.327
Treatment	0.293

Table 5. Homogeneity Test Results

Uji N-Gain	Levene Statistic	df1	df2	Sig
Based on Mean	4.519	1	51	0.038
Based on Median	2.922	1	51	0.093
Based on Median and with adjusted of	2.922	1	45.789	0.094
Based on trimmed mean	4.292	1	51	0.043

As the data in **Table 4**, the N-Gain value data which is tested for normality using the test Shapiro-Wilk shows that the data in the control group ($p = 0.327$) and the treatment group ($p = 0.293$) are normally distributed because the p value > 0.05 so that further data analysis can use the test of parametric statistics. Meanwhile, in **Table 5**, the results of the homogeneity test obtained a Levene Statistic value

based on the mean of the N-Gain test with a significance value (Sig) of 0.038 ($p < 0.05$). Therefore, it can be concluded that the data is not homogeneous, so that the next data analysis uses the N-Gain difference test between groups using the Welch's t-test which can be seen in **Table 6**.

Table 6. Welch's T-Test Analysis Results

Variables	Sig. (2-tailed)	Mean Difference	95% CI (Low – Upper)
N-Gain	0.004	-0.18326	-0.30412 – -0.06240

The Independent Sample T-test produced a p -value of 0.004, which is below the significance threshold of 0.05. This indicates that the difference between the mean N-Gain scores of the two groups was statistically significant. The Mean Difference value of -0.18326 indicates that the mean

N-Gain in the control group was lower by 0.183 compared to the treatment group. In addition, the 95% Confidence Interval results which are completely below 0 indicate that the differences found are not due to random variation, but are a real effect of the treatment given.

In the treatment group that received neuroanatomy material with mnemonic techniques, they also filled out a questionnaire containing 10 positive questions and 5 negative questions regarding the role of mnemonic techniques as a neuroanatomy learning strategy. The answers to the questionnaire questions have a score of 1-5 with each category being very appropriate, appropriate, less appropriate, quite appropriate, and inappropriate. Based on the results of descriptive analysis of the observation

questionnaire filled out by the participants, an overall average score of 63.5 was obtained with a minimum score of 51 and a maximum score of 73 from the maximum ideal score of 75. These results show that participants tend to agree that mnemonic techniques have an effect on facilitating the process of learning neuroanatomy, while rejecting the statement that mnemonic techniques are actually boring.

Table 7. Reliability Test Results

Tool	Amount of Question	Participle	Cronbach's Alpha
Questionnaire Observation Influence Technique Mnemonics	15	27	0.893

The filling out of the observation questionnaire was also subjected to an analysis test in the form of a reliability test to ensure the internal consistency of the questionnaire used with the result $\alpha = 0.893$ as can be seen in **Table 7**. From the results of the reliability test, it can be concluded that the questionnaire instrument is reliable because the 'a value' is > 0.7 so it can be trusted to measure the variables studied.

DISCUSSION

The analysis results from this study show that among the two groups, there was an improvement in the treatment group's ability to learn neuroanatomy material after receiving mnemonic techniques as part of their learning strategy. This is evidenced by the analysis data from the differences in pretest and post-test scores in the control group and the treatment group. The average pre-test score in the control group (55.86) was found to be higher than the treatment group (48.36). After completing the pre-test, each group was given exposure to neuroanatomy material with different treatments, the control group with the conventional method and the treatment group with the mnemonic method. In the post-test results, the average score of the treatment group (80.21) experienced a significant increase compared to the control group (75.09). This data is also supported by the results of the N-Gain test score in the treatment group ($p = 59.02$) which was found to be higher than the control group ($p = 40.69$). In addition, the results of the Welch's t-test analysis also showed a significance value of 0.004 ($p < 0.05$).

The improvement in learning outcomes in the treatment group is in line with the cognitive load theory proposed by Sweller in 1988, this theory suggests that human working memory has a limited capacity, and when individuals are presented with excessive or highly complex information, it

can lead to an overwhelming cognitive load. The branch of science studied, namely neuroanatomy, is known to be a complex material and has the potential to cause high cognitive load in students if only studied using conventional methods.^{12,13} This can be reflected in students in the control group tend to face high cognitive load (intrinsic cognitive load) because they have to memorize neuroanatomy terms without appropriate learning strategies. The continuation of this burden can cause extraneous cognitive load in the form of difficulty remembering detailed terms, feelings of boredom, and anxiety or known as neurophobia phenomenon can hinder the process of storing information in long-term memory.¹⁴ By using appropriate learning strategies, the learning process can be enjoyable, reducing extraneous cognitive load and fostering motivation and enthusiasm for learning.¹⁵

Mnemonic techniques are one of the learning strategies that can be used to help simplify neuroanatomy material into a more concise, memorable, and enjoyable form through acronyms, word associations, or chunking techniques. In accordance with cognitive load theory, mnemonic techniques can be used to suppress extraneous cognitive load and allocate more working memory capacity for germane load, which is a cognitive load that is useful in forming knowledge schemas by helping convert information into long-term memory.^{16,17} This align with the study's findings, which showed a greater increase in post-test scores in the treatment group. Therefore, it can be inferred that students in the treatment group were better able to manage their cognitive load in studying neuroanatomy.

In the learning process, there are generally four learning styles that can be combined, including visual (V), auditory (A), read/write (R), and kinesthetic (K), collectively known as VARK.¹⁸ This learning style is also further clarified as Dual Coding Theory by the findings of a figure named Paivio which was put forward in 1971. Paivio stated that information received by humans will be processed through two representation systems,

divided into the verbal system and the non-verbal or visual system.¹⁹ When humans process information using only one pathway, the information is likely less effectively retained in long-term memory. Conversely, when information is processed using both pathways simultaneously, memory strength increases.²⁰

The application of mnemonic techniques as a neuroanatomy learning strategy provides an opportunity for students to connect neuroanatomy terms explained verbally with visual associations of acronyms or other forms so that they are easier to remember.²¹ This is reflected in the results of this study, as shown by the observation questionnaire on the effects of mnemonic techniques completed by the treatment group. The use of mnemonic techniques as a learning strategy with two-way information processing (verbal and non-verbal) makes the process of memorizing neuroanatomy easier and learning feels more interesting.

The research data is not only based on theory and previous research. This study also used a questionnaire completed by the treatment group regarding the use of the mnemonic technique as a neuroanatomy learning strategy. The observation questionnaire consisted of ten positive questions and five negative questions. After analysis, it was found that this questionnaire strengthened the objective findings. The average score for each questionnaire question showed a positive response, especially for the statement "I found it easier to memorize neuroanatomy because of the strategies provided during the learning process," with a mean analysis result of 4.48, included in the very high category. Meanwhile, the negative statement "I felt bored with the strategies taught," obtained a very low score (mean = 1.52). These results were also reflected in each questionnaire question item. This indicates that students feel helped, motivated, and more interested in learning neuroanatomy thanks to the use of mnemonic techniques while rejecting the assumption that mnemonic techniques are boring and ineffective as a learning strategy.

The practical implication of this research is that mnemonic techniques can be used as a strategy and alternative learning method in the medical education curriculum, particularly for materials that require high memorization. The use of mnemonic techniques not only improves cognitive learning outcomes but also positively impacts affective aspects such as student motivation, interest, and engagement. This supports the implementation of innovative student-centered learning methods.

The limitations of this study include its relatively small size and the inability to fully control for factors such as individual learning styles, motivation, and prior academic ability, all of which may influence student learning outcomes. Furthermore, this study did not evaluate long-term retention to determine whether the memorization technique fully impacts student retention over time.

CONCLUSION AND RECOMENDATION

Based on the research conducted, it was found that mnemonic techniques have an influence as an effective learning strategy in improving medical students' learning

outcomes for neuroanatomy material. This is reflected in the comparison of the average pre-test and post-test scores of the treatment group, which were higher than those of the control group. Welch's t-test analysis produced a p value of 0.04 ($p < 0.05$), which interpreted that there was a significant difference between the two group in this research.

There is also an analysis of the observation questionnaire which shows that the majority of participants in the treatment group gave a positive response to the application of the mnemonic technique. The highest average score indicates that mnemonic techniques make memorization easier for participants, making the learning process more enjoyable. Meanwhile, negative statements received very low scores, indicating that participants disagreed with the statement that mnemonic techniques are boring.

Suggestions for future research include conducting research using a larger sample size and not focusing on just one educational institution. Furthermore, the introduction of mnemonic techniques in treatment classes should be tested over a longer period of time to further determine their effectiveness.

REFERENCES

1. Kumar R, Singh R. Model pedagogy of human anatomy in medical education. Vol. 42, Surgical and Radiologic Anatomy. 2020.
2. Chung MS, Chung BS. Visually Memorable Neuroanatomy for Beginners. Visually Memorable Neuroanatomy for Beginners. 2020.
3. Nicolosi F, Pessina F, Gelmi CAE, Belotti F, Mahoney DE, Agosti E, et al. New neuroanatomy learning paradigms for the next generation of trainees: A novel literature-based 3D methodology. Vol. 210, Clinical Neurology and Neurosurgery. 2021.
4. Moreno-Zambrano D, Sandrone S, Meza-Venegas J, Jimenez J, Freire-Bonifacini A, Santibanez-Vasquez R, et al. Exploring the key factors behind neurophobia: A systematic review of the English, Spanish and Portuguese literature. Vol. 2, Brain Disorders. 2021.
5. Venter G, Lubbe JC, Bosman MC. Neurophobia: A Side Effect of Neuroanatomy Education? J Med Syst. 2022;46(12).
6. Javaid MA, Schellekens H, Cryan JF, Toulouse A. eNEUROANAT-CF: a Conceptual Instructional Design Framework for Neuroanatomy e-Learning Tools. Med Sci Educ. 2021;31(2).
7. Singh K, Bharatha A, Sa B, Adams OP, Majumder MAA. Teaching anatomy using an active and engaging learning strategy. BMC Med Educ. 2019;19(1).
8. Mitra NK, Aung HH, Kumari M, Perera J, Sivakumar A, Singh A, et al. Improving the learning

- process in anatomy practical sessions of chiropractic program using e-learning tool. *Transl Res Anat.* 2021;23.
9. Ni LB, Hassan NA. The Use of Mnemonic and Mathematical Mnemonic Method in Improving Historical Understanding. *Int Sch Sci Res Innov* 13(2) 2019. 2019;13(2).
10. Smith CF, Border S. The Twelve Cranial Nerves of Christmas: Mnemonics, Rhyme, and Anatomy – Seeing the Lighter Side. Vol. 12, *Anatomical Sciences Education*. 2019.
11. Yung AHW, Pak CS, Watson B. A scoping review of clinical handover mnemonic devices. Vol. 35, *International Journal for Quality in Health Care*. 2023.
12. Du YC, Fan SC, Yang LC. The impact of multi-person virtual reality competitive learning on anatomy education: a randomized controlled study. *BMC Med Educ.* 2020;20(1).
13. Arantes M, Arantes J, Ferreira MA. Tools and resources for neuroanatomy education: A systematic review. Vol. 18, *BMC Medical Education*. 2018.
14. Harris E, Santhosh L. Dual Process Theory and Cognitive Load: How Intensivists Make Diagnoses. Vol. 38, *Critical Care Clinics*. 2022.
15. Evans P, Vansteenkiste M, Parker P, Kingsford-Smith A, Zhou S. Correction to: Cognitive Load Theory and Its Relationships with Motivation: a Self-Determination Theory Perspective (*Educational Psychology Review*, (2024), 36, 1, (7), 10.1007/s10648-023-09841-2). Vol. 36, *Educational Psychology Review*. 2024.
16. Munusamy S, Koenigsfeld C, Torry R. Mnemonics Improve Pharmacy Students' Knowledge Retention, Clinical Application, and Exam Performance in a PharmD Pharmacology Course. *FASEB J.* 2022;36(S1).
17. Hochstrasser K, Stoddard HA. Use of Cognitive Load Theory to Deploy Instructional Technology for Undergraduate Medical Education: a Scoping Review. Vol. 32, *Medical Science Educator*. 2022.
18. Kadek N, Tena A, Dewi O, Ayu IG, Sundariyati H, Ganesha IGH, et al. LEARNING STYLE PROFILE OF MEDICAL EDUCATION STUDENTS UDAYANA UNIVERSITY FACULTY OF MEDICINE. 2025;14(05):44–51.
19. Soper K, Geske JA, Bronner L, Godfrey M. Improving Student Understanding of Academic Assessment Vocabulary Words Using Visual Cues: A Collaborative Effort. *J Community Engagem Scholarsh.* 2022;15(1).
20. Meyerhoff HS, Jaggy O, Papenmeier F, Huff M. Long-term memory representations for audio-visual scenes. *Mem Cogn.* 2023;51(2).
21. Agnes D, Srinivasan R. Redefining the Association Between Memory, Mnemonics and Vocabulary Acquisition— Reviewing Paradigms in Research. *J Lang Teach Res.* 2024;15(3):697–706.

