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Effect of mnemonics enhanced tutorial on chemistry education students' achievement and mindfulness in a university

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ARTICLE INFO	ABSTRACT
Received: 13 Oct. 2022 Accepted: 08 Mar. 2023	This study elicits the effect of mnemonics tutorial method (MTM) on academic achievement and mindfulness among chemistry education students of Yusuf Maitama Sule University, Kano. Quasi-experimental design was employed. The University has 1,002 chemistry education students, which formed the study population. However, intact class of level 200 containing 250 students with an average age of 20 years was sampled for the study. Five-facet mindfulness questionnaire with the reliability coefficient of 0.85 and the students' academic records were used as data collection instruments. Research questions were answered through mean and standard deviation while the hypotheses were tested using t-test and analysis of variance. By the end of level 200, MTM was found to have improved the students' academic achievement, saved over 50% of the students on probation from dropping out of the university and drastically increased students' mindfulness. Consequently, MTM is hereby recommended for the teaching of chemistry education students not only in Nigerian universities, but globally to save the students on probation from becoming a university's drop-outs. **Keywords:** chemistry education, mindfulness, mnemonics tutorial method, academic achievements

INTRODUCTION

The economic growth witnessing in the developed world by their citizens was due to the impact that science and technology have had on their general development (Kamp, 2019). As an example, India which was formerly backward economically has resuscitated and become a notable exporter of scientific workforce globally. The nation has become both medical and educational tourism centers for global patronage. This was due to the critical intellectual capacity building embraced, which leads to industrial revolution achieved through greater commitment to science education (Chogyel & Wangdi, 2021).

Science education is the teaching and learning of science subjects including chemistry in schools, colleges and universities. Unfortunately, literature has proven that students at all levels have difficulty understanding chemistry for different reasons, but majorly for its abstract nature (Lu & Bi, 2016; Nakiboglu & Nakiboglu, 2019). It has been observed in the literature that studying chemistry is a stressful endeavor for many students causing poor academic achievement (Orimogunje, 2018). This is because the classrooms use to be dominated with bad teaching methods (Babalola & Abdullahi, 2015; Tsaparlis, 2017). Another reason is that classroom explanations of chemistry were subjugated by the interactions between invisible entities and the teaching approaches adopted by the teachers were not favorable for students' conceptual understanding (Fitzgerald et al., 2017). Chemistry teaching was therefore characterized with merely conceptual clarifications using expository method. This was done with less consideration on students' capacity to connect the new concept with previous knowledge as recommended by the constructivism theories (Kay & Kibble, 2016). Also, students' are usually assessed by testing their abilities to answers logical questions with no concern about building association among the learning concepts and daily activities (Nyachwaya et al., 2014). So, Eilks and Hofstein (2015) reported that one of the goals of chemistry researchers is to develop effective and scientifically aligned strategies for teaching chemistry.

The major concern here is that chemistry education dons at university level are still very much inclined with traditional lecture method of delivering chemistry instructions to teachers in training causing slow learners among them to be on probation as early as their first year in university. It is, however, necessary to acknowledge that chemistry education courses, upon which students' achievements are evaluated in teacher education programme, transcends chemistry to education and general studies courses. The courses are therefore complex and multidimensional in nature requiring more than one teaching pedagogies to achieve their diversified instructional objectives. Hence, the amalgamation of effective teaching strategies is needed not only to address students' individual differences such as learning styles, temperaments and intelligent level but also to improve their academic

achievement while promoting mindfulness among the low performing students. The strategy required could be Mnemonics-enhanced Tutorial Method (MTM).

MTM is a hybrid of mnemonics instructional strategy and famous tutorial teaching method. Hereby, MTM involves the use of mnemonics devices in teaching a big class which has been divided into smaller classes by the teacher inform of group discussions with the best students in the class being the tutorial masters. As described by Adepoju (2014) and Agbowuro et al. (2016), mnemonics devices are key words, rhymes, acronyms, notes card, model, short memory phrases, poems, note organization and diagrams, or imagery. The process of formulating mnemonics device is called "coding and encryptions". Mnemonics are memory support strategies which help to develop relationships and associations which do not exist naturally in the content to be learnt through coding. Such strategies constitute artificial links between old and new information. Generally, memory support strategies classified as coding with images and coding with verbal symbols are designed to help learners remember important concepts.

Chemistry education courses at university level requires high level of thinking, problem solving skills, concentration, and confidence to write legibly. Thus, their teaching and learning may not be easy without a sharp memory. Memory is a skill like others, which is an integral part of learners that can be improved with practice. The neuroplasticity researchers (specialists on human brains) have found that, human memory changes on daily bases (Legg & Cafasso, 2018). They concluded that; meditation through senses utilization, adequate sleeping, eating well, managing stress, grouping of learning information, exercises and socializing, as well as learning with mnemonics increase human memory retention capability.

Memory retention is the learners' ability to remember and retrieve the information they have learnt and stored in their memory over time. Thus, the primary focus for bringing MTM into the teaching of chemistry education courses in this study is to improve the students' interest in classroom participation, facilitate learning, increase students' memory retention which will in turn reduce their stress and anxiety and improve their academic achievement. This is for the reason that good memory retention, academic achievements, and mindfulness are panaceas to school dropout which is a serious wastage in education (Babalola & Aliyu, 2015).

Mindfulness is an act of paying attention to purpose in the present without judgment by providing disconnection from the constant stream of thoughts and worries about the past or future (Holly, 2020). Mindfulness relieves students from unfavorable thoughts, allowing them to be gentle, relaxed and show compassion to self and others (Gerritsen & Band, 2018). Mindfulness teaches that emotions are temporary feelings that will surely come to end. Despite knowing that thoughts about the past or future can be stressful, students are besieged with constant worry about their past results, intimation of bad grade and possibility of dropout. Miller et al. (2019) observed that mindfulness is now increasingly popular in education system leading to creating its centers in colleges and universities because evidence have shown that it improves students' learning and test scores. Passmore (2019) also reported that there is a growing body of research showing positive effects of mindfulness practices to learning in the university because of its ability to increase attention span, help manage stress and emotion, improve resilience and ability to self-regulate. It also encourages self-reflection, decreases depression and anxiety and improves students and teacher communication skills. This study hereby predicts a connection between the theory and practice of mindfulness and the teaching of chemistry with MTM.

As observed by Legg and Cafasso (2018), mnemonics involves encoding and encrypting system and it has been tested since 1960s as a learning strategy. Adzape (2015) observed that the study of chemistry education courses at university level has been too teacher-centered, making the students passive recipients. Mnemonics enhanced tutorial being an innovative strategy could increase the number of strategies in the archives of teaching methods available for addressing multidimensional nature of instructional objectives in chemistry education courses.

THEORETICAL FRAMEWORK

The theory adopted for this study is information process learning theory, which provides the basis for explaining the characteristics of MTM. The theory has many versions of information processing model. One of them which focus on the aspects of memory encoding and retrieval used by Johnstone (1997) was considered for this study. The model assumed that successful learning requires a trio of efficient perception filter, working memory, and long-term memory. Dye (2000) explained that whenever students come across information, the information enters their sensory register and stays there for few seconds. If the information is chosen to be processed by the students, it then moves from the sensory register to short-term memory. The longer a piece of information stays in the short-term memory, the greater is the tendency that it will move to the long-term memory.

An important part of long-term memory is semantic memory whose function is to stores facts and general information in networks of connected ideas or relationships. MTM fits in to this theory because it deals with associating the chemistry concepts, ideas and information with familiar words, funny sentences, acronyms, items, images, diagrams, rhymes, and familiar figures. Familiar figures include date of birth, independence day, room number, house address, mobile number among others. Funny sentences/jokes, attractive images, and nice rhymes tend to stay longer in the short memory which increases the tendency of the information migrating to the long term memory. By so doing, the process aid memory retention and retrieval through network of interconnected ideas.

Statement of the Problem

Observation of chemistry education students during examinations have shown that many of them were experiencing signs of academic stress and anxiety such as poor memory retention, examination tension, blurred eyes sight, fainting, or crying in the examination hall and hand shaking among others which are referred to as academic struggle signs in this study. According to Legg and Cafasso (2018), when students are stressed emotionally, their bodies release stress hormones like cortisol which has been

shown to greatly impair human memory process, especially their ability to retrieve longtime information. This usually results to emotional issues. Nevertheless, emotional competence in higher education has become the central focus in the recent decades and training for this competence through intervention programs to stop university dropout and to improve students' performance academically have been suggested (Gilar-Corbi et al., 2019). This is because positive emotions have been found to associate with learning and decrease in drop-out among students who face difficulties in the first year of universities (Russell et al., 2020). Also, negative emotions such as fear of failure have been trans-culturally associated with failures.

The main research problem amplified by this study is the menace of poor academic achievement and high level of academic struggles among chemistry education students, which may result to moral decadence if nothing timely is done for it to be addressed. Poor academic achievement is an infamous issue in Nigerian education system while the academic struggle may sound new to many scholars. Academic struggles have many features of anxiety with cognitive, behavioral, and psychological signs.

According to Oluoch et al. (2018), the cognitive anxiety signs include worry, problem solving difficulties, loss of memory, and oversensitivity problems. The behavioral anxiety signs are task avoidance, nervousness, lack of participation, easy task seeking, withdrawal, and irritability. Likewise, physical anxiety signs include rapid heartbeats, headaches, vomiting, nausea, perspiration, recurrent localized pain, and fainting. Also, psychological signs are eyes problems, stomach ulcer, drug abuse, hand shaking excessive sweating and temporary loss of sanity. All these and even more were the challenges observed among chemistry education students at the undergraduate level in university.

As observed by Holly (2020), despite the improved understanding of the human brain, "mental health" among university students is a major concern. Thus, seeing students that are experiencing high levels of stress and anxiety is a common occurrence but many teachers themselves might have been trained in such environments that emphasize not on the importance of well-being for effective learning. So, they ignore emotional impacts on students' learning of chemistry. David and Charles (2018), however, explained that chemistry, being a subject that most students are afraid of, requires teachers to use appropriate teaching method that will arouse the students' interest and encourage them to develop positive attitude towards learning. Consequently, this study investigates the effect of MTM on academic achievement and mindfulness among chemistry education students.

Objectives of the Study

Having considered the background and research problem of this study, the objectives are to:

1. examine the mean difference in academic achievement among chemistry education students before and after teaching them with MTM,
2. determine the mean difference in academic achievement between male and female chemistry education students taught with MTM in university,
3. examine the mean difference in students' mindfulness among chemistry education students taught with mnemonic tutorial method in university, and
4. find out the mean difference in mindfulness between male and female chemistry education students taught using MTM in university.

Research Questions

The above research objectives were transformed into the following research questions:

1. What is the mean difference in academic achievement among chemistry education students before and after teaching them with MTM?
2. Is there any mean difference in academic achievement between male and female chemistry education students taught with MTM in university?
3. What is the mean difference in students' mindfulness among chemistry education students taught with mnemonic tutorial method in university?
4. Is there any mean difference in mindfulness between male and female chemistry education students taught using MTM in a university?

Research Hypothesis

The following null hypotheses were tested to guide the study.

1. **H1:** There is no significant mean difference in academic achievement among chemistry education students before and after teaching them with MTM.
2. **H2**: There is no significant mean difference in academic achievement between male and female chemistry education Students taught with MTM in university.
3. **H3**: There is no significant mean difference in students' mindfulness among chemistry education students taught with mnemonic tutorial method in university.
4. **H4**: There is no significant mean difference in mindfulness between male and female chemistry education students taught using MTM in university.

RESEARCH METHODOLOGY

A single group pre-/post-test quasi-experimental design was used for this study. 1,002 students of chemistry education in the Department of Science Education, Yusuf Maitama Sule University, Kano, Nigeria formed the study population. Using purposive sampling techniques (PST), 250-students in the intact class of level 200 constituting 25% of the study population were used as sample based on the recommendation of Israel (2005). The treatment involved the researcher who is the level coordinator to the sampled students taking the best five students in the level who acted as the tutorial master through mnemonics device formulation and usage. Each of the trained tutors was put in charge of every 50-sampled student. All difficult concepts reported by the low performing students in all chemistry, education, and elective courses of level 200 were addressed. The students' raw scores used for data analysis were taken from their academic records where the semester before and after the treatments were considered pretest and posttest academic achievement. The adapted five facet mindfulness questionnaire (FFMQ) by Baer et al. (2006) with the reliability coefficient of 0.85 was used as instruments of data collection for mindfulness test. This FFMQ was face and content validated by experts in test and measurement in university while all the students' examination question papers, which served as the achievement tests were all moderated by external moderator who professors were engaged for the faculty. The research questions were answered with mean and standard deviation (SD) while the hypotheses were tested with t-test and analysis of variance (ANOVA) at 0.05-level of significance.

Data Analysis and Presentation

The results of data collected for the study and analyzed are presented indicating answer to the five research questions and test of five research hypotheses.

Table 1 shows that post-test achievement score are by far higher than the pre-test achievement scores. This is an indication that mnemonics enhanced tutorial improved chemistry education students' academic achievement in university.

Table 1. Mean difference between pre- and post-test academic achievements scores

Academic achievements	n	Minimum	Maximum	Mean	SD
Pre-test achievement	250	12.00	78.00	43.0120	11.11404
Post-test achievement	250	23.00	98.00	64.7280	16.64217

Note. Source: Field Study (2021)

Table 2 shows that female achievement scores after treatment are almost the same with their male counterparts. This is an indication that mnemonics enhanced tutorial improves cemistry education students' academic achievements almost equally across gender.

Table 2. Gender difference in academic achievements of students taught with MTM

Academic achievements	n	Minimum	Maximum	Mean	SD
Female achievement	125	43.00	98.00	73.0720	14.51261
Male achievement	125	34.00	98.00	70.0960	16.30576

Note. Source: Field Study (2021)

Table 3 shows the existence of greater mindfulness mean among above average students and the least among below average students indicating a direct proportional relationship between the students' academic achievement status and their mindfulness in the university.

Table 3. Pre-test mean difference in students' mindfulness across academic classes

Students academic performance classes	n	Minimum	Maximum	Mean	SD
Mindfulness among below average students	83	12.00	68.00	43.2771	13.14396
Mindfulness among average students	84	23.00	87.00	47.0357	13.30046
Mindfulness among above average students	83	43.00	98.00	73.0000	14.56943

Note. Source: Field Study (2021)

Also, as presented in **Table 4**, post-test scores of mindfulness with mean=75.91 and SD=11.18 are huge compared to pre-test scores with mean=43.69 and SD=12.25. This indicates that the teaching of chemistry with mnemonics helps to promote students' mindfulness.

Table 4. Mindfulness among the chemistry education students taught with MTM

Mindfulness scores	n	Range	Mean	SD	Variance
Post-test scores	250	86.50	75.9100	11.17912	124.973
Pre-test scores	250	53.00	43.6920	12.25028	150.069

Note. Source: Field Study (2021)

Hypotheses Testing

Statistics in **Table 5** shows that the t(249)=17.52, p(0.00)<0.05 and the null hypothesis is rejected. This is an indication that there is a statistically significant positive difference between the pre- and post-test scores of students taught with mnemonics enhanced tutorial in their chemistry education courses.

Table 5. t-test on academic achievement of students taught chemistry with MTM

Academic achievement	n	Mean	SD	df	t-value	p-value (2-tailed)
Pre-test	250	43.0120	11.11404	249	17.52	.000
Post-test	250	64.7280	16.64217			

Note. Significant at p<0.000 & Source: Field Study (2021)

Similarly, the second null hypothesis tested in **Table 6** shows that the p(0.127)>0.05. Thus, this null hypothesis is accepted, indicating that there is no significant gender difference among the students taught chemistry education courses with mnemonics ehanced tutorial.

Table 6. t-test on gender difference in achievements of students taught with MTM

Academic achievement	n	Mean	SD	df	t-value	p-value (2-tailed)
Female achievement	125	73.0720	14.51261	124	1.536	.127
Male achievement	125	70.0960	16.30576			

Note. Not significant at p<0.127 & Source: Field Study (2021)

As seen in **Table 7** showing the statistics of the third null hypothesis, it could be deduced that the p-values for the three groups (0.965, 0.781, & 0.250) are all greater than 0.05. Thus, the null hypothesis is accepted, indicating that there is no significant difference in chemistry education sudents' mindfulness across academic classes in university.

Table 7. ANOVA of chemistry education students' mindfulness across academic classes

Students' academic classes		Sum of squares	df	Mean square	F	Sig.
Below average	Between groups	2,464.702	24	102.696	.509	.965
	Within groups	11,701.924	58	201.757		
	Total	14,166.627	82			
Average	Between groups	3,594.605	25	143.784	.752	.781
	Within groups	11,088.288	58	191.177		
	Total	14,682.893	83			
Above average	Between groups	5,896.720	24	245.697	1.238	.250
	Within groups	11,509.280	58	198.436		
	Total	17,406.000	82			

Note. Not significant at p<(0.965, 0.781, & 0.250) & Source: Field Study (2021)

As shown in **Table 8**, the statistics for null hypothesis four (**H4**) is p(0.000)< 0.05 at 95% confidence 2-tailed. Hence, the null hypothesis is rejected, indicating that there is a statistically significant difference between pre- and post-test mindfulness scores before and after teaching the students chemistry education courses using mnemonics enhanced tutorial. This confirmed that mnemonics enhanced tutorial significantly improved the mindfulness of chemistry education students in university.

Table 8. Paired sample test on mindfulness among students taught with MTM

Mindfulness scores	n	Mean	SD	df	t-value	p-value (2-tailed)
Post-test scores	250	75.9100	11.17912	249	30.69	.000
Pre-test scores	250	43.6920	12.25028			

Note. Significant at p<0.000 & Source: Field Study (2021)

Summary of Major Findings

1. There is a significant positive effect of MTM on students' academic achievements in chemistry education courses in university.
2. There is no significant difference in the academic achievements of chemistry education students taught with MTM across gender in university.
3. High performing chemistry education students in university were experiencing better mindfulness compared to their low and average performing counterparts before teaching them with MTM in university.
4. There is no significant difference in sudents' mindfulness across academic classes after being taught with MTM in university.
5. MTM significantly improved chemistry education students' mindfulness in university.

DISCUSSION OF FINDINGS

The findings from **Table 3**, which targeted at knowing the level of mindfulness among the sampled students before they were exposed to the treatment shows a higher value of mean indicating better mindfulness among high performing students compared to the other two groups. There are almost the same level of mindfulness between average and below average students. However, low performing students (below average group) showed greater signs of academic stress and anxiety compared to other two academic groups. This support Legg and Cafasso (2018) who emphasizes that, strong support systems is vital for students emotional and brain health, if they must be successful academically. By the virtue of this study, mnemonics seems to be one of such support systems suggested, being a memory support system. Hereby, if the test on its ability to ameliorate students' emotional struggle (mindfulness) is also positive which this study is set to examine, MTM could be the best emotional and brain health remedy for chemistry education students going through stress and anxiety due to low performance.

This study shows that there is a significant positive effect of MTM on chemistry education students' academic achievements in university. This finding provides a strong support for studies such as Akinsola and Adeyemo (2014) and Nja et al. (2017) who found positive effects of using mnemonic devices in facilitating learning and increasing students' academic achievements in their various studies. The study also revealed that there is no statistically significant gender difference in the academic achievements of students taught with MTM across gender. This finding agreed with that of Enderly and Leanne (2016) and Olasheinde and Olatoye (2014) who found that gender is not a significant factor to be associated with students' achievement in sciences because, if given equal opportunity with the right teaching pedagogy and learning process, male, and female students will achieve equally. This disagreed with Amedu (2015) who found significant gender difference among science students when exposed to the use of different technological tools in electrolysis in chemistry.

This study also revealed that high performing chemistry education students were experiencing lower academic struggles(high mindfulness, lesser stress, and anxiety) compared to their counterparts in low and average academic class before teaching them with mnemonics teaching method. This finding corroborated with Victor's theory of academic class struggle (VTACS), which proposed that despite that all students are in different academic classes they are going through academic struggles to sustain their present academic class; to prevent retrogression and migrate to the higher class. Finally, this study discovered that there is a significant positive effect of teaching chemistry with mnemonics on students' mindfulness. This finding agreed with that of Agbowuro et al. (2016), which revealed that mnemonic is an instructional and learning strategy designed to help students improve their memory retention capacity. This is because as the memory retention capacity improves, the students' anxiety and stress reduces meaning MTM gives student confidence to face examination without the fear of past, present or future failure which is all mindfulness is all about.

CONCLUSION

The ideology that is behind this study is that chemistry education students generally are in different academic classes such as above average, average and below average and as well going through different academic struggles (VTACS). The essence of the struggle is either to sustain their present academic classes or to migrate into a higher class, which often manifested inform of stress and anxieties and its related challenges. Therefore, the chemistry teaching community should be concerned with the challenges affecting the students' academic performances. They are expected to be approachable, intelligent, and creative and as well committed to researching into the student learning challenges, which is the rationale behind this study. Therefore, the essence of this study is to create awareness to teachers and provide solutions to the challenges. The study hereby concluded that; the use of mnemonics devices vis-à-vis, acronyms, diagrams, images, rhymes, and codes among others improves students' academic achievements in chemistry Education courses irrespective of gender or academic classes. The study also concluded that teaching chemistry education courses with MTM is a mindfulness strategy to help students cope with their academic struggles, improve their academic achievements and reduce university dropout rate to the barest minimum.

Recommendations

Based on the analyses of chemistry education students' academic class struggle discussed under the purview of this study and the conclusions made on the findings, the following recommendations were raised to improve the teaching and learning of chemistry education courses in Nigeria tertiary institutions and universities in particular.

1. The use of MTM in teaching chemistry education courses should be prioritized by chemistry teachers in Nigerian tertiary institutions.
2. Since the teaching of chemistry education courses with MTM helps to improve students' academic achievements across gender, it should be adopted by all chemistry teachers irrespective of their school type and students' gender.
3. The school counselors should start introducing mnemonics-based learning styles to students that are experiencing lack of mindfulness due to poor achievement to improve their academic achievements.
4. MTM should be approved as an important teaching method in chemistry, and this should be included into the curriculum of teacher education programme by the curriculum planners.
5. The school administrators should make counseling services available in their schools so as to help manage chemistry education students' academic stress for mindfulness and academic achievements sake.

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