Effect of Artificial Intelligence (AI)-Scaffolded Planning Tools on Research Question Formulation Among Students with Mild Intellectual Disabilities: A Randomized Controlled Trial Analysis

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Abstract: *Introduction:* Students with mild intellectual disabilities often encounter significant difficulties when faced with complex academic tasks, particularly in developing research topics. These challenges are not only linked to their cognitive limitations but are also compounded by limited instructional support within learning environments. As a result, there is an increasing need for innovative strategies that can simplify learning without diluting academic standards. One promising approach is the use of artificial intelligence–based scaffolding tools, which provide learners with structured guidance to help them navigate demanding academic tasks.

Purpose: This study aimed to explore how AI-supported planning tools influence students' ability to formulate research topics. Beyond this central objective, the study also examined whether differences in school type and gender affected students' performance when supported with AI scaffolding.

Methods: The study adopted a pretest–posttest randomized controlled trial involving 94 students. Participants were randomly assigned to either the experimental group, which received AI-scaffolded support, or the control group, which did not receive any support. The *Research Topic Quality Scale*, adapted from Creswell and Clark (2018), was employed to evaluate the clarity, feasibility, and alignment of research topics generated by the students. Data analysis was conducted using ANCOVA to examine both main effects and interaction effects of the independent variables.

Results: The findings revealed that students who had access to the AI-scaffolded tool performed significantly better in developing their research topics compared to those in the control group. In addition, results showed that private school students achieved higher scores than their counterparts in public schools, suggesting that resource availability played a role. Gender, however, did not emerge as a significant factor in students' performance. No significant interaction effects were found between school type, gender, and intervention.

Conclusion: The study demonstrates that AI-based scaffolding has the potential to enhance the ability of students with mild intellectual disabilities to engage with higher-order academic tasks, such as formulating research topics. While the intervention proved effective for both male and female learners, the differences observed between private and public schools highlight persistent inequalities in educational resources that still need to be addressed.

Originality/Value: This research contributes to the growing body of evidence supporting the integration of artificial intelligence into inclusive education. By demonstrating that AI-driven scaffolding can enhance complex academic skills, the study underscores its value as a practical and innovative approach for promoting educational success among students with mild intellectual disabilities.

Keywords: Artificial intelligence, scaffolding, research topic formulation, mild intellectual disabilities, inclusive education, school type, gender equity.

INTRODUCTION

Research engagement empowers students with mild intellectual disabilities (MID) by fostering critical thinking, building self-efficacy, and encouraging civic participation [1]. However, research activities demand higher-order skills—such as framing questions, evaluating literature, and designing methods—that often exceed conventional expectations for learners with MID [2]. Among these skills, the ability to formulate a viable research question is pivotal. It demonstrates comprehension of a problem, establishes feasible avenues for investigation, and anchors the methodological process.

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Formulating research topics is a cornerstone of the research process, laying the foundation for all subsequent inquiry. For higher education students, the ability to craft clear, relevant, and researchable questions reflects academic maturity and showcases critical thinking, creativity, and independence. For students with MID, however, this step is particularly challenging due to difficulties in cognitive processing, abstract reasoning, and information synthesis [3]. Topic formulation not only requires identifying an area of interest but also translating it into a structured, answerable question that aligns with academic standards and expectations. For students with MID, this process is both a pedagogical necessity and a developmental milestone in building academic confidence and identity.

The importance of research topic formulation for students with MID lies in its broad developmental benefits. It fosters ownership of learning [4], enhances cognitive growth through problem identification and conceptual mapping [5], strengthens communication [6], and promotes academic inclusion by enabling participation alongside peers without disabilities [7]. It also builds employability by developing transferable skills such as analysis, problem-solving, and digital literacy [8]. Topic development provides an outlet for self-expression, allowing students to explore issues tied to their experiences and cultural contexts [9]. Furthermore, it nurtures resilience [10], facilitates mentorship opportunities that enhance supervisor–student relationships [11], develops digital competence through research technologies [12], and helps close equity gaps by ensuring that students with MID are included in a critical academic rite of passage [13].

Despite its importance, topic formulation is shaped by multiple challenges. These include cognitive limitations, limited exposure to research conventions, and difficulties with language and literacy [14]. Socio-emotional factors such as anxiety and low self-efficacy may reduce engagement, while limited access to assistive technologies and adaptive resources presents further obstacles [15]. Institutional shortcomingssuch as weak inclusivity policies[16] inadequate mentorship, and unsupportive research cultures—also impede progress. Additionally, cultural and socioeconomic factors [17], difficulties with peer interaction in collaborative research settings, and limited training in navigating rapidly evolving digital tools contribute to these barriers.

In recent years, scholars have examined topic formulation in higher education. For example, [18] investigated the role of structured peer support in refining topics, while [19] highlighted the benefits of cognitive scaffolding. Other studies have considered the impact of digital tools [20], literacy interventions [21], AI-based platforms [22], and collaborative writing technologies Additional research has explored cultural influences on topic choice [23], inclusive pedagogies for students with disabilities [24], the role of personal relevance [25], and the use of assistive technologies in research planning [26]. However, studies specifically addressing how AI-scaffolded planning tools affect topic formulation for students with MID remain scarce, if not absent.

AI-scaffolded planning tools are designed to guide learners through structured reasoning in academic tasks such as brainstorming, organizing, and refining ideas. By leveraging adaptive algorithms, natural language processing, and cognitive scaffolding, these tools break down complex tasks into manageable steps, promote metacognitive reflection, and provide personalized feedback [27, 28]. They foster inclusivity, strengthen academic confidence, encourage critical thinking, and enhance autonomy [29-35]. For students with MID, these tools clarify research relevance, simplify language, synthesize prior knowledge, and reduce ambiguity in idea generation [36-40]. In doing so, they create pathways for equitable participation in academic inquiry.

Although AI applications in education are well documented, most research focuses on general student populations. For example, [41] demonstrated that AI-driven learning platforms enhanced personalization and engagement, while [42] found that intelligent tutoring systems supported metacognition; however, neither addressed learners with cognitive impairments. Similarly, e-learning studies have emphasized accessibility [43] and the role of generative AI in supporting idea generation [44], but without considering students with MID. Research in special education often emphasizes assistive technologies such as text-to-speech and communication devices [45], overlooking AI-based scaffolds that target higher-order reasoning. While some studies confirm that AI enhances deep learning [46], they remain focused on neurotypical learners.

Two critical gaps emerge from the existing literature. First, little attention has been given to how students with mild intellectual disabilities (MID) can be supported in formulating research topics, despite the centrality of this skill to their academic development.

Second, although recent studies highlight the potential of artificial intelligence (AI) in enhancing learning among general student populations, none have explicitly examined the effect of AI-scaffolded planning tools on research question formulation for students with MID. Existing research remains primarily focused on neurotypical students in higher education, leaving a significant void in understanding how AI innovations can be adapted to promote equity and accessibility for marginalized learners. This gap is particularly pressing in an era where AI is rapidly integrated into education, raising questions about inclusivity and technological fairness.

The present study seeks to examine the effect of AI-scaffolded planning tools on research question formulation among students with MID. By focusing on this underrepresented population, the study addresses two gaps: the lack of disability-inclusive research in higher education and the limited application of AI to academic skill development. The findings have the potential to generate empirical evidence on how AI tools can support cognitively diverse learners, contributing to the broader discourse on inclusive education, equity in technology use, and the democratization of research opportunities. In doing so, the study positions AI as a potentially transformative intervention for overcoming the challenges that students with MID face in generating meaningful and researchable questions.

Research Questions

i. What is the effect of AI-scaffolded planning tools on research topic formulation among students with mild intellectual disabilities?

ii. What is the interactive effect of school type and AI-scaffolded planning tools on research topic formulation among students with mild intellectual disabilities?

iii. What is the interactive effect of gender and AI-scaffolded planning tools on research topic formulation among students with mild intellectual disabilities?

METHODOLOGY

The study employed a pretest–posttest randomized controlled trial design, which is appropriate for establishing causal relationships while minimizing confounding effects. Two groups were used: an experimental group that received support from an AI-based planning tool, which offered step-by-step prompts, examples, and feedback, and a control group that received standard teacher guidance without AI support.

The population consisted of 187 students with MID enrolled in special or inclusive education programs in Cross River State. All participants had been diagnosed with MID through standardized psychological assessments, were in their third year of study, had completed a research methods course, and possessed basic computer literacy. Students with severe intellectual or sensory impairments were excluded from the study.

A multistage sampling procedure was adopted. First, schools offering programs for students with MID were purposively selected. Second, eligible classes were identified. Third, students were listed, and 50% of the population (94 students) was selected through simple random sampling. Participants were randomly assigned to the experimental group (n = 48) and the control group (n = 46) using a computer-generated sequence in SPSS. Randomization was conducted by a research assistant not involved in delivering the intervention to minimize bias.

Instrumentation

The instrument used in this study was a structured questionnaire known as the Research Topic Formulation Scale (RTFS), specifically designed to evaluate students' ability to generate quality research topics following their participation in the intervention. The RTFS comprised three sections with distinct purposes. The first section collected demographic information from respondents, including age (divided into three categories: below 12 years, 12–16 years, and 16–18 years), gender (male or female), and school type (public or private). This section provided essential background information that enabled the categorization of participants and facilitated the analysis of potential performance differences across demographic subgroups.

The second section of the RTFS focused on capturing the treatment process of the study. Participants in the experimental group received scaffolds through an AI-based research planning tool, which offered step-by-step guidance, examples, and constructive feedback to assist them in generating research topics. This training lasted for eight weeks and engaged students in structured activities that

progressively enhanced their skills in formulating research topics. In contrast, the control group received only standard teacher guidance without the use of AI tools. The inclusion of this section was crucial in distinguishing the exposure of the two groups, thereby enabling the evaluation of the effectiveness of the AI-supported intervention compared to traditional methods.

The third section of the RTFS consisted of the Research Topic Quality Scale, which was adapted from [48] and designed to evaluate the essential elements of a good research topic, such as clarity, feasibility, focus, and alignment with research objectives. After completing the training, participants were required to formulate five original research topics, which were then independently evaluated by two trained assessors. The evaluators applied specific criteria, including clarity of expression, feasibility within available resources and timeframe, relevance to the subject area, and alignment with objectives. Responses in this section were measured using a four-point Likertscale ranging from 1 = Strongly Disagree to 4 = Strongly Agree. Example items included statements such as "*The topic is clearly expressed and easy to understand," "The topic can reasonably be completed within the available time and resources,""The topic is directly relevant to the subject area under consideration,"* and *"The topic demonstrates strong alignment with the stated objectives."*The Likert scale enabled a quantitative assessment of students' responses, providing insights into the varying degrees of topic quality. Modifications made to this section ensured that the items were age-appropriate and accessible to students with mild intellectual disabilities. Collectively, the RTFS served as a reliable tool for capturing both demographic data and the impact of the intervention on students' ability to produce quality research topics.

Validation

To establish the validity of the RTFS, the instrument underwent a rigorous content validation process using both the Item Content Validity Index (I-CVI) and the Scale Content Validity Index (S-CVI). A panel of five experts, including two specialists in educational measurement and evaluation, two in educational psychology, and one in research methodology, reviewed the draft instrument. They independently assessed the clarity, relevance, and appropriateness of each item using a four-point scale, ranging from 1 (not relevant) to 4 (highly appropriate). The I-CVI for each item was calculated as the proportion of experts who rated the item as 3 or 4, resulting in values between 0.80 and 1.00, which exceeded the recommended minimum of 0.78 for a panel of five experts. This indicated that all items met acceptable standards of relevance. The overall validity of the instrument, as measured by the S-CVI/Ave, was found to be 0.93, which surpasses the benchmark of 0.90 [41-44], typically considered excellent. This high index reflected strong expert consensus on the quality and representativeness of the items included in the scale.

Procedure for Data Collection

Before implementing the intervention, the study protocol was reviewed and approved by the Institutional Review Board (IRB) of the University of Calabar, Nigeria (IRB/UNICAL/2025/19822). Ethical clearance was granted after the study was confirmed to adhere to established principles of research ethics, including voluntary participation, confidentiality of responses, informed consent, and the assurance of no harm to the students. These ethical safeguards ensured that the study was conducted responsibly and in accordance with international research standards and guidelines.

Data collection was carried out in three stages: pre-test, treatment, and post-test. During the pre-test phase, participants in both the experimental and control groups were presented with educational issues, including classroom management, inclusive education practices, and the integration of technology in teaching. They were then instructed to generate two research topics each, which were later assessed using the RTFS to establish a baseline measure of their ability to formulate relevant and coherent research topics before the intervention.

During the treatment phase, the experimental group participated in an eight-week program that utilized AI-Scaffolded Planning Tools (AI-SPT). These included ChatGPT, which supported brainstorming, idea generation, and topic clarification; Elicit, which assisted with literature exploration, feasibility analysis, and evidence-based refinement; and Research Rabbit, which helped map connections between research ideas and strengthen alignment with research objectives. Under the close guidance of a facilitator, students in this group engaged in scaffolded practice that systematically built their capacity to refine and structure research topics. The control group, on the other hand, continued with their regular classroom activities without exposure to AI-based tools.

At the post-test stage, both groups were again presented with the same educational problems from the pre-test, but were required to generate five research topics each. These topics were evaluated independently by trained assessors using the RTFS, applying the same criteria of clarity, feasibility, focus, and alignment with objectives. This final phase of data collection enabled a systematic comparison of the two groups, ensuring that any observed improvements in the experimental group could be attributed to the AI-Scaffolded Planning Tools, thereby establishing their efficacy in enhancing research topic formulation skills among students with mild intellectual disabilities.

Procedure for Data Analysis

The data gathered for the study were analyzed using a combination of descriptive and inferential statistics. Descriptive statistics, including mean scores and standard deviations, were first used to summarize how students performed on the Research Topic Formulation Scale (RTFS) at both the pre-test and post-test stages. This offered a clear picture of the general trends and variations in students' ability to formulate research topics across the experimental and control groups. For the inferential analysis, Analysis of Covariance (ANCOVA) was employed to examine the impact of the AI-scaffolded planning tools on students' topic formulation skills, while adjusting for any initial differences in pre-test scores. This approach provided a more accurate estimate of the intervention's effect by accounting for covariates and reducing error variance. To further interpret the results, effect sizes (partial eta squared, η^2) were calculated to indicate the strength of the intervention, and pairwise comparisons with the Bonferroni adjustment were conducted to pinpoint specific differences between groups at the post-test. All analyses were performed using SPSS version 27.0, with statistical significance set at $p < 0.05$. This careful analytical process ensured that the findings were not only statistically valid but also meaningful in answering the research questions.

RESULTS

Hypothesis One**:** There is no significant effect of AI-scaffolded planning tools on the formulation of research topics among students with mild intellectual disabilities.The descriptive results presented in Table **1** show that 91 students with mild intellectual disabilities participated in the study, with 46 assigned to the experimental group (AI-scaffolded planning tools) and 45 to the control group (no intervention). Posttest scores on research topic formulation revealed that students in the experimental group (n = 46) achieved a higher mean score (M = 13.96, SD = 1.94) compared to their counterparts in the control group (n = 45; M = 8.58, SD = 0.89). The overall sample mean across groups was 11.30 (SD = 3.10). This difference of approximately 5.38 points suggests that students who received AI-scaffolded planning support demonstrated substantially stronger performance in developing research topics.

Inferential statistics confirmed these observations. As shown in Table **1**, there was a statistically significant effect of group on posttest scores, $F(1, 88) = 235.67$, $p < .001$, partial $\eta^2 = .728$. This indicates that 72.8% of the variance in posttest scores was explained by the intervention, after accounting for pretest performance. The covariate (pretest) was not a significant predictor of posttest outcomes, $F(1, 88) = 0.20$, $p = .654$, partial $\eta^2 = .002$, suggesting that baseline differences did not influence the observed effect. The corrected model was statistically significant, $F(2, 88) = 141.75$, $p < .001$, with $R^2 = .763$ (adjusted $R^2 = .758$), meaning that

Table 1: Analysis of Covariance (ANCOVA) Result on the Effect of AI-Scaffolded Planning Tools on Research Topic Formulation

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	η^2
Corrected Model	658.568[a]	2	329.284	141.751	.000	.763
Intercept	238.841	1	238.841	102.817	.000	.539
Pre test	.470	1	.470	.202	.654	.002
group	547.464	1	547.464	235.674	.000	.728
Error	204.421	88	2.323			
Total	12476.000	91				
Corrected Total	862.989	90				
a. R Squared = .763 (Adjusted R Squared = .758)						

approximately 76% of the variance in students' ability to formulate research topics was explained by the model.

Hypothesis Two

There is no significant interactive effect of school type and AI-scaffolded planning tools on research topic formulation among students with mild intellectual disability. Descriptive statistics indicated that posttest performance differed across school type (public vs. private) and group (experimental vs. control). In the experimental group, students in public schools had a mean score of M = 13.50, SD = 2.08, n = 30, whereas those in private schools achieved slightly higher performance (M = 14.81, SD = 1.33, n = 16). Overall, the experimental group completed a mean of M = 13.96, SD = 1.94, n = 46, indicating that exposure to the AI-scaffolded planning tool improved students' posttest performance compared to the control group.

In the control group, students from public schools scored *a mean of* M = 8.29, *with a standard deviation of* SD = 0.95, and a sample size of n = 24. Those from private schools recorded a slightly higher mean of M = 8.90, *with a standard deviation of* SD = 0.70, *and a sample size of* n = 21. Collectively, the control group obtained a mean score of M = 8.58, SD = 0.89, n = 45. When performance was collapsed across groups, public school students had an overall mean of M = 11.19, SD = 3.10, n = 54, while private school students achieved *a mean of* M = 11.46, SD = 3.13, n = 37. The full sample (N = 91) yielded an overall mean posttest score of M = 11.30, SD = 3.10. These results indicate that students in the experimental condition consistently outperformed those in the control condition, regardless of school type. However, private school students tended to achieve slightly higher scores than their public school counterparts.

Inferential analysis (Table **2**; Figure **1**) showed significant main effects of both school type and group on posttest performance. Students from private schools significantly outperformed those from public schools, $F(1, 86) = 9.46$, $p = .003$, partial $\eta^2 = .099$, indicating that school type explained approximately 10% of the variance in scores. Similarly, students in the experimental group scored substantially higher than those in the control group, $F(1, 86) = 256.92$, $p < .001$, partial $\eta^2 = .749$, demonstrating a large effect of the intervention, which accounted for nearly 75% of the variance. However, the interaction between group and school type was not significant, $F(1, 86) = 1.06$, $p = .306$, partial $\eta^2 = .012$, suggesting that the positive effect of the AI-scaffolded planning tool was consistent across both public and private schools. Overall, the model explained 79% of the variability in students' posttest scores ($R^2 = .789$, adjusted $R^2 = .779$).

Hypothesis Three

There is no significant interactive effect of gender on the formulation of research topics among students with mild intellectual disabilities. As presented in Table **3**, participants in the experimental group demonstrated higher posttest scores compared to those in the control group. Specifically, males in the experimental group obtained a mean score of 14.07 (SD = 1.98, n = 27), while females had a slightly lower mean of 13.79 (SD = 1.93, n = 19), resulting in an overall mean of 13.96 (SD = 1.94, n = 46). Conversely, participants in the control group recorded considerably lower posttest scores,

Table 2: Analysis of Covariance (ANCOVA) Result on the Interactive School Type and Effect of AI-Scaffolded Planning Tools on Research Topic Formulation

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	η^2
Corrected Model	680.498[a]	4	170.124	80.172	.000	.789
Intercept	238.787	1	238.787	112.530	.000	.567
Pre-test	.214	1	.214	.101	.751	.001
Ggroup	545.180	1	545.180	256.919	.000	.749
Type	20.083	1	20.083	9.464	.003	.099
Group * Type	2.255	1	2.255	1.063	.306	.012
Error	182.491	86	2.122			
Total	12476.000	91				
Corrected Total	862.989	90				
a. R Squared = .789 (Adjusted R Squared = .779)						

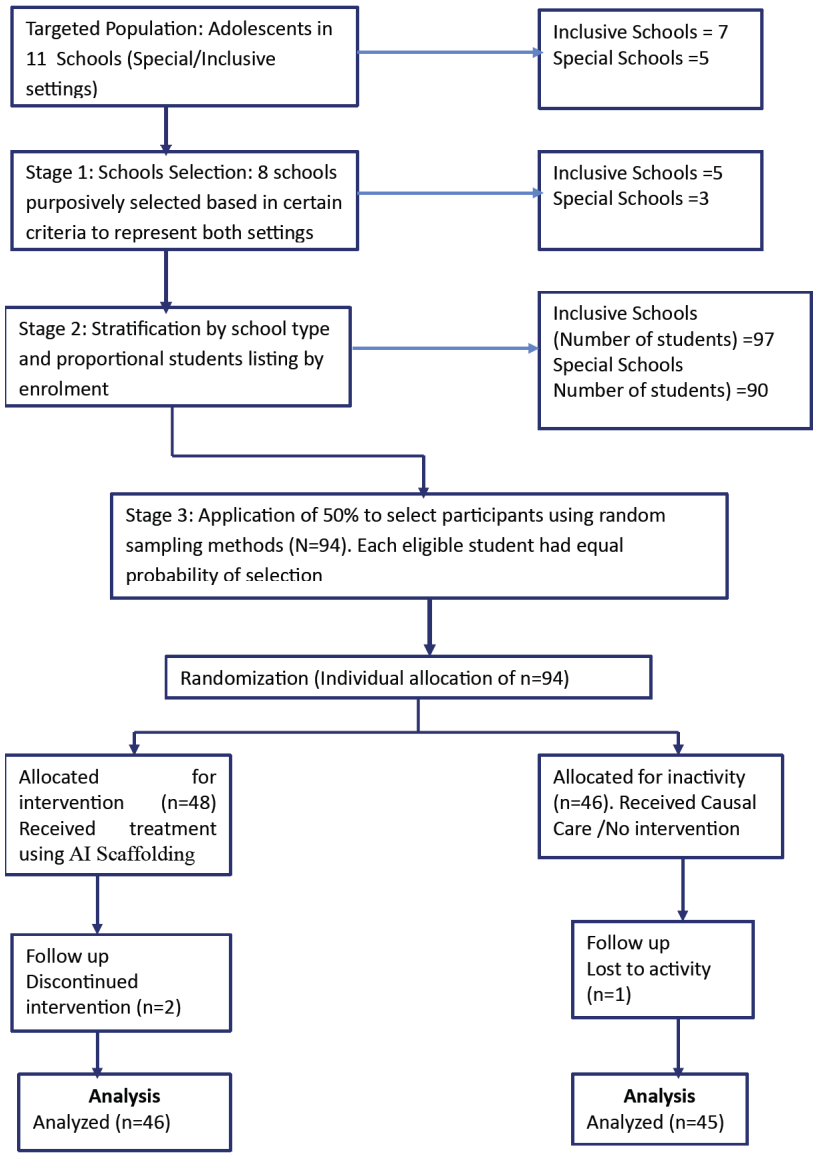

Figure 1: Consort flow diagram.

Table 3: Analysis of Covariance (ANCOVA) Result on the Interactive Gender and Effect of AI-Scaffolded Planning Tools on Research Topic Formulation

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	η^2
Corrected Model	659.390[a]	4	164.848	69.631	.000	.764
Intercept	238.434	1	238.434	100.714	.000	.539
Pre-test	.381	1	.381	.161	.689	.002
Group	539.429	1	539.429	227.854	.000	.726
Gender	.377	1	.377	.159	.691	.002
Group * Gender	.448	1	.448	.189	.665	.002
Error	203.599	86	2.367			
Total	12476.000	91				
Corrected Total	862.989	90				
a. R Squared = .764 (Adjusted R Squared = .753)						

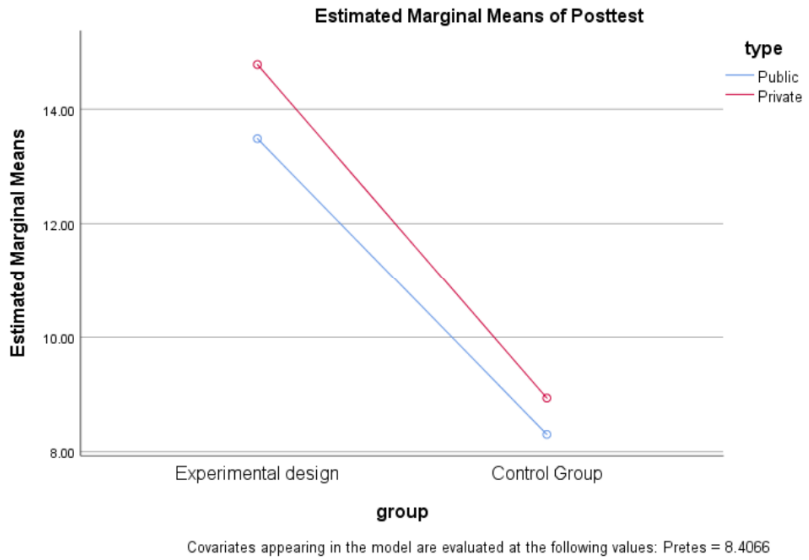

Figure 2: Estimated marginal means of posttest scores for public and private school students across experimental and control groups, controlling for pretest scores (covariate = 8.41).

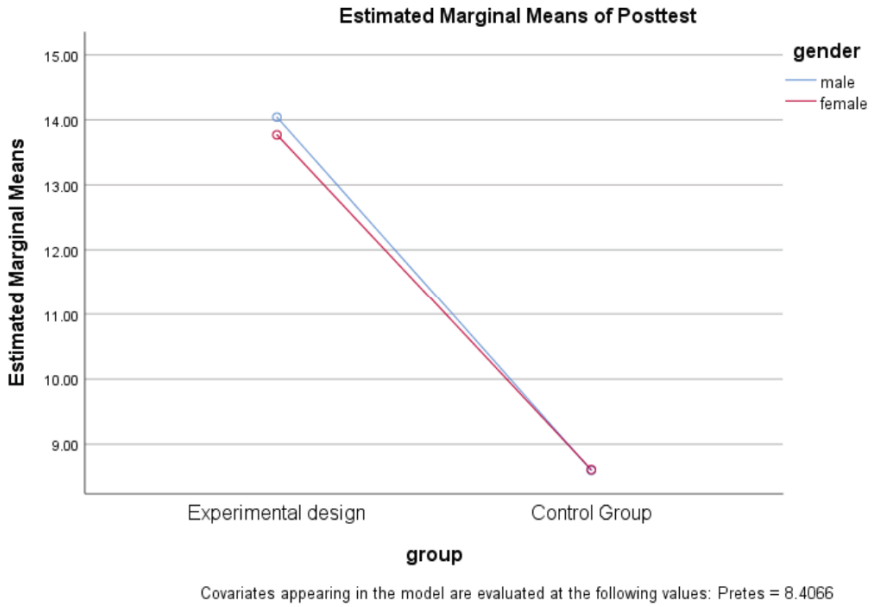

Figure 3: Interaction effect of gender and group on students' posttest scores (controlling for pretest scores).

with males scoring an average of 8.57 (SD = 0.79, n = 23) and females averaging 8.59 (SD = 1.01, n = 22), yielding a combined mean of 8.58 (SD = 0.89, n = 45). When scores were compared across groups, males attained a slightly higher overall mean (M = 11.54, SD = 3.17, n = 50) than females (M = 11.00, SD = 3.02, n = 41), although the combined group mean was 11.30 (SD = 3.10, n = 91). These results indicate that students exposed to the experimental condition consistently outperformed those in the control condition, with gender differences contributing only marginally to performance outcomes.

The inferential results presented in Table **3** and illustrated in Figure **2** confirmed a significant main effect of group on posttest scores after controlling for pretest scores, $F(1, 86) = 227.85$, $p < .001$, partial $\eta^2 = .726$. This demonstrates that participants in the experimental group performed significantly better than those in the control group, suggesting that the AI Scaffoldingintervention had a strong positive effect on outcomes. By contrast, neither the covariate (pretest) nor gender nor the interaction between group and gender yielded significant effects on posttest scores, $F(1, 86) = 0.16$, $p = .689$, partial $\eta^2 = .002$; $F(1, 86) = 0.16$, $p = .691$, partial $\eta^2 = .002$; and $F(1, 86) = 0.19$, p

= .665, partial η^2 = .002, respectively. The overall model was statistically significant, $F(4, 86) = 69.63$, $p < .001$, accounting for approximately 76% of the variance in posttest scores (R^2 = .764, adjusted R^2 = .753). Taken together, these findings confirm that the AI Scaffoldingintervention substantially enhances students' ability to formulate research topics, regardless of gender differences.

Discussion of Findings

The study showed that students who used the AI-scaffolded planning tool performed significantly better than those in the control group when it came to formulating research topics. This improvement can be attributed to the tool's structured support, which makes complex academic tasks more manageable for learners with mild intellectual disabilities. By breaking the process into smaller, ordered steps, the tool reduces mental strain and helps students focus on the most critical parts of the task. This approach reflects Vygotsky's concept of the zone of proximal development, which stresses that guided assistance enables learners to achieve outcomes they could not accomplish independently [32]. In addition, the AI tool provided personalized feedback and adaptive prompts that responded to individual needs, helping students develop persistence and self-regulation [33]. These results align with previous research, which has shown that AI-supported learning environments enhance performance, critical thinking, and problem-solving among students with learning difficulties [35]. Beyond the educational outcomes, these improvements have essential clinical and psychosocial implications: reduced cognitive overload is associated with lower anxiety, while increased persistence and self-regulation are key predictors of emotional resilience and adaptive behavior among students with intellectual disabilities**.** Beyond improving skills, the tool also built students' confidence in handling research tasks, which is essential for sustaining motivation and developing long-term academic competence. Confidence in educational contexts is not merely motivational but also clinically significant, as higher academic self-efficacy has been linked to improved self-esteem, reduced risk of depressive symptoms, and stronger social adjustment in individuals with intellectual disabilities**.** Taken together, the findings suggest that AI-based scaffolding can serve as a valuable strategy in inclusive education, reducing barriers and offering fairer opportunities for students with different cognitive abilities. At the same time, these findings demonstrate how educational technology can contribute to clinically and psychologically robust developmental outcomes, thereby bridging academic competence with broader psychosocial well-being.

The results also indicated that students with mild intellectual disabilities in private schools generally performed better than their peers in public schools. This advantage may stem from the more supportive learning conditions that private schools tend to provide—such as smaller class sizes, greater access to learning resources, and individualized instruction. The presence of trained teachers who use tailored strategies, combined with stronger parental involvement, likely further enhances students' ability to formulate research topics. These findings are consistent with previous studies that have highlighted the importance of resources, teacher expertise, and school culture in shaping the success of students with disabilities [39, 40]. From a psychosocial developmental perspective, such supportive environments also foster stronger peer relationships, greater emotional security, and healthier identity formation, which are critical for long-term adjustment among students with intellectual disabilities. The better outcomes in private schools, therefore, reflect environmental and structural advantages rather than differences in students' inherent ability. This highlights the urgent need for policymakers to strengthen public schools through increased resources, specialized teacher training, and inclusive teaching practices, ensuring that learners with disabilities receive equitable support. In doing so, public education can better promote not only academic competence but also the clinical and psychosocial resilience necessary for successful integration into society.

Interestingly, the analysis revealed no significant interaction between school type and the use of AI-scaffolded planning tools. In other words, the effectiveness of the AI intervention remained consistent whether students attended public or private schools. This consistency may be due to the individualized, adaptive nature of the AI tool, which provides tailored guidance that helps balance out disparities in resources or teacher expertise across schools. As previous studies have argued [40], AI-driven technologies can minimize educational inequalities by offering learning pathways that focus on individual needs rather than institutional differences. This suggests that AI-based scaffolding may serve as a compensatory mechanism, offering structured support that mitigates the psychosocial risks commonly

associated with under-resourced educational settings, such as increased stress and diminished self-worth. This suggests that once implemented, AI tools can "level the playing field," ensuring that both public and private school students benefit equally in developing research skills. Such equity is not only educationally valuable but also developmentally protective, fostering psychological stability and social inclusion regardless of school context.

The study further revealed no significant differences between male and female students in their ability to formulate research topics, nor any interaction between gender and the AI intervention. This finding suggests that gender does not substantially influence performance in this context, particularly when adequate instructional support is available. The uniform scaffolding provided by the AI tool benefits both male and female students equally by offering consistent prompts, feedback, and guidance. These results align with earlier studies that report minimal gender differences in special education outcomes when structured support is present [41]. The absence of gender effects reinforces the idea that well-designed AI tools promote equity by focusing on learners' needs rather than demographic factors, creating a more balanced learning environment for students with mild intellectual disabilities. From a psychosocial viewpoint, this finding is significant: equitable outcomes across gender indicate that both male and female students can experience similar improvements in academic self-efficacy, emotional resilience, and social participation, which are vital components of holistic developmental growth.

Limitations of the Study

This study has several limitations that should be taken into consideration. The research involved only students with mild intellectual disabilities, limiting the extent to which the findings can be generalized to individuals with more severe impairments or other learning difficulties. Future research should therefore explore the applicability of AI-scaffolded planning tools across a broader range of cognitive profiles. Data collection relied mainly on self-report questionnaires, which may have introduced response biases since some participants could face challenges in accurately expressing their thoughts or emotions. Although the instruments were simplified, incorporating observational or mixed methods might have yielded deeper insights. Moreover, while improvements were noted in research question formulation and academic self-efficacy, the study did not assess related clinical or psychosocial outcomes such as reduced anxiety, enhanced adaptive behavior, or social inclusion. Finally, the sample was drawn from a small number of schools, which limits external validity; however, the findings remain an essential contribution.

CONCLUSION

The study found that AI-scaffolded planning tools significantly enhanced research topic formulation among students with mild intellectual disability, underscoring the potential of digital scaffolding to foster higher-order academic skills in learners who face cognitive and instructional barriers. Students in private schools outperformed those in public schools, likely reflecting differences in resources and instructional support. Gender did not affect performance, and no interaction effects were found among school type, gender, and the use of AI-scaffolded tools. Overall, while school context influenced outcomes, the consistent effectiveness of AI scaffolding highlights its capacity to provide equitable academic support across diverse groups.

IMPLICATIONS OF THE FINDINGS

The findings of this study have both theoretical and practical implications. Theoretically, they reinforce Vygotsky's sociocultural theory, particularly the role of scaffolding within the zone of proximal development, by demonstrating that AI-driven supports can extend the academic capabilities of students with mild intellectual disability. The significant effect of AI-scaffolded planning tools illustrates how technology can serve as a mediator, enabling learners to accomplish tasks they may not achieve independently. The absence of gender differences aligns further with the principles of inclusive education, indicating that learning outcomes depend more on access to appropriate instructional support than on demographic factors.

Practically, the study emphasizes the importance of integrating AI-based scaffolding tools into instructional practices to improve the academic performance of students with mild intellectual disabilities. The superior performance of private school students underscores systemic disparities in resources, teacher training, and infrastructure, which must be addressed to promote equity. Providing public schools with adequate facilities and professional development can help close this gap. Moreover, the gender-neutral effects suggest that AI-

based interventions are broadly applicable, making them practical tools for fostering inclusivity and ensuring equitable learning opportunities for all students.

RECOMMENDATIONS

Based on the findings of this study, several recommendations are advanced to strengthen educational practice and inform policy.First, education policymakers should prioritize the systematic integration of AI-scaffolded learning tools into curricula across both mainstream and special education contexts. Such integration will provide students with mild intellectual disabilities with broader access to technology-driven supports in critical academic tasks such as research topic formulation.

Second, there is a pressing need to enhance resources in public schools. Governments and stakeholders must deliberately invest in adequate infrastructure, digital devices, and reliable internet connectivity to support the development of digital technologies. Addressing these deficiencies will help bridge the resource gap between public and private schools, thereby reducing inequalities that currently disadvantage students in public institutions.

Third, teacher capacity building must be emphasized. Continuous professional development programs should be implemented to equip teachers with the pedagogical and technical skills necessary to adopt and utilize AI-driven learning technologies effectively. Well-trained educators are better positioned to maximize the benefits of these tools and to adapt them to the diverse needs of students with mild intellectual disabilities.

Ultimately, the gender-neutral outcomes observed in this study highlight the potential of AI-based interventions to promote inclusive education. Schools should adopt these tools universally to encourage equity, ensuring that both male and female students benefit equally. Moreover, future research should employ longitudinal designs to investigate the long-term effects of AI scaffolding on both academic achievement and the development of transferable life skills across diverse school contexts.

CONFLICT OF INTEREST

The author(s) affirm that there are no conflicts of interest associated with the publication of this manuscript. The research was conducted with objectivity, and no financial, professional, or personal affiliations existed that could have biased the findings or interpretations in any way.

INFORMED CONSENT

Informed consent was obtained from all participants who participated in the study. Participants were adequately informed about the research objectives, assured of the confidentiality of their responses, and reminded of their right to withdraw from the study at any stage without facing any penalty. All procedures followed adhered to the ethical standards of relevant institutional or national research committees, in line with the 1964 Helsinki Declaration and its subsequent revisions.

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CONSENT TO PARTICIPATE

Participants voluntarily agreed to take part in the study, and their participation was based on informed decision-making. They were informed of their right to withdraw at any time without any consequences.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are not publicly available due to confidentiality agreements and ethical considerations related to participant privacy. However, anonymized data may be made available from the corresponding author upon reasonable request and with appropriate institutional approvals.

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