



Gender Differences in Performance, Interest, and Knowledge Retention Within a Moodle-Supported Advanced Real Analysis Cohort

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Abstract

This study examined gender differences in academic performance, mathematics interest and knowledge retention among undergraduate mathematics students exposed to Moodle-supported instruction in Advanced Real Analysis at Gombe State University. The study addressed three objectives and was guided by three corresponding research questions and null hypotheses focusing on gender differences in post-test academic performance, post-intervention interest and knowledge retention. A secondary analysis of a Moodle-supported cohort comprising 31 undergraduate mathematics students, including 22 male and 9 female students, was conducted. Data were collected using the researcher-developed Advanced Real Analysis Performance Test (ARAPT) and the Mathematics Interest Questionnaire (MIQ). The instruments were subjected to face and content validation by three experts comprising two mathematics educators and one specialist in Measurement and Evaluation. The ARAPT yielded a KR-20 reliability coefficient of .83, while the MIQ produced a Cronbach's alpha coefficient of .87. Data were analysed using descriptive statistics and analysis of covariance (ANCOVA) at the .05 level of significance. The results showed no statistically significant gender difference in post-test academic performance after controlling for pre-test performance, $F(1, 28) = 1.023$, $p = .321$, $\eta^2 = .035$; post-intervention interest after controlling for pre-intervention interest, $F(1, 28) = 0.221$, $p = .642$, $\eta^2 = .008$; or knowledge retention after controlling for post-test performance, $F(1, 28) = 1.964$, $p = .172$, $\eta^2 = .066$. The findings indicate that male and female students demonstrated broadly comparable outcomes within the Moodle-supported cohort. However, given the small and unequal gender groups, the results should be interpreted cautiously and should not be taken as evidence of statistical equivalence or a causal effect of Moodle.

Keywords: gender differences, moodle, advanced real analysis, academic performance, mathematics interest, knowledge retention

1 Introduction

Gender differences in mathematics achievement have received sustained attention across educational levels and national contexts. Evidence from large-scale syntheses suggests that average differences in mathematics performance between male and female students are generally small, although their direction and magnitude vary across educational settings, age groups, mathematical domains and opportunity structures (Else-Quest et al., 2010; Lindberg et al., 2010). These findings challenge explanations that attribute differences in mathematical performance to inherent ability. Rather, gender-related patterns in mathematics are more appropriately understood within the social and educational contexts in which students learn, including differences in prior experiences, expectations, participation opportunities and access to supportive learning environments. At the university level, comparable mean achievement does not necessarily imply comparable educational experiences. Research in undergraduate mathematics has shown that gendered patterns of participation, classroom authority and engagement may persist even when students are exposed to the same curriculum and instructional approach. Johnson et al. (2020), for example, identified gender inequities within inquiry-oriented undergraduate mathematics classrooms, while Reinholz et al. (2022) showed that differences in classroom participation were associated with inequities in mathematical performance. Nigerian evidence similarly highlights the distinction between representation and performance. Iji and Abah (2017) reported comparable graduation proficiency among male and female mathematics education students despite the under-representation of female students. These findings suggest that gender analysis in university mathematics should move beyond simple comparisons of mean scores to consider the learning context in which such outcomes occur.

The increasing integration of Learning Management Systems (LMSs) into higher education has added a further dimension to this discussion. Platforms such as Moodle support the organisation of learning materials, formative assessment, feedback, assignment submission, discussion and access to learning resources beyond scheduled classroom

periods. In mathematics education, Saygılı and Çetin (2021) reported an overall positive effect of LMS-supported instruction on mathematics achievement across experimental studies. Moodle has also been used effectively for online assessment in university mathematics settings (Padayachee et al., 2018), while Nigerian evidence has linked effective use of Moodle with students' motivation and self-regulated learning (Mustapha et al., 2023). These studies establish the potential educational value of LMS-supported learning; however, they do not demonstrate that male and female students necessarily experience or benefit from such environments in identical ways. This issue is particularly relevant in Advanced Real Analysis, where students are expected to work with abstract definitions, logical arguments, proofs and interconnected mathematical concepts. Successful engagement with such content requires more than procedural competence; it also demands sustained attention, confidence, persistence and the ability to retain and connect ideas over time. Gender-related differences in participation, prior preparation or motivational beliefs may therefore become relevant even when students receive the same instructional content. Yet evidence examining gender, Moodle-supported learning and proof-oriented undergraduate mathematics remains limited, particularly within Nigerian university settings.

A theoretical basis for examining these differences is provided by Situated Expectancy-Value Theory (SEVT) (Eccles & Wigfield, 2020). SEVT explains achievement-related behaviour in terms of students' expectations of success and the value they attach to particular learning tasks, while recognising that these beliefs develop within social and educational contexts. From this perspective, gender differences are not treated as consequences of gender itself. Instead, differences in achievement, interest or persistence may emerge from students' previous experiences, perceptions of competence, encouragement, participation opportunities, perceived task value and the costs associated with engagement. This perspective is particularly relevant to technology-supported mathematics learning because features such as repeated access to course materials, formative quizzes, immediate feedback, visible progress and online discussion may interact with students' existing motivational beliefs and learning experiences. In the present study, interest, academic performance and knowledge retention are therefore treated as related but distinct outcomes of students' learning experiences. Academic performance reflects immediate demonstrated achievement following instruction, interest represents students' affective and motivational engagement with mathematics, while retention concerns the extent to which previously learned mathematical knowledge is maintained after a period of delay. Examining these outcomes together provides a broader view of gender-related patterns than achievement scores alone.

Importantly, the present study does not evaluate the effectiveness of Moodle relative to another instructional approach. The analysis is limited to one intact Advanced Real Analysis class that received Moodle-supported instruction, and no traditional or non-Moodle comparison condition is included in this paper. Consequently, any differences observed between male and female students cannot be attributed causally to Moodle. The study instead examines whether gender differences were detectable within the Moodle-supported cohort after accounting for relevant prior or immediate performance measures. The analytical context also requires caution. The intact class comprised 31 undergraduate mathematics students, including 22 male and 9 female students. The unequal gender distribution reflected the actual composition of the class rather than a sampling decision. Nevertheless, the small and unbalanced groups reduce statistical power, particularly for detecting small gender differences. Non-significant findings are therefore interpreted as an absence of sufficient evidence of a difference within this cohort and not as proof that male and female students are statistically equivalent. Against this background, the study examined gender differences in academic performance, mathematics interest and knowledge retention among undergraduate mathematics students in a Moodle-supported Advanced Real Analysis class. Specifically, the study sought to determine whether male and female students differed in post-test academic performance after controlling for pre-test performance, whether they differed in post-intervention mathematics interest after controlling for pre-intervention interest, and whether they differed in knowledge retention after controlling for immediate post-test performance.

1.1 Research Questions

1. Is there a significant gender difference in post-test academic performance after controlling for students' pre-test performance?
2. Is there a significant gender difference in post-intervention mathematics interest after controlling for pre-intervention interest?
3. Is there a significant gender difference in knowledge retention after controlling for immediate post-test academic performance?

1.2 Research Hypotheses

The following null hypotheses were tested at the .05 level of significance:

- H01: There is no significant gender difference in post-test academic performance after controlling for pre-test performance.
- H02: There is no significant gender difference in post-intervention mathematics interest after controlling for pre-intervention interest.
- H03: There is no significant gender difference in knowledge retention after controlling for immediate post-test academic performance.

2 Literature Review

Evidence on gender differences in mathematics performance generally shows small and context-dependent differences rather than a consistent male or female advantage. Meta-analytic studies by Lindberg et al. (2010) and Else-Quest et al. (2010) reported minimal average differences, although variation was observed across educational and social contexts. At university level, differences in participation and classroom experience may still occur even when achievement is similar (Johnson et al., 2020; Reinholz et al., 2022). Nigerian evidence also suggests that female under-representation does not necessarily correspond to lower mathematics performance (Iji & Abah, 2017). Learning management systems such as Moodle provide access to instructional materials, assessment, feedback and interaction. Studies have reported positive contributions of LMS-supported learning to mathematics achievement and engagement (Padayachee et al., 2018; Saygılı & Çetin, 2021; Mustapha et al., 2023). However, evidence on gender differences in e-learning remains inconsistent. Yu and Deng (2022) found no uniform gender advantage across motivation, satisfaction, self-efficacy, attitudes and performance. In the present study, Moodle is therefore treated as the common instructional environment rather than as an intervention being compared with another teaching approach.

Interest is an important component of mathematics learning because it influences engagement and persistence, while knowledge retention reflects the extent to which learning is maintained over time. Gender differences in affective variables may occur even where achievement is comparable (Ng & Teoh, 2019). Although previous studies have examined LMS-supported achievement and self-regulated learning (Roick & Ringeisen, 2018; Saygılı & Çetin, 2021), evidence on gender differences in delayed retention in undergraduate mathematics remains limited. The study is guided by Situated Expectancy-Value Theory (SEVT), which explains achievement, engagement and persistence in relation to learners' expectations of success and the value they attach to learning tasks within particular social and instructional contexts (Eccles & Wigfield, 2020). From this perspective, gender differences are not assumed to arise from gender itself but may reflect differences in prior experiences, confidence, task value and participation opportunities. SEVT therefore provides an appropriate framework for interpreting gender differences in academic performance, mathematics interest and knowledge retention within the shared Moodle-supported environment.

3 Methodology

3.1 Research Design

The study adopted a secondary analytical design using data from the Moodle-supported group of a larger quasi-experimental study. The analysis focused specifically on gender differences in academic performance, mathematics interest and knowledge retention among students who received Moodle-supported instruction in Advanced Real Analysis. Gender was an observed participant characteristic and was not manipulated. Since the present paper analysed only the Moodle-supported class, it was not designed to determine the comparative effect of Moodle against another instructional approach.

3.2 Population of the Study

The population for the present analysis comprised all students enrolled in the intact Advanced Real Analysis class that received Moodle-supported instruction during the 2023/2024 academic session at Gombe State University. The class consisted of 31 undergraduate mathematics students, comprising 22 male and 9 female students. The unequal gender distribution reflected the actual composition of the class.

3.3 Sample Size and Sampling Procedure

All 31 students in the intact class were included in the study; therefore, no additional sampling procedure was undertaken for the secondary analysis. The entire available Moodle-supported class constituted the analytic sample. A sensitivity analysis indicated that, with the available sample size and unequal gender groups, the study had adequate statistical power mainly for detecting large adjusted gender effects. Consequently, small or moderate differences may have remained undetected, and non-significant findings were interpreted as an absence of a detected difference rather than evidence of statistical equivalence.

3.4 Instruments for Data Collection

Two instruments were used for data collection: the Advanced Real Analysis Performance Test (ARAPT) and the Mathematics Interest Questionnaire (MIQ). The ARAPT was a researcher-developed 50-item multiple-choice test designed to assess students' academic performance in Advanced Real Analysis. The items covered major course topics including metric spaces, bounded sets, open and closed sets, neighbourhoods, convergence and related concepts. The test was developed using a table of specifications to ensure adequate representation of the instructional content. The same instrument was later reshuffled and administered to assess knowledge retention. The MIQ was used to assess students' interest in mathematics. The questionnaire covered dimensions such as enjoyment, intrinsic motivation, perceived relevance and engagement. Responses were rated on a five-point scale, with higher scores representing greater mathematics interest.

3.5 Validity and Reliability of the Instruments

The ARAPT and MIQ were subjected to face and content validation by three experts comprising two Mathematics Education specialists and one specialist in Measurement and Evaluation. Their observations on item relevance, clarity, appropriateness and content coverage were incorporated into the final instruments. The instruments were subsequently pilot-tested. The ARAPT yielded a Kuder–Richardson Formula 20 (KR-20) reliability coefficient of .83, while the MIQ produced a Cronbach's alpha coefficient of .87. KR-20 was considered appropriate for the dichotomously scored achievement items, whereas Cronbach's alpha was used for the rating-scale interest items. The coefficients indicated satisfactory internal consistency of both instruments.

3.6 Data Collection Procedure

Before the commencement of instruction, students were oriented to the Moodle platform and guided on how to access course materials, participate in discussion forums, complete quizzes and submit assignments. The ARAPT and MIQ were then administered as pre-intervention measures. This was followed by six weeks of Moodle-supported instruction in Advanced Real Analysis. The instructional modules contained lecture notes, instructional videos, worked examples, discussion activities and formative quizzes with immediate feedback. Synchronous clarification sessions were also conducted to address difficult concepts and provide additional explanations. Immediately after the six-week instructional period, the ARAPT and MIQ were re-administered as post-intervention measures. Two weeks later, a reshuffled version of the ARAPT was administered as the retention test. Only the order of the items was changed; the content and scoring remained unchanged.

3.7 Data Analysis

Means and standard deviations were used to describe students' academic performance, mathematics interest and knowledge retention according to gender. Three analyses of covariance (ANCOVAs) were conducted in line with the

three research questions and hypotheses. Pretest performance served as the covariate for post-test academic performance, pre-intervention interest was used as the covariate for post-intervention interest, and immediate post-test performance was used as the covariate for knowledge retention. Statistical significance was determined at the .05 level, while partial eta squared (η^2) was reported as the measure of effect size. Because the archived statistical output did not contain complete diagnostic information for all ANCOVA assumptions, particularly homogeneity of regression slopes and normality of residuals, the inferential findings were interpreted cautiously. Values reported as .000 in the original output were presented as $p < .001$ in accordance with standard statistical reporting practice.

4 Results

The results are presented with consideration of the small and unequal gender groups. Accordingly, non-significant findings are interpreted as indicating no detected gender difference rather than statistical equivalence.

4.1 Descriptive Statistics

Academic performance by gender is summarised in Table 1. Female students had a lower mean pretest score than male students but a larger unadjusted mean gain, whereas male students recorded a slightly higher mean post-test score. Because the groups differed at baseline, the gain scores are presented only as descriptive information and are not interpreted as evidence of a differential effect by gender.

Table 1

Academic Performance by Gender

Gender	<i>n</i>	Pretest <i>M</i>	Pretest <i>SD</i>	Posttest <i>M</i>	Posttest <i>SD</i>	Mean gain
Male	22	23.36	6.89	72.14	9.16	48.78
Female	9	16.56	6.65	69.33	7.73	52.77

Note. *M* = mean; *SD* = standard deviation; mean gain = posttest - pretest.

Mathematics interest by gender is presented in Table 2. Male students recorded slightly higher mean interest scores at both measurement points, while the unadjusted increase was larger among female students. As with academic performance, these raw changes are descriptive and do not indicate that Moodle had a different effect on male and female students.

Table 2

Mathematics Interest by Gender

Gender	<i>n</i>	Pre-interest <i>M</i>	Pre-interest <i>SD</i>	Post-interest <i>M</i>	Post-interest <i>SD</i>	Mean gain
Male	22	3.13	0.36	3.64	0.25	0.51
Female	9	2.93	0.33	3.56	0.23	0.63

Note. *M* = mean; *SD* = standard deviation; mean gain = post-interest - pre-interest.

Post-test and retention scores are shown in Table 3. The unadjusted mean decrease from post-test to the retention test was smaller among female students than among male students. This pattern is descriptive only; the subsequent ANCOVA compares retention scores after adjustment for immediate post-test performance and does not test a time-by-gender interaction.

Table 3

Knowledge Retention by Gender

Gender	<i>n</i>	Posttest <i>M</i>	Posttest <i>SD</i>	Retention <i>M</i>	Retention <i>SD</i>	Mean loss
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Gender	<i>n</i>	Posttest <i>M</i>	Posttest <i>SD</i>	Retention <i>M</i>	Retention <i>SD</i>	Mean loss
Male	22	72.14	9.16	66.77	8.89	5.37
Female	9	69.33	7.73	68.78	7.87	0.55

Note. *M* = mean; *SD* = standard deviation; mean loss = posttest - retention test.

4.2 Hypothesis Testing

For the first hypothesis, an ANCOVA examined gender differences in post-test academic performance after adjusting for pretest performance. The results are presented in Table 4.

Table 4

Analysis of Covariance for Posttest Academic Performance by Gender

Source	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>	Partial η^2
Corrected model	86.575	2	43.287	0.550	.583	.038
Intercept	16401.994	1	16401.994	208.355	< .001	.882
Pretest	36.392	1	36.392	0.462	.502	.016
Gender	80.520	1	80.520	1.023	.321	.035
Error	2204.199	28	78.721			
Total	159985.000	31				
Corrected total	2290.774	30				

Note. *SS* = sum of squares; *MS* = mean square; partial η^2 = partial eta squared. Values displayed as .000 in the original statistical output are reported as $p < .001$.

After adjustment for pretest performance, no statistically significant gender difference was detected in post-test academic performance, $F(1, 28) = 1.023$, $p = .321$, partial $\eta^2 = .035$. The first null hypothesis was therefore not rejected. Given the limited statistical sensitivity of the sample, this finding indicates that a gender difference was not detected in the present cohort; it should not be interpreted as evidence that the groups were equivalent.

For the second hypothesis, an ANCOVA examined gender differences in post-intervention mathematics interest after adjusting for pre-intervention interest. The results are presented in Table 5.

Table 5

Analysis of Covariance for Post-Intervention Mathematics Interest by Gender

Source	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>	Partial η^2
Corrected model	1.175	2	0.588	26.453	< .001	.654
Intercept	1.323	1	1.323	59.570	< .001	.680
Pre-interest	1.130	1	1.130	50.857	< .001	.645
Gender	0.005	1	0.005	0.221	.642	.008
Error	0.622	28	0.022			
Total	407.021	31				
Corrected total	1.797	30				

Note. *SS* = sum of squares; *MS* = mean square; partial η^2 = partial eta squared. Values displayed as .000 in the original statistical output are reported as $p < .001$.

Pre-intervention interest was significantly associated with post-intervention interest, $F(1, 28) = 50.857$, $p < .001$, partial $\eta^2 = .645$. After adjustment for pre-intervention interest, no statistically significant gender difference was detected in post-intervention interest, $F(1, 28) = 0.221$, $p = .642$, partial $\eta^2 = .008$. The second null hypothesis was therefore not rejected. As with the first analysis, the non-significant result is interpreted as an absence of a detected difference rather than evidence of gender equivalence. For the third hypothesis, an ANCOVA examined gender differences in knowledge-retention scores after adjusting for immediate post-test performance. The results are presented in Table 6.

Table 6

Analysis of Covariance for Knowledge Retention by Gender

Source	SS	Df	MS	F	p	Partial η^2
Corrected model	914.686	2	457.343	10.112	< .001	.419
Intercept	237.274	1	237.274	5.246	.030	.158
Posttest	889.009	1	889.009	19.656	< .001	.412
Gender	88.823	1	88.823	1.964	.172	.066
Error	1266.411	28	45.229			
Total	142818.000	31				
Corrected total	2181.097	30				

Note. *SS* = sum of squares; *MS* = mean square; partial η^2 = partial eta squared. Immediate posttest performance was entered as the covariate. Values displayed as .000 in the original statistical output are reported as $p < .001$.

Immediate post-test performance was significantly associated with retention scores, $F(1, 28) = 19.656$, $p < .001$, partial $\eta^2 = .412$. After adjustment for immediate post-test performance, no statistically significant gender difference was detected in knowledge retention, $F(1, 28) = 1.964$, $p = .172$, partial $\eta^2 = .066$. The third null hypothesis was therefore not rejected. This result does not establish equal retention between male and female students; it indicates only that no statistically significant gender difference was detected in this small cohort.

5 Discussion

The analysis of academic performance revealed no statistically significant gender difference in post-test scores after controlling for pretest performance. This finding is consistent with evidence that gender differences in mathematics achievement are generally small and context-dependent (Else-Quest et al., 2010; Lindberg et al., 2010) and with Iji and Abah (2017), who reported comparable mathematics proficiency among male and female students. Although female students recorded a larger raw gain, they also began with a lower pretest mean; since no gender-by-baseline interaction was tested, the gain difference is interpreted descriptively rather than as evidence of a gender-specific advantage. From the perspective of Situated Expectancy-Value Theory, achievement may be shaped by prior experiences, expectations of success and task value rather than gender itself (Eccles & Wigfield, 2020). Given the small and unequal groups, the result indicates that no gender difference was detected rather than that the groups were statistically equivalent. A similar pattern emerged for mathematics interest. No statistically significant gender difference was found in post-intervention interest after controlling for pre-intervention interest. This is broadly consistent with Yu and Deng (2022), who found no consistent gender advantage across several e-learning outcomes. Comparable interest scores, however, do not necessarily imply identical affective experiences, as gender differences may still occur in self-efficacy, enjoyment and anxiety (Ng & Teoh, 2019). Since the study did not examine gender differences in the use of specific Moodle features, the larger raw increase in female students' interest remains descriptive and cannot be attributed to the platform.

For knowledge retention, no statistically significant gender difference was detected after controlling for immediate post-test performance. Immediate post-test performance was significantly associated with retention, indicating that students with stronger immediate achievement also tended to perform better after the two-week interval. Although female students

showed a smaller descriptive decline, the analysis did not directly test whether changes from post-test to retention differed by gender. The finding should therefore be interpreted cautiously, particularly given the limited evidence on gender and delayed retention in Moodle-supported undergraduate mathematics (Padayachee et al., 2018; Roick & Ringeisen, 2018; Saygılı & Çetin, 2021). The analyses detected no statistically significant gender differences in academic performance, mathematics interest or knowledge retention within the Moodle-supported cohort. Interpretation is nevertheless constrained by the small intact class, unequal gender representation, absence of a non-Moodle comparison condition and unavailable diagnostic information for some ANCOVA assumptions. Future studies should draw on larger multi-cohort samples with adequate representation of both genders and incorporate measures of participation, motivation and Moodle use.

6 Conclusion

The study examined gender differences in academic performance, mathematics interest and knowledge retention within one Moodle-supported Advanced Real Analysis class. After adjustment for the relevant covariates, no statistically significant gender differences were detected in the three outcomes. The descriptive patterns observed among female students should not be interpreted as evidence of superiority or as a gender-specific effect of Moodle. Rather, the study provides a cautious gender-disaggregated account of outcomes within a small proof-oriented university mathematics cohort. Stronger conclusions will require larger samples, direct measures of participation and platform use, and designs capable of testing instructional-method-by-gender interactions.

7 References

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