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Inquiry-based learning as an approach to tertiary mathematics instruction

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ABSTRACT

The study aimed to determine the effectiveness of inquiry-based learning (IBL) as a method of instruction for college mathematics by employing a quasi-experimental methodology with a pretest-posttest design, where two groups of students were randomly selected as the control and experimental groups. There were thirty students in each group. The control group was taught via traditional lecture-based instruction, while the experimental group was taught through the IBL approach. The study took place at a community college in Cebu, Philippines. Validated researcher-made pretest-posttest questionnaires were employed in the study. The study's findings indicated that the control and experimental groups initially performed below average in the pretest but demonstrated average performance in the posttest. Both groups showed a significant improvement in their performance from pretest to posttest. These outcomes provided empirical support for Joseph Schwab's IBL model and Siegfried Engelmann's direct instruction theory, respectively. The performance of the control and experimental groups was comparable, suggesting that IBL is equally effective as the lecture-based approach in enhancing students' mathematics performance. The results of the study further suggest that incorporating IBL alongside the conventional lecture method when teaching tertiary mathematics enhances the academic performance of students.

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1. INTRODUCTION

One of the educational systems' most important needs is searching for useful and effective methods for instructing and learning through research and investigation. Mathematics instructors must decide on the most effective strategy or approach for teaching the subject. The approach must resolve the gap in mathematical knowledge, as reflected in the outcomes of international assessments such as the Program for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS). Selecting an effective approach is crucial for creating a dynamic and engaging learning process [1]. Students increase their understanding of the lessons taught when a dynamic and effective learning approach is used [2]. For students to independently expand their knowledge based on new information, the learning method must allow them to examine and explore the information [3]. Although the traditional lecture-based approach remains a common teaching method in higher education, student-centered instruction is found to be more effective in increasing learning [4]. This study advocates for the perspective that teachers should encourage students to use self-regulated learning and inquiry methods to explore and uncover patterns, formulas, and concepts. It is also expected that students participate actively in the process to ensure understanding and appreciation of mathematical concepts.

Within the realm of education, inquiry serves as a structured approach that fosters the active involvement of students. Inquiry-based learning (IBL) stands out as an instructional technique designed to promote dynamic and engaged learning experiences [5]. Instead of concentrating on finding the ideal solution, it emphasizes the process of learning via observation and inquiry. Inquiry denotes careful and critical thought, and its implementation in laboratory settings has been associated with enhanced comprehension of scientific knowledge, heightened confidence in applying scientific principles, and more positive student attitudes toward science [6]. The primary tenet of IBL aligns with constructivist learning theory [5], [7]. It operates based on principles and approaches that emphasize a focus on learners, knowledge acquisition, continuous assessment, and community engagement.

Students often struggle with mathematics due to the complex processes involved in solving problems, particularly in understanding concepts and formulas. Research indicates that students' difficulties with mathematics are often linked to the use of the traditional lecture method [8]–[10]. The conventional lecture method may lead students to miss and grasp integral parts of mathematical concepts, hindering their ability to fully learn topics and answer related problems. The IBL approach instills in students a sense of responsibility for their own learning, motivating them to exert greater effort and cultivate advanced, independent, and self-assured research skills, ultimately leading to successful outcomes [11]. Students engage in a meaningful, inquiry-driven process to address mathematical problems, involving activities such as hypothesis testing, investigation, and experimentation [12]. Through this kind of instruction, students are given real-world experiences within a traditional classroom setting.

IBL contrasts with traditional teaching methods by emphasizing students' active participation. As the teacher transitions from being a lesson instructor to a facilitator of problem-solving, students evolve from passive listeners to engaged explorers in an active learning environment. The rise of the Internet has also made knowledge more accessible, further enhancing the effectiveness of IBL [13]. Research suggests that IBL is commonly perceived as more authentic for students as it grants them the autonomy to make decisions about their learning, fostering critical thinking skills and deeper learning experiences [14]. IBL encourages students to learn "Through guided and increasingly independent investigation of complex questions, problems, and situations, frequently for which there is no single answer". Knowledge emerges through social construction, and learning occurs when people participate in communities of practice.

Studies on inquiry-learning initiatives suggest that students can develop relational understanding using this strategy. Students have demonstrated improvements in their capacity to apply their mathematical knowledge to various settings and solve challenging problems when inquiry-based approaches are used in instruction. It has been shown that students taught using IBL techniques demonstrate better ability to apply their knowledge to new problems while still maintaining their capacity to perform well on tests [15]. IBL involves changes to the teacher-student relationship, requiring students to bear greater responsibility for their learning. Teachers, in turn, must guide and exemplify the learning process for students while providing intentional support and scaffolding throughout different stages of inquiry [14]. Unlike discovery learning, which lacks guided instruction, IBL ensures structured guidance that enhances learning outcomes [16].

Regarding academic performance, multiple studies indicate that engagement in IBL significantly enhances students' academic progress. IBL fosters active student involvement in scientific discovery, connecting mathematics to real-world issues. Ensuring student success and achievement requires a thorough comprehension and application of mathematical concepts within the IBL framework [17]. In an investigation employing IBL for teaching mathematics in early childhood, findings revealed that introducing this method early establishes a strong foundation for students. Participants reported improved student involvement and the development of solid mathematical skills [18]. Classrooms incorporating IBL reported a distinct and recognized improvement in student achievement in mathematics. Teachers and administrators' express confidence in IBL's potential benefits for math students, anticipating positive outcomes and success.

IBL not only enhances critical thinking skills but also improves students' success in the sciences, as demonstrated by various studies [19]–[22]. Aytaç and Kula [23], assert that the impact of IBL on students' achievement surpasses that of process skills and attitude toward science. The implementation of IBL is directly and positively correlated with students' academic success. However, its effectiveness depends on the teacher and the manner in which it is implemented. Planning and developing IBL lessons require significant time and effort, and resources may be scarce. However, these efforts are worthwhile, as IBL allows students to experience first-hand learning, make direct connections, and gain a deeper understanding, all of which enhance academic performance, retention, and recall [24]. Contextualizing learning outcomes through IBL has shown a significant positive association with student achievement in mathematics and science [20]. This instructional approach engages students in meaningful, authentic, analytical, logical, and critical tasks [25]. However, IBL is not a universal, one-size-fits-all method. Teachers must adapt IBL to their students' unique characteristics to optimize learning outcomes.

Despite its benefits, IBL is less commonly used in higher education institutions compared to general education schools, where it is frequently applied in science and math classes [26]. Some studies indicate that IBL does not always yield significantly better performance in mathematics. Chengay's [27], findings showed that the improvement in mathematics performance after inquiry-based instruction was not statistically significant, preventing the assertion that IBL is more effective than traditional methods. Furthermore, some research suggests that IBL has minimal impact on student enjoyment and lacks statistical significance in positively influencing academic achievement [28].

This study seeks to examine the effectiveness of IBL in mathematics instruction at the college level, particularly in a community college setting. The study aims to verify whether similar results from previous research can be expected. The following research questions guided this study; i) Is there a significant mean gain in mathematics performance from the pretest to the posttest of the students in the control and experimental groups? ii) Is there a significant difference in the mean gains in mathematics performance between the control and experimental groups? and iii) What insights and feedback do students in the experimental group have regarding their experience with IBL?

This research is important because it offers empirical proof on the effectiveness of IBL in a tertiary mathematics setting, particularly in a community college in the Philippines. By evaluating its impact on students' performance and attitudes, this study adds to the expanding literature on student-centered instructional approaches in higher education. This study is novel in its application of IBL in discrete mathematics and its examination of IBL's effectiveness within a community college environment, offering insights into its potential scalability and adaptability for similar institutions.

2. METHOD

A quasi-experimental method was used in determining the effectiveness of IBL in tertiary level mathematics instruction. The study used the pretest-posttest design in particular. The impact of the intervention was evaluated using the independent samples t-test, to assess the difference in mean gains from pretest to posttest scores between the experimental and control groups.

2.1. Participants

This study was conducted to first-year college students from a community college in Cebu, Philippines who were taking up discrete mathematics during the second semester of the academic year 2022-2023. A total of 192 students were distributed into six heterogeneous sets, were enrolled in the said course. Using cluster sampling, two sets were randomly selected as the control and experimental groups, resulting in a total sample of 60 students (30 per group). The remaining 132 students were not included as they belonged to sections not selected in the sampling process. The sample size of 60 is supported by Cohen's [29] guidelines, which suggest that for a moderate effect size (d=0.50), a significance level of 0.05, and a power of 0.80, approximately 64 participants are required for independent t-tests. This indicates that the selected sample is close to the recommended size for detecting significant effects in experimental research.

2.2. Research instrument

The research employed validated test questionnaires developed by the researchers for both the pretest and posttest phases. These questionnaires consist of multiple-choice questions to ensure objectivity. The validation process involved at least three teachers with master's degrees or a minimum of five years of experience in teaching mathematics. After the validation, the questionnaires underwent pilot testing. To ensure that the questionnaires are highly reliable for use in the actual pretest and posttest, the data obtained from the pilot test underwent analysis through a split-half reliability test. The pretest and posttest questionnaires were found to have a reliability score of 0.881 and 0.901, respectively. These coefficients, which are higher than the passing base (0.7) for instrument reliability, mean that the questionnaires have high reliable values. The data collected from the pilot testing were also used to make an item analysis and determine the difficulty index and index of discrimination of the questions included in the instrument. Lastly, a final revision was made to validate each item and ensure the overall validity of the research instrument.

2.3. Ethical considerations

The research ethics checklist for investigations involving human participants obtained from the University of the Philippines Research Ethics Committee was completed first. A letter was written and sent to the research environment after the checklist had been accepted. Once approved, an Assent Form outlining the study's objectives, data collection procedures, confidentiality measures, participation expectations, withdrawal process, and the researchers' contact information was provided to the respondents.

2.4. Pedagogical approach

In this study, two pedagogies were used to teach the selected topics in mathematics. The experimental group received instruction through materials based on IBL. In contrast, the control group was taught using the traditional or lecture method.

2.4.1. Control group

As shown in Figure 1, before the commencement of the experiment, the control group underwent a pretest utilizing a validated questionnaire created by the researchers. Relations and functions, which are topics in mathematics, were discussed in a face-to-face setup via the traditional lecture method. After all the lessons were discussed, the students took the posttest.

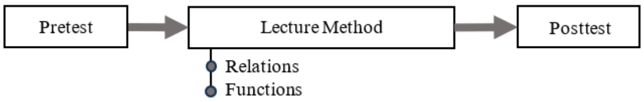

Figure 1. Control group flow diagram

2.4.2. Experimental group

The same as the control group, this group took the pretest before the experimental intervention was implemented. The group was instructed and taught the same selected mathematics topics through the use of the IBL approach and IBL instructional materials. The instructor's role involved facilitating the IBL approach, providing the IBL instructional materials for the selected topics, and assisting the students by clarifying questions they may have along the process. After the topics were covered, the students took the posttest. A focus group discussion (FGD) was carried out to collect insights from students who were exposed to IBL. This progression is shown in Figure 2.

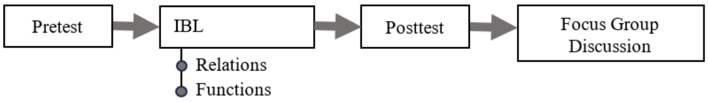

Figure 2. Experimental group flow diagram

2.5. Data analysis

Various statistical tools were utilized to analyze the collected data. To compare the pretest and posttest performance of both the control and experimental groups against a hypothetical mean, a one-sample t-test was performed. The mean improvement from pretest to posttest within each group was assessed using a paired-sample t-test. An independent-samples t-test was used to investigate the difference in mean improvement between the control and experimental groups. Furthermore, thematic analysis was employed to examine the FGD responses and uncover patterns in students' perspectives on IBL.

3. RESULTS AND DISCUSSION

3.1. Level of performance of the students in mathematics

The control and experimental groups underwent pretests and posttests to assess their performance in mathematics. Table 1 and Table 2 provide a detailed summary of the corresponding performance results for the pretest and posttest, respectively. These tables provide a detailed comparison of the performance before and after instruction was given to the control and experimental groups.

Table 1 illustrates the pretest performance levels of first-year students in mathematics. As indicated in the Table 1, both groups exhibit actual means considerably below the hypothetical mean (hypothetical mean=50%), representing the school's passing standard. The observed mean of 10.13 (standard deviation=3.44) for the control group and 10.33 (standard deviation=2.97) for the experimental group is notably lower than the hypothetical mean, indicating a significant difference. The calculated t-values of -7.754 ($p<0.001$) for the control group and -8.612 ($p<0.001$) for the experimental group both fall below the significance level. The results show that the observed and hypothetical means differ significantly in the pretest performance of both groups. Consequently, it can be inferred that students in both groups exhibit performance levels below the school's passing standard, which is set at 50% of the perfect score.

Table 1. Pretest performance level of the students in mathematics

Group	n	HM	AM	S_d	Computed t	p-value	Description
Control	30	15	10.13	3.44	-7.754	<.001	Below average
Experimental	30	15	10.33	2.97	-8.612	<.001	Below average

Note: HM=hypothetical mean, AM=actual mean, and S_d=standard deviation.

The pretest results of both the control and experimental groups were below average since their mean scores were lower than the passing standard (hypothetical mean=50%). The outcomes of the pretest suggest that the students may possess minimal or no understanding of relations and functions. This outcome could be attributed to the topics not having been covered or discussed at that point in the instructional process.

The results from the pretest further indicate that, before the teaching intervention, the mathematics knowledge levels of students in both the control and experimental groups were similar. This comparability of pretest performance corresponds to the pretest results of several similar studies [5], [30], [31]. In quasi-experimental pretest-posttest studies, interpreting differences in test scores at the conclusion becomes challenging if there are initial group disparities [32]. In this case, the control and experimental groups were regarded as suitable for comparative study.

Table 2 shows the posttest performance level of the first-year students in mathematics. As shown, the control group achieved an actual mean of 17.57 (standard deviation=3.97) which is slightly higher than the hypothetical mean. On the other hand, the experimental group had an actual mean of 19.03 (standard deviation=3.21) which is higher than the hypothetical mean. Thus, the posttest performances of both groups were mathematically higher than the hypothetical mean. The calculated t-values for the control and experimental groups were 3.546 and 6.876, respectively, with both results demonstrating statistical significance ($p \leq 0.001$); the p-values, which are lesser than the significance level, revealed that a statistically significant difference exists between the observed and hypothetical means in the posttest performance of both groups. The results may imply that the posttest performances on relations and functions of both control and experimental groups were statistically higher than the hypothetical mean.

Table 2. Posttest performance level of the students in mathematics

Group	n	HM	AM	S_d	Computed t	p-value	Description
Control	30	15	17.57	3.97	3.546	<.001	Above average
Experimental	30	15	19.03	3.21	6.876	<.001	Above average

Note: HM=hypothetical mean, AM=actual mean, and S_d=standard deviation.

The comparably improved performance of both control and experimental groups in the posttest could be attributed to the acquisition of more knowledge by the students after the conventional lecture and the inquiry-based instruction were given to present the topics, respectively. The control group's average performance in the posttest may be ascribed to the traditional lecture method, which is based on direct instruction [33]. In many college courses, lecture is still the main method of instruction [34]. One of the advantages of the lecture method is that it is useful in tertiary setup [35]. This method is found to be effective when an ample number of examples are provided and teaching aids are used. On the other hand, the above average performance in the posttest by the experimental group can be credited to the implementation of IBL instruction. The utilization of the inquiry-based teaching method fosters conceptual understanding and boosts students' academic performance [36]. This supports the study of Ogumah *et al*. [37], wherein their findings stated that IBL is an approach that can enhance students' academic achievements. Overall, these findings suggest that both the control and experimental groups met the 50% passing standard of the school in the posttest performance. This implies that through both traditional lecture and inquiry-based instructions, students were able to acquire a substantial increase in knowledge on the subject matter.

3.2. Mean improvement in students' scores from pretest to posttest

The mean improvement of first-year students' mathematics performance from pretest to posttest is shown in Table 3. As shown, there is a mean improvement of 7.44 from the pretest to posttest for the control group and a mean improvement of 8.70 from the pretest to posttest for the experimental group. The t-statistics were computed to be -12.008 ($p<0.001$) for the control group, and -13.023 ($p<0.001$) for the experimental group.

Table 3. The pretest-posttest performance of the students in mathematics

Group	n	Pretest mean	Posttest mean	Mean difference	Computed t	p-value
Control	30	10.13	17.57	7.44	-12.008	<.001
Experimental	30	10.33	19.03	8.70	-13.023	<.001

In both groups, the data reveals a statistically significant difference in the pretest and posttest performance of first-year students, leading to the rejection of HO1. This indicates that both the control and experimental groups demonstrated improvements in their mathematics performance. These outcomes may be attributed to the increased knowledge acquired by students following exposure to the topics. The overall mean improvements of the control and experimental groups indicate that utilizing traditional lecture and inquiry-based approaches effectively improved the test performance of first-year students in mathematics.

The significant improvement in performance observed in the control group, from the pretest to posttest, may be attributed to factors like active listening, note-taking, direct instruction, interaction, and clarification, which were present during the lectures. With the use of the traditional lecture method, the students in the control group actively engaged in listening to the instructor and taking notes which helped reinforce learning and retention. The traditional lecture method allowed the students in the control group to seek further explanations, or request additional examples. This helped them overcome difficulties and clarify misconceptions. The results further show that direct instruction helps students build a solid foundation of understanding, especially for fundamental mathematical principles.

The significant improvement in performance within the experimental group can be credited to students' active engagement in the learning process, specifically with the utilization of an inquiry-based approach and IBL materials to comprehend mathematical topics and concepts. The implementation of IBL proved instrumental in the experimental group as it facilitated the active participation of students in group discussions, aiding them in constructing a deeper understanding. This aligns with the research by Yeboah and Siaw [36], emphasizing that the inquiry-based approach enables students to build new concepts by leveraging their existing knowledge, experiences, observations, and ideas. The present study's findings are consistent with prior research, including studies by Ogumah *et al.* [37] and Khasawneh *et al.* [5], which demonstrated that the use of the IBL approach enhances students' performance. Additionally, the results highlight that incorporating hands-on IBL activities positively influenced students' comprehension of mathematics.

3.3. Comparison of the mean gains between the control and experimental groups

An independent samples t-test was conducted to assess the difference in mean gains between the control and experimental groups. As shown in Table 4, the mean gain of the control group, who were taught using the traditional lecture method, was 7.43 (standard deviation=3.390), while the mean gain of the experimental group, who were instructed using the inquiry-based approach, was 8.70 (standard deviation=3.660). These results indicate that the experimental group achieved a mathematically higher mean gain in mathematics compared to the control group. However, the mean gain difference between their performance is statistically not significant, t=1.391 (p=0.170); thus, HO2 is accepted. This means that both the control and experimental groups had a comparable performance in mathematics. This further shows that the use of the traditional lecture method and inquiry-based approach in teaching mathematics had a comparable effect on the performance of the students.

Table 4. The mean gain difference of the students

Group	n	Mean gain	S_d	Mean difference	Computed t	p-value
Control	30	7.43	3.390	1.26	1.391	0.170
Experimental	30	8.70	3.660			

Note: S_d=standard deviation.

The comparable mean gains in the performance of both control and experimental groups underscore the idea that the traditional lecture method and the inquiry-based approach yielded similar performance outcomes. This result supported the study of Chengay [27], wherein his findings revealed that the substantial improvement in mathematics performance after inquiry-based instruction, as compared to the performance outcome after traditional instruction, is not statistically significant to assert that inquiry-based mathematics instruction proved more effective than traditional mathematics instruction. Similarly, as stated by Frezell [28], IBL exhibits minimal to no impact on student enjoyment and is not statistically significant in positively influencing students' academic outcomes. Although the difference between the mean gains of the performances of the control and experimental group is not statistically significant, the slightly higher mean gain of the experimental group compared to that of the control group might still be meaningful in some contexts.

3.4. Students' insights and feedback toward IBL as a method of instruction

A FGD was facilitated to collect more information and better understand the IBL experience of the students in the experimental group. Their insights and feedback regarding the use of IBL were gathered and analyzed. After performing a thematic analysis, four themes were identified based on the students' responses: engagement and active learning, critical thinking and problem-solving, autonomy, and support and guidance.

3.4.1. Engagement and active learning

Students agreed that IBL emphasizes engagement and active learning. One student voiced out that her experience with IBL made her feel like an active contributor of learning and not just a passive recipient of information. Students also expressed how more immersed in mathematical concepts and engaged in discussions with classmates they were with the IBL instruction. The IBL approach encouraged them to participate actively instead of just sitting through lectures. This theme supports the claims of Prince & Felder on Khasawneh's [5] research stating that IBL, as a teaching strategy, encourages active learning.

3.4.2. Critical thinking and problem solving

The use of IBL in mathematics instruction encourages students to think critically and solve problems analytically [38]. Student participants mentioned that IBL allowed them to engage with mathematical concepts and find their own answers. They also agreed that the approach challenged them to think independently, ask questions, and approach problems with a creative mindset. One student responded that it was amusing how questions and asking the right questions led to the answer to the math problem. These statements are supported by the findings of Khasawneh *et al*. [5] and Khan [39], who affirmed that the utilization of IBL aims to cultivate learners with proficiency in critical thinking and problem-solving. Furthermore, it is the responsibility of the teacher to establish a conducive environment that fosters student motivation for curiosity, critical thinking, problem-solving, collaborative teamwork, effective communication, adaptability, and a commitment to lifelong learning [40].

3.4.3. Autonomy

In terms of autonomy, students agreed that the IBL approach to mathematics instruction had given them the freedom to explore the topics at their own pace. This approach fosters autonomy and individual engagement in students while improving their educational outcomes and motivating them to take charge of how they learn [41], [42]. IBL, alongside inquiry-based materials and activities, requires students to independently solve and investigate problems which consequently increases their skills and knowledge. According to Khalid [43], IBL and other student-directed learning strategies encourage students to develop into independent, self-directed learners. This supports the idea that allowing students to take charge of and lead their own learning makes them feel more independent and self-directed.

3.4.4. Support and guidance

Students expressed the importance of support and guidance when learning mathematics using the IBL approach. They felt comfortable knowing that the instructor was available to give clarification, answer questions and offer guidance when they encountered difficulties. Students also expressed that they had expected the instructor to provide the resources and assistance they needed during the IBL instruction. Nevertheless, in constructivist classrooms, teachers serve as guides by promoting and accepting student autonomy, and by fostering a pleasant environment for student expression [44].

4. CONCLUSION

Based on the results of the study, the use of IBL as an approach to mathematics instruction was proven to be comparable to the traditional lecture method. Results showed that both lecture-based and IBL approaches are effective in improving the performance of first-year college students in Mathematics. This is based on the significant mean gains from the pretest to posttest performance of both control and experimental groups. This significant improvement of the control group validates Siegfried Engelmann's direct instruction theory, wherein students learn from structured lessons, guided instructions, clear illustrations, explanations and examples. The significant improvement of the experimental group affirms the IBL model of Joseph Schwab, in which students can learn by investigating scenarios and problems, and through active engagement. Thus, a balance of teacher-directed instruction and student-centered IBL makes an effective approach to mathematics instruction. Furthermore, the study revealed that students exposed to IBL had favorable feedback towards the approach which is confirmed by their positive statements in the FGD. These results support Jean Piaget's constructivism theory, which states that students create their learning by linking their previous experiences with new ones. Therefore, when students actively participate in the teaching-learning process, their learning outcomes and attitudes toward the subject can be improved.

This study recommends that teachers incorporate IBL as a complement to direct instruction in teaching mathematics. It also suggests that school administrators organize and provide teachers with training workshops and seminars on planning and implementing the inquiry-based teaching approach to enhance their knowledge and skills in using guided inquiry to improve students' academic performance and interest. Furthermore, future researchers are encouraged to use a larger sample size from a different student population to gain a more comprehensive understanding of how IBL impacts various student groups. They should also consider extending the duration of the study to gather more extensive data and further evaluate the use of IBL in teaching mathematics. Additionally, incorporating the perspectives of teachers who regularly use inquiry-based instruction in their classrooms would offer valuable insights into the most effective applications and practical recommendations for this approach.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

DATA AVAILABILITY

The data that support the findings of this study are available on request from the corresponding author, [NTCJ]. The data, which contain information that could compromise the privacy of research participants, are not publicly available due to certain restrictions.

REFERENCES

[1] K. E. Omagwa, "Influence of practical approaches of teaching agriculture on academic performance in high schools in Kisii County, Kenya," Kisii University, 2022.

[2] L. Tetzlaff, F. Schmiedek, and G. Brod, "Developing personalized education: a dynamic framework," *Educational Psychology Review*, vol. 33, no. 3, pp. 863–882, Sep. 2021, doi: 10.1007/s10648-020-09570-w.

[3] L. Velić, and M. Decaro, "Comparing effectiveness of exploratory learning activities given before instruction: generating multiple strategies vs. inventing one strategy," *Instructional Science*, vol. 53, pp. 1537-1572, Jan. 2025, doi: 10.1007/s11251-024-09701-8.

[4] L. Murphy, N. B. Eduljee, and K. Croteau, "Teacher-centered versus student-centered teaching: preferences and differences across academic majors," *Journal of Effective Teaching in Higher Education*, vol. 4, no. 1, 2021, doi: 10.36021/jethe.v4i1.156.

[5] E. Khasawneh, A. Hodge-Zickerman, C. S. York, T. J. Smith, and H. Mayall, "Examining the effect of inquiry-based learning versus traditional lecture-based learning on students' achievement in college algebra," *International Electronic Journal of Mathematics Education*, vol. 18, no. 1, pp. 1–11, Jan. 2022, doi: 10.29333/iejme/12715.

[6] P. S. Cetin, "Effectiveness of inquiry based laboratory instruction on developing secondary students' views on scientific inquiry," *Journal of Chemical Education*, vol. 98, no. 3, pp. 756–762, Mar. 2021, doi: 10.1021/acs.jchemed.0c01364.

[7] J. Zajda, "The use of constructivist pedagogies and inquiry based learning to overcome discrimination," in *Discourses of Globalisation and Education Reform, Globalisation, Comparative Education and Policy Research*, Springer, 2022, pp. 89–103, doi: 10.1007/978-3-030-96075-9_7.

[8] M. Demssie, "Perceived factors affecting students' mathematics performance in North Showa zone secondary schools in Ethiopia," *International Journal of Advanced Research in Engineering and Applied Sciences*, vol. 8, no. 5, pp. 21–36, 2019.

[9] Y. Mekuria and M. Teketel, "Factor affecting student`s achievement in mathematics: the case of Agarfa secondary school, Ethiopia," *Education Journal*, vol. 8, no. 6, pp. 307–319, 2019, doi: 10.11648/j.edu.20190806.21.

[10] G. S. Walde, "The actual status of general secondary school mathematics teaching and learning: the case of Ethiopia," *Journal of Physics: Conference Series*, vol. 1176, no. 4, Mar. 2019, doi: 10.1088/1742-6596/1176/4/042097.

[11] Y. D. Li and G. H. Ding, "Student-centered education: a meta-analysis of its effects on non-academic achievements," *SAGE Open*, vol. 13, no. 2, Apr. 2023, doi: 10.1177/21582440231168792.

[12] C. Lombardi, "Acquisition and retention of STEM concepts through inquiry based learning," *ProQuest LLC*, vol. 56, no. 1, 2016.

[13] J. W. Wu, J. C. R. Tseng, and G. J. Hwang, "Development of an inquiry-based learning support system based on an intelligent knowledge exploration approach," *Educational Technology and Society*, vol. 18, no. 3, pp. 282–300, 2015.

[14] R. Sam, "Systematic review of inquiry-based learning: assessing impact and best practices in education," *F1000Research*, vol. 13, pp. 1–12, Sep. 2024, doi: 10.12688/f1000research.155367.1.

[15] S.-C. Lin and H. Lee, "The impact of process-oriented guided inquiry learning on students' academic achievement and capacities for collaboration and problem-solving," *Journal of Social Science Studies*, vol. 10, no. 2, pp. 111–125, Dec. 2023, doi: 10.5296/jsss.v10i2.21548.

[16] N. F. Aras, M. Lestari, S. S. D. Pendit, and N. K. Sani, "The critical thinking skills of students through guided inquiry models in elementary school," *Jurnal Studi Guru dan Pembelajaran*, vol. 7, no. 3, pp. 1142–1152, Nov. 2024, doi: 10.30605/jsgp.7.3.2024.4703.

[17] L. Darling-Hammond, L. Flook, C. Cook-Harvey, B. Barron, and D. Osher, "Implications for educational practice of the science of learning and development," *Applied Developmental Science*, vol. 24, no. 2, pp. 97–140, Apr. 2020, doi: 10.1080/10888691.2018.1537791.

[18] N. Farooqi, "Teacher perception of inquiry-based teaching in mathematics in early childhood," Concordia University, 2020.

[19] Sutrisno, G. A. M. Nanda, and H. R. Widarti, "The effectiveness of inquiry based learning with OE3R strategy for conceptual understanding of molecular shape of high school students'," in *AIP Conference Proceedings*, 2020, doi: 10.1063/5.0000620.

[20] T. T. S. Strat, E. K. Henriksen, and K. M. Jegstad, "Inquiry-based science education in science teacher education: a systematic review," *Studies in Science Education*, vol. 60, no. 2, pp. 191–249, Jul. 2024, doi: 10.1080/03057267.2023.2207148.

[21] M. A. Baker and J. S. Robinson, "The effect of two different pedagogical delivery methods on students' retention of knowledge over time," *Journal of Agricultural Education*, vol. 59, no. 1, pp. 100–118, Mar. 2018, doi: 10.5032/jae.2018.01100.

[22] S. Schmid and F. X. Bogner, "How an inquiry-based classroom lesson intervenes in science efficacy, career-orientation and self-determination," *International Journal of Science Education*, vol. 39, no. 17, pp. 2342–2360, Nov. 2017, doi: 10.1080/09500693.2017.1380332.

[23] T. Aytaç and S. S. Kula, "The effect of student-centered approaches on students' creative thinking skills: a meta-analysis study," *International Journal of Contemporary Educational Research*, vol. 7, no. 2, pp. 62–80, Oct. 2022, doi: 10.33200/ijcer.723894.

[24] C. E. Wilson, "The effects of inquiry-based learning and student achievement in the science classroom," University of Mary Washington, 2020.

[25] S. Chususiyah, Dafik, and T. D. Prastiti, "The analysis of application of learning materials based on inquiry based learning and its effect on critical thinking skills of students in solving fractions problems," *Journal of Physics: Conference Series*, vol. 1563, no. 1, pp. 1–16, Jun. 2020, doi: 10.1088/1742-6596/1563/1/012072.

[26] K. Kori, "Inquiry-based learning in higher education," in *Lecture Notes in Educational Technology*, Springer Nature Singapore, 2021, pp. 59–74, doi: 10.1007/978-981-16-2082-9_4.

[27] F. B. Chengay, "Inquiry-based learning: its impact to students problem solving performance in series," pp. 1–58, Apr. 11, 2023, doi: 10.21203/rs.3.rs-2760659/v1.

[28] D. Frezell, "Impact of inquiry based learning on students' motivation, engagement and attitude in science," University of Windsor, 2018.

[29] J. Cohen, *Statistical power analysis for the behavioural sciences*. Lawrence Erlbaum Associates, 1998.

[30] W. W. Cobern *et al.*, "Experimental comparison of inquiry and direct instruction in science," *Research in Science & Technological Education*, vol. 28, no. 1, pp. 81–96, Apr. 2010, doi: 10.1080/02635140903513599.

[31] A. A. Tawfik, W. Hung, and P. J. Giabbanelli, "Comparing how different inquiry-based approaches impact learning outcomes," *Interdisciplinary Journal of Problem-based Learning*, vol. 14, no. 1, pp. 1–17, Jun. 2020, doi: 10.14434/ijpbl.v14i1.28624.

[32] C. S. Reinhart and S. F. Rallis, "The qualitativequantitative debate: new perspectives," *New directions for program evaluation*, vol. 1–98, 1994.

[33] G. Adams and D. Carnine, "Direct instruction," in *Handbook of learning disabilities*, 2003, pp. 403–416.

[34] B. A. Bucklin, N. L. Asdigian, J. L. Hawkins, and U. Klein, "Making it stick: use of active learning strategies in continuing medical education," *BMC Medical Education*, vol. 21, no. 1, pp. 1–9, Dec. 2021, doi: 10.1186/s12909-020-02447-0.

[35] F. S. S. Oloda, S. G. Ojo, and D. S. Durojaiye, "Methods and strategies for effective teaching of mathematics in secondary schools in Nigeria," *Teacher Education and Curriculum Studies*, vol. 9, no. 4, pp. 103–109, Oct. 2024, doi: 10.11648/j.tecs.20240904.11.

[36] A. Yeboah and W. N. Siaw, "The impact of inquiry-based method of teaching on the academic performance of primary education students of Atebubu College of Education in general," *European Journal of Basic and Applied Scienceuropean Journal of Basic and Applied Science*, vol. 7, no. 1, pp. 47–54, 2020.

[37] B. A. O. Ogumah, H. U. Babaji, S. A. Alome, and A. Taiye, "Effect of guided inquiry teaching method on students' academic performance in electrical installation and maintenance work in technical colleges in Gombe State," *ATBU Journal of Science, Technology and Education*, vol. 7, no. 4, pp. 343–352, 2020.

[38] K. Beswick, "Inquiry-based approaches to mathematics learning, teaching, and mathematics education research," *Journal of Mathematics Teacher Education*, vol. 24, no. 2, pp. 123–126, Apr. 2021, doi: 10.1007/s10857-021-09494-4.

[39] N. M. Khan, "Implementation of inquiry-based learning in Pakistani Government Colleges: an exploratory study," *Journal of Asian Development Studies*, vol. 12, no. 4, pp. 796–807, 2023.

[40] M. Muhammadiah, A. Hamsiah, A. Muzakki, N. Nuramila, and Z. A. Fauzi, "The role of the professional teacher as the agent of change for students," *Al-Ishlah: Jurnal Pendidikan*, vol. 14, no. 4, pp. 6887–6896, Nov. 2022, doi: 10.35445/alishlah.v14i4.1372.

[41] K. T. Kotsis, "Integrating inquiry-based learning in the New Greek Primary Science Curriculum," *European Journal of Education and Pedagogy*, vol. 5, no. 6, pp. 63–71, Dec. 2024, doi: 10.24018/ejedu.2024.5.6.899.
[42] M. Kersting, S. Karlsen, M. Ødegaard, M. Olufsen, M. Kjærnsli, and M. L. Suhr Lunde, "Studying the quality of inquiry-based teaching in science classrooms. A systematic video study of inquiry-based science teaching in primary and lower-secondary schools," *International Journal of Science Education*, vol. 45, no. 17, pp. 1463–1484, Nov. 2023, doi: 10.1080/09500693.2023.2213386.
[43] M. Khalid, S. Bashir, and H. Amin, "Relationship between self-directed learning (SDL) and academic achievement of university students: a case of online distance learning and traditional universities," *Bulletin of Education and Research*, vol. 42, no. 2, pp. 131–148, 2020.
[44] L. S. Keiler, "Teachers' roles and identities in student-centered classrooms," *International Journal of STEM Education*, vol. 5, no. 1, p. 34, Dec. 2018, doi: 10.1186/s40594-018-0131-6.

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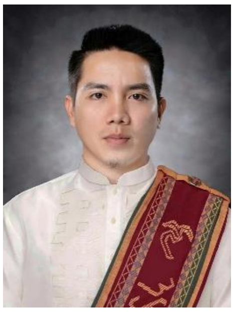

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