



METACOGNITIVE DIFFERENCES IN GENDER AND ACADEMIC OUTCOME AMONG CHEMISTRY EDUCATION STUDENTS OF KADUNA STATE UNIVERSITY

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Abstract

This study investigated the gender differences in metacognitive ability and academic outcome among chemistry education students of Kaduna State University in Nigeria. A total of 75 students (20males and 55females) of 2023/24 academic session drawn randomly from a population of one hundred and fifty 200level first degree chemistry education students of the institution constituted the sample size for the study. A survey research design was used for the study with two instruments, viz, the Metacognition Assessment Scale (MAS) and Chemistry Achievement Test (CAT) deployed to gather data to answer two research questions and test two corresponding null hypotheses. The data collected were analysed using means, standard deviations and t-test comparison of means. The results of the study revealed that the female students had higher metacognition than their male counterparts while on the basis of academic outcome, the reverse was recorded. However, the observed differences were not statistically significant (P -metacognition = 0.42 > 0.05; P -academic performance = 1.17 > 0.05, $df = 73$). This implies that the students might not have well developed metacognitive strategies for effective learning. It is recommended, among other things, that the science (chemistry) students should be exposed to training in metacognition and its various strategies so as to deploy them in learning situations for effective academic outcome.

Keywords: Metacognition, gender differences, academic outcome

Introduction

The development and use of strategies for effective teaching and learning to improve learners' academic outcome has often occupied the minds of science educators. When it comes to how best to learn for effective academic achievement, metacognition should not be overlooked. Moreover, the importance of metacognition is echoed in its study in the domain of artificial intelligence (AI) and modelling. It is a construct that has attracted the attention of the psychologists for decades now. According to Flavell (1979), who is typically known as the founding father of metacognition, metacognition is "knowledge and cognition about cognitive phenomena". It is often quoted in literature as "thinking about one's thinking or "cognition about cognitions" (Flavell, 1999; Bogdan, 2000). In its original conceptualization, metacognition refers to the learner's knowledge about his cognitive activities and the regulations of these activities in the learning process. Metacognition was later modified to mean learner's awareness of his skills, strategies and resources that he needs in order to carry out his learning task effectively and his ability to deploy self-regulatory mechanism to successfully complete the task (Noushad, 2008).

In plain language, metacognition is all about the learner's self-knowledge/ stored knowledge or beliefs or self-awareness of how he learns/thinks he learns and the approaches he uses to process information in the learning process; his feelings of how well or badly he learns often challenges and ushers him into recognizing and developing alternative skills /abilities or strategies to redirect and monitor his learning progress for better results.

Over the years, metacognition has been implicated in helping learners to monitor and manage their cognitive functions (Young & Fry, 2008); monitor and have oversight function of their thoughts (Shehzad, 2012); develop strategies or learning approaches (Narang & Saini, 2013); select the most appropriate learning/cognitive strategies for achievement of their personal goals (Abdelrahman, 2020); prepare for future actions, evaluate their learning, memorization and readiness for examinations (Shea, 2019); improve on their academic performance (Sword, 2021 & Joseph, 2023); take control of their learning process (Ozcakmak *et al*, 2021); and learn independently, persevere to do better, grow socially and emotionally and transfer knowledge and understanding gained in one situation to another task (Sword, 2021).

Above all, metacognition gives an insight into how learners learn; provides an opportunity for optimal teaching and learning for greater efficiency (Joseph, 2023).

From the foregoing, it can be deduced that metacognition is a powerful predictor of learning or academic outcome and therefore deserves investigation.

It is worth noting that metacognitive components have been identified and studied by many researchers (Mwangi *et al*, 2024; Ajaja & Eravwoke, 2017; Bidjerano, 2005). These components include metacognitive knowledge (i.e. the learners' awareness of how they learn and the various approaches they use to process their information; metacognitive experience which is about reflection on the learning for feedback to regulate their learning; metacognitive thoughts which involve the learners` designing strategies to overcome barriers/challenges to their learning in order to succeed. Although significant improvement on academic performance of students has been reported about the deployment of metacognition to learning (Young & Fry, 2008; Narang & Saini, 2013; Abdelrahman, 2020; Stanton *et al*, 2021; Sword, 2021; Joseph, 2023; Mwangi *et al*, 2024), reports regarding the differences between gender and metacognition remained inconclusive. For instance, Akin (2016), using secondary school students as his subjects in the country of Turkey noted that girls have higher metacognitive skills than boys in listening and understanding. Also, Bidjerano (2005) noted a higher metacognitive awareness level of females than the males among 198 university undergraduates of Northeastern USA offering basic education courses. In an Indian University of Tezpur, Pradhan & Das (2021) noted that metacognitive ability could account for about 43% of academic performance of undergraduate students of humanity, social sciences, school of engineering and school of sciences without mention of gender. Lavinia and Ciascai, (2011) in Rumania, working with primary school pupils noted than female pupils have greater metacognitive skills that their male counterparts. In Nigeria, Odofin *et al*, (2024) showed that females who utilized appropriate metacognitive reading strategies outperformed their male counterparts in reading ability in secondary schools. However, Popoola *et al*, (2021), still in Nigeria noticed no significant influence of metacognition of students` gender on performance in mathematics among secondary school students.

Similarly, studies conducted with primary school pupils in Thai by Chantharanuwong *et al*, (2012) and the one carried out by Duvan *et al*, (2020) in Columbia with secondary school students showed no significant difference in metacognitive skills between the female the male respondents.

Statement of the Problem

From available literature reviewed, there seems to be no studies on metacognition in the Nigerian setting involving university students especially regarding science education students- most studies on metacognition have been on the foreign scene. For instance, Bidjerano (2005) worked on undergraduate students that offered basic education courses in Northeastern USA. Abdelrahman (2020) studied the undergraduate sociology students of Ajman University in the United Arab Emirates while Pradhan and Das (2021) dwelt on undergraduate students of humanity, social sciences, school of engineering and school of sciences in Tezpur University of India. Also, Mir and Peerzada (2022) in India performed their study among college students of Kashmir. It is therefore necessary to investigate in the situation in the Nigerian university setting. Moreover, as findings of studies on metacognition and gender are unsettled and contradictory, this study seeks to make its contribution.

Objectives of the Study

The study sought to accomplish the following two objectives:

- i. Investigate the metacognitive ability of male and female chemistry education students of Kaduna State University, Kaduna.
- ii. Determine the impact of the metacognitive ability of the students` gender on their academic performance in chemistry.

Research Questions

The following research questions were stated for the study:

- i. Does the metacognitive ability of the male chemistry education students of Kaduna state University differ from that of their female counterparts?
- ii. How does the metacognitive ability of the students` gender impact on their academic performance in chemistry?

Hypotheses for the Study

The following corresponding null hypotheses were framed for the study:

Ho¹: There is no significant difference between the metacognitive ability of the male and female chemistry education students of Kaduna State University.

H_0^2 : There is no significant impact of the metacognitive ability of the students' gender on their academic performance in chemistry.

Methodology

The study was designed to describe the differences or otherwise in metacognitive ability of male and female students and its influence on the students' academic performance in chemistry. Since the description of the situation was desired and questionnaires were used to gather information, the survey research design was considered appropriate for the study. A total of seventy-five 200L first degree chemistry education students (20 males of 55 females) of 2023/24 academic session drawn randomly from a population of 150 students (50 males and 100 females) in the University constituted the sample size for this study. The Metacognition Assessment Scale (MAS) of Joseph (2023) in its questionnaire format was adopted for the study. MAS, as reported by the designer, had its face validity established by experts' judgment and its content and construct validity settled by factorial analysis. Its reliability value was .73 by Cronbach's Alpha index. It has 13 valid items designed to measure 5 different components of metacognition using the four-point Likert Scale of Strongly Agreed (4), Agreed (3), Disagreed (2), & Strongly Disagreed (1). 75 copies of this instrument were administered to the respondents during a normal class session and were successfully retrieved, marked and recorded. All the data collected from the students using the five metacognitive components of the scale, namely, cognitive knowledge, procedural knowledge, evaluation, cognitive monitoring and information management strategies were pulled together and judged as a reflection of students' metacognitive ability in this study. Also, scores from moderated Chemistry Achievement Test (CAT) on a chemistry course titled introductory organic chemistry (CHM204) administered to these same students were extracted and used as a measure of their performance (academic outcome). CAT was designed by the researchers and had 14 multiple choice questions of 1 mark each; 5 fill-in-the blank questions of 2 marks each and one essay question (subdivided into sections a-e) of 16 marks, giving a grand total of 40 marks. Its validity was ascertained by four experts in the subject while its reliability by test-retest method on a sample of the same level of students in another university gave an index of .70 by Pearson's Product Moment reliability formula. These two instruments were, therefore, judged adequate for gathering data for the study. The data obtained for the study were processed using SPSS version 26 and the results are presented in Tables 1- 4:

Table 1: Difference in metacognitive ability between male and female chemistry education students

Gender&	N	X	SD	Standard Error
Metacognition				
Male	20	3.25	0.49	0.11
Female	55	3.33	0.35	0.05

Table 1 shows that the metacognitive ability of the female students is slightly higher than that of the male students by a mean difference of 0.08.

Table 2: Difference in impact of metacognitive ability of gender on academic outcome

Gender&	N	X	SD	Standard Error
Performance				
Male	20	13.62	3.90	0.87
Female	55	12.54	3.46	0.47

In terms of performance, Table 2 shows that the male students had a higher mean score of 13.62 while their female counterparts recorded the mean performance score of 12.54, the difference between both sexes being 1.08.

To test the level of significance of the differences in metacognitive ability in gender and performance of both sexes, t-test was applied at 0.05 confidence level and the results are as shown in Tables 3 and 4 respectively.

Table 3: t-test comparison of metacognitive ability difference between male and female chemistry education students

Gender&	N	X	SD	Standard Error	df	t-value	P
Metacognition							
Male	20	3.25	0.49	0.11	73	.81(NS)	0.42
Female	55	3.33	0.35	0.05			

NS= Not significant, $P > 0.05$; t-critical = 1.98

There is statistically no significant difference between the metacognitive ability of the male and female chemistry education students, $P=0.42 > 0.05$ at $df = 73$; $t = .81 < 1.98$.

Table 4: t-test comparison of impact of metacognitive ability of gender on academic outcome

Gender& Performance	N	X	SD	Standard Error	df	t-value	P
Male	20	13.63	3.90	0.87	73	1.17(NS)	0.25
Female	55	12.54	3.46	0.47			

NS= Not significant, $P > 0.05$, t critical = 1.98

There is statistically, no significant difference of the impact of metacognitive ability of students` gender on their academic (outcome) performance, $p = 0.25 > 0.05$ at df 73; $t = 1.17 < 1.98$

Discussion

The results of this study reveal that the female undergraduate chemistry education students of the university recorded higher metacognitive ability than their male counterparts (Table1). But in terms of academic outcome, the opposite was observed: the male undergraduates outperformed their female counterparts (Table2). However, these gender differences noted in metacognition and academic performance (outcome) are not statistically significant (Tables3&4: P-metacognition = $0.42 > 0.05$; P-academic performance = $1.17 > 0.05$). The findings of this study tend to corroborate the findings of studies by Mir and Peerzada (2022) about college students in Kashmir, India; and Chantharanuwong *et al* (2012) in Thai about primary school pupils; Duvan et al (2020) in Columbia and Popoola (2021) about secondary school students in Nigeria.

With particular reference to university setting, the findings of this study deviate from those of Bidjerano(2005) and Abdelrahman(2020) who noticed a significantly higher metacognitive ability in females than in males with a corresponding higher academic performance of the former than the latter. The findings of these authors lend credence to the findings of Lavina and Ciascai (2011) about primary pupils; Akin (2016) and Odofin *et al* (2024) about secondary school students, although Mwangi in a Kenyan setting found the opposite about secondary school students. Pradhan and Das (2021) had also reported in their study that metacognition accounted for 43% of variability of academic achievement of undergraduate students thus portraying that metacognition is still a powerful predictor of academic success.

The non-significant difference in metacognition and academic performance of the gender in the

present study can be explained simply by reasoning that the students do not seem to have well developed metacognitive strategies to help them cope with their academic tasks. This might as well explain the findings of studies of Chantharanuwong et al (2012), Duvan et al (2020), Popoola(2021) and Mir and Peerzada(2022). This is reflected in their overall performance in the CAT administered to them. Out of the total raw score of 40marks for the test with 20marks as half of the score, the mean score for the entire test for 75 students was 12.88 with a standard deviation of 3.51. Therefore, for a raw score of 19marks, the standard score (Z) can be predicted to be 1.74 implying that 95.91% of the students (i.e. 72 students) scored below 19 while only 4.09% (only 3 students) scored above 19. This is an indication of poor academic outcome or performance.

Conclusion and Recommendations

The main thrust of this study was to investigate the gender differences in metacognitive ability and academic outcome/ performance of chemistry education students of Kaduna State University. Findings of this study show that the female students have higher metacognition than their male counterparts. But on the basis of academic outcome, the male students outperformed their female folks. However, these differences were found to be statistically not significant.

In line with the findings of this study, it is recommended that:

- i. Metacognition and its various strategies for learning should be introduced to students and properly taught, preferably, in a general study course to show its relation and application to effective learning.
- ii. A workshop on metacognition and its strategies should be organised for science (chemistry) teachers so to enable them bring the knowledge acquired periodically into the teaching-learning situations to aid students learn effectively.

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