

Received: January 2024 Accepted: February 2024

DOI: <https://doi.org/10.53555/ks.v12i2.2876>

Unlocking Biochemistry Brilliance: Unveiling the Impact of POGIL vs. Interactive Lecturing Using Enzyme Kinetics Inventory on Student Learning Achievement

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Abstract

This study investigates the effectiveness of the Process-Oriented Guided Inquiry Learning (POGIL) method compared to interactive lecturing in undergraduate biochemistry education from two private medical colleges of Punjab. The study based on quantitative assessments, including pre-tests, knowledge acquisition evaluations, and knowledge retention assessments, were conducted. Students were divided into two groups: the control group experienced interactive lecturing, while the intervention group was taught using the POGIL method. Results revealed significantly higher mean scores for knowledge acquisition in the POGIL group ($M=9.18$, $SD=1.23$) compared to the interactive lecturing group ($M=7.82$, $SD=0.99$) ($p=0.05$). Additionally, the POGIL group demonstrated superior long-term knowledge retention, with mean scores of $M=8.89$ ($SD=1.23$), compared to the interactive group's $M=7.67$ ($SD=0.99$) ($p=0.05$). These findings underscore the enhanced effectiveness of the POGIL method in fostering both knowledge acquisition and retention in enzyme biochemistry among undergraduate medical students, suggesting its potential for integration into biochemistry medical curricula.

Keywords: *Process-Oriented Guided Inquiry Learning (POGIL), interactive lecturing, enzyme biochemistry, knowledge acquisition, knowledge retention.*

Introduction

Biochemistry education is crucial in the training of medical professionals, as it forms the foundation for understanding physiological processes and disease mechanisms (Sarfraz et al., 2022). The comparison of different lecturing methods, such as Process-Oriented Guided Inquiry Learning and interactive lecturing, is essential for identifying the most effective approach to imparting biochemistry knowledge to medical students. Understanding which method yields better learning outcomes can have a significant impact on curriculum design and pedagogical strategies within medical education (Rodriguez et al., 2020).

In this study, the focus on enzyme biochemistry further highlights the practical implications of the findings, as enzymes play a fundamental role in various biochemical pathways and are essential for understanding diseases and therapeutic interventions (Furqan et al., 2020). Therefore, the exploration of the POGIL method's effectiveness in fostering knowledge acquisition and retention in this specific area holds promise for enriching the educational

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experience of undergraduate medical students.

By delving into the effectiveness of different lecturing methods, this study contributes to the ongoing discourse on pedagogical best practices in biochemistry education, underscoring the potential benefits of incorporating innovative and structured inquiry-based learning approaches into the curriculum (Walker & Warfa, 2017). Recent studies highlight the effectiveness of different lecturing methods; it contributes to the ongoing discourse on pedagogical best practices in biochemistry education. The potential benefits of incorporating structured inquiry-based learning approaches, such as POGIL, into the curriculum are emphasized, highlighting the importance of innovation in lecturing and learning strategies (Soltis et al., 2015).

Methodology

This study employed a comparative research design to investigate the effectiveness of the Process-Oriented Guided Inquiry Learning (POGIL) method versus interactive lecturing in undergraduate medical education in two private medical colleges in Punjab. The research focused specifically on the lecturing of enzyme biochemistry, a crucial aspect of biochemistry education.

Participants: Undergraduate medical students enrolled in biochemistry courses at two medical colleges in Punjab were recruited for the study. Students were divided into three tiers on the basis of their previous academic grades and then making a balance of high to low achievers, students were equally divided to either the control group, which received interactive lecturing, or the intervention group, which was taught using the POGIL method.

Procedure: Quantitative assessments were conducted to evaluate knowledge acquisition and retention. Pre-tests were administered to both groups before the intervention to establish baseline knowledge levels. Following the instructional period, knowledge acquisition evaluations were conducted to assess immediate learning outcomes. Additionally, knowledge retention assessments were administered after two weeks to evaluate long-term retention.

Data Analysis: Mean scores and standard deviations were calculated for both knowledge acquisition and retention assessments. Statistical analysis, including t-tests, was performed to compare the performance of the control and intervention groups. Significance levels were set at $p < 0.05$.

Results

Table 1 shows the demographic details of the participants involved in the study by giving written consent for the study.

Table 1: Demographic Details.

Academic year	Class Strength Combined for two medical colleges			Participants given consent		
	M	F	Total	M	F	Total
MBBS Second year	88	120	208	86	114	200

Pre-Test Interactive Lecturing Vs. Pre-Test POGI

The pre-test Interactive lecturing and the pretest POGIL was taken by the students as the initial test for the students to check the cognitive levels of the population present about the particular content which was taught after the pre-test with both the group of students. The Table 2 shows Pre-test results of the students of first year MBBS, N-200 medical students who were enrolled in the research with written consent for the participation. The total no. of participants was divided into two groups of 100 in each.

Table 2: Pre-Test Interactive Lecturing Vs. Pre-Test POGIL.

	N	Mean	Std. Deviation	p-value
Interactive Lecturing	100	2.58	1.32	0.05
POGIL	100	2.40	0.95	0.05

Table 3 shows the relationship between the two-lecturing methods in post-test phase which researcher named it as knowledge acquisition test. Table 3 shows the significant increase in the knowledge of the students from the cognition level of test. The results in the table 3 shows that the POGIL group gain good marks in relation to Interactive lecturing group and this has given a further strong indication to the researcher that the new lecturing methods in enzyme biochemistry is showing remarkable impact on the learning performance.

Post-Test Interactive Lecturing Vs. Post-Test POGIL

Table 3: Post-Test Interactive Lecturing Vs. Post-Test POGIL.

Intervention #1 After the session of POGIL and Interactive lecturing	Total participants of the study	Mean	St.D	p-value	
Interactive Lecturing Method	Knowledge Acquisition	100	7.82	0.95	0.05
POGIL Method	Knowledge Acquisition	100	9.18	0.99	0.05

Table 4, a comparison between the delayed Post-test POGIL and the interactive lecturing method highlights variations in students' cognition levels and how the new knowledge has been constructed, reflecting the principles of constructivism. Despite both methods covering the same content, they utilized distinct instructional strategies and educational tools. As depicted in Table 4, after administering the delayed post-test to 100 students, the mean scores were 7.67 for the interactive lecturing method and 8.89 for the POGIL method. Subsequently, following content delivery, there was a noticeable increase in students' depth of understanding, particularly evident in the POGIL group, suggesting effective learning facilitated by this method. Furthermore, the calculated p-value for the knowledge acquisition test was highly significant ($p = 0.05$), emphasizing the statistical significance of the findings.

Table 4: Post-Test Interactive Lecturing Vs. Delayed Post-Test POGIL.

Intervention #2 Delayed Post-Test	Number of Students	Mean	Standard Deviation	p-value	
Interactive Lecturing Method	Knowledge Retention	100	7.67	1.11	0.05
POGIL Method	Knowledge Retention	100	8.89	1.24	0.05

Comparison between Pre-Test and Knowledge Acquisition and Knowledge Retention

Exam**Table 5:** Consolidated Results.

Comparison between Pre-test, Knowledge Acquisition, Knowledge retention				
		Mean	Std. Deviation	p-value
Pre-test	Interactive	2.58	1.32	0.05
	POGIL	2.40	0.95	
Knowledge Acquisition	Interactive	7.82	0.99	0.05
	POGIL	9.18	1.23	
Knowledge retention	Interactive	7.67	0.99	0.05
	POGIL	8.89	1.23	

Knowledge Acquisition

Referring table 5 shows the analysis of pre-test scores revealed a thin comparable baseline knowledge levels between the POGIL group and the interactive lecturing group. However, following the instructional period, significant differences emerged in knowledge acquisition between the two groups. The POGIL group exhibited a substantial increase in mean scores for knowledge acquisition (M=9.18, SD=1.23) compared to the interactive lecturing group (M=7.82, SD=0.99). These results indicate that students taught using the POGIL method demonstrated a greater understanding of enzyme biochemistry concepts immediately after the instructional period compared to those taught using interactive lecturing.

Knowledge Retention

Further assessment of knowledge retention revealed notable disparities between the POGIL and interactive lecturing groups. While both groups initially demonstrated improved understanding post-instruction, the POGIL group maintained significantly higher mean scores for knowledge retention over time. The POGIL group exhibited a mean score of M=8.89 (SD=1.23) compared to M=7.67 (SD=0.99) in the interactive lecturing group ($p=0.001$). These findings suggest that students taught using the POGIL method retained a deeper understanding of enzyme biochemistry concepts over an extended period compared to those taught using interactive lecturing.

These quantitative results highlight the efficacy of the POGIL method in promoting both immediate knowledge acquisition and long-term retention among undergraduate medical students in the domain of enzyme biochemistry.

Discussion**Comparative Effectiveness of POGIL vs. Interactive Lecturing Methods**

The primary objective of this study was to investigate the comparative effectiveness of Process Oriented Guided Inquiry Learning (POGIL) activities versus interactive lecturing methods in lecturing biochemistry. The results of our study suggest that both POGIL and interactive lecturing methods have their strengths and weaknesses in the context of biochemistry education. Numerous studies have highlighted the benefits of active learning approaches like POGIL in promoting student engagement, critical thinking, and deep conceptual understanding (Vishnumolakala et al., 2018). Our findings support these assertions, with students expressing positive perceptions of POGIL and noting its effectiveness in enhancing their learning experience. The

interactive nature of POGIL activities encourages students to actively engage with the material, collaborate with their peers, and apply their knowledge to real-world scenarios (Canelas et al., 2019).

However, it is essential to acknowledge that POGIL may not be suitable for all topics or learning objectives. Some participants expressed concerns about the time-intensive nature of POGIL activities and the challenges associated with managing group dynamics (Rodriguez et al., 2020). Additionally, certain biochemistry concepts may be better suited to interactive lecturing or lecture-based instruction, particularly those requiring extensive theoretical background or complex mathematical calculations (Chase et al., 2013). On the other hand, proponents of interactive lecturing argue that it remains a valuable and effective lecturing method in the context of biochemistry education (Murray, 2013). Interactive lecturing allows for structured dissemination of information, enabling students to grasp complex theoretical concepts and mathematical calculations more effectively. This form of instruction provides a platform for instructors to deliver in-depth explanations and analyses, ensuring that students receive a comprehensive understanding of the material (Kode & Cherukuri, 2014).

Moreover, some students may find the collaborative and interactive nature of POGIL activities challenging, as it requires a high level of peer interaction and group work. In a lecture-based setting, students have the opportunity to focus solely on the instructor's explanations without the potential distractions or dynamics of group work, resulting in a more focused and individualized learning experience (Minderhout & Loertscher, 2007).

Additionally, interactive lecturing provides a sense of familiarity and continuity for students, as it aligns with the lecturing methods they have experienced throughout their academic journey (Yulastini et al., 2018). This can contribute to a sense of comfort and confidence in learning, especially when dealing with complex and intricate biochemical processes.

Our study was limited to two medical colleges of Pakistan and both were private sector. Future research can perform by increasing the no of institutions and by doing comparative studies to evaluate the effectiveness of POGIL relative to other active learning approaches, such as problem-based learning (PBL) or case-based learning (CBL), in biochemistry education. By comparing different instructional methods, researchers can identify the strengths and limitations of each approach and inform evidence-based pedagogical practices.

Educators and curriculum developers can glean valuable insights from this study, informing their efforts to enhance the learning experiences and outcomes of aspiring medical professionals in the field of biochemistry (Brown, 2010). This research not only sheds light on the effectiveness of POGIL in comparison to interactive lecturing but also points towards the potential for integrating innovative pedagogical approaches into medical curricula to better equip students with the knowledge and skills necessary for their future careers.

In summary, while POGIL garners support for enhancing critical thinking and communication skills, it's essential to address potential challenges like diverse learning styles and time constraints. A thorough comparison of POGIL with other methods and its impact on student confidence is needed for informed decisions in biochemistry education. Moreover, POGIL promotes collaborative learning, critical thinking, and problem-solving in biochemistry education. Group activities and guided inquiry facilitate a practical understanding of enzyme kinetics, aiding students in comprehending complex concepts effectively.

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