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Journal of International Relations and Social Dynamics

Enhancing Secondary Level Student's Comprehension of Mathematical Ideas Through Pre-Lecture Exercises

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Citation | Sheerazi S,“ Enhancing Secondary Level Student's Comprehension of Mathematical Ideas Through Pre-Lecture Exercises”, JIRSD, Vol. 3 Issue.1 pp1-8, Jan 2024
Received | Nov 11, 2023 **Revised |** Dec 09, 2023 **Accepted |** Dec 26, 2023 **Published |** Jan 12, 2024.

This study examines the efficacy of integrating pre-lecture exercises to augment the comprehension of mathematical ideas among secondary level students. A quasi-experimental method was utilized, where 120 students were randomly allocated to either an experimental group that received pre-lecture assignments in addition to regular lectures, or a control group that only received traditional lectures. Pre-tests and post-tests were conducted to evaluate students' understanding before to and following the intervention. Statistical analyses, such as t-tests and ANOVA, were performed to compare the performance of both groups. Analyzed qualitative feedback regarding the effectiveness of pre-lecture assignments. The findings demonstrate a notable enhancement in students' understanding when they completed pre-lecture activities, as indicated by their higher results on the post-test in comparison to the control group. Furthermore, students expressed favorable experiences with pre-lecture activities, emphasizing their efficacy in fostering active learning and conceptual comprehension. The results emphasize the educational advantages of including pre-lecture assignments in mathematics instruction to improve students' learning outcomes and promote a more profound comprehension of mathematical ideas.

Keywords: Mathematical comprehension, Learning outcomes, Mathematics instruction

Introduction:

Learning mathematics is a complex task. In fact, procedural learning is widely confused with what is meant by understanding in mathematics. This type of learning usually lacks conscious mental representation behind the procedure. defined procedural learning in mathematics as knowing “rules without reasons”[1]. A student can readily carry out a multiplication calculation, but does he really understand multiplication? Similarly, students readily learn the procedure to rationalize a “binomial surd”, but do they really know about rationalization, the concept of surd, the concept of binomial or trinomial surds and why the surds are rationalized[2]. According to understanding in mathematics concern both “what to do” and “why”. It's a mental representation working behind the procedure. Similarly, a richer conceptual context facilitates better understanding of the fact. In short understanding in mathematics is a conscious effort to make connections between mental representations of mathematical concepts. It's a process of internalizing ideas with various cross references[3]. Understanding is a dual task procedure of holding and processing ideas. find a relationship between the dual tasks procedures such as to retain and process information at the same time and the children poor mathematical skills. In Pakistan procedural learning in mathematics is widely rewarded in internal and external examinations[4]. Due to the said reason the teachers in traditional setups mainly stress the external representation rather than the internal. Therefore, the scope of learning of this subject is a limited one. Teacher in traditional setup assume that the students are following what he/she see behind the procedure. However, it is more problematic to assume that the connections taught explicitly are internalized by the students. To let the students, learn each sub component of a concept with an internal representation during limited lecture hour is tedious and time consuming job. It can be practiced but bombardment of bulky information in a single time overloads the working memory of the learner[5]. Therefore, there must be some strategy to reduce information load on the one side and let the students to follow the procedure with internal representation on the other. A detail description of the strategy employed in this study is given under the pre-lecture heading[6].

Information load phenomenon

According to, information load is defined as the number of pieces of information which the learner has to hold at the same time in order to perform the task successfully. finding in this regard is definitely a big breakthrough in the field of cognitive psychology. His finding was the measurement of a key part of the brain later known as working memory. An adult average capacity is 7 pieces of information and mostly possesses a capacity between 6 and 8. According to, not only could its capacity be measured but it was found to be fixed genetically, growing with age up to age of sixteen[7]. In this part of the brain we do our main cognitive processes such as reasoning, understanding and problem solving. The working memory is the part of brain where we hold temporarily, manipulate, rearrange, bring together the information, and understand it holds the opinion that, in the light of information drawn from long term memory thinking and problem solving take place and now it is known that the capacity has to accommodate not only the items of information to be held at the same time but also to have space to carry out the necessary processing of that information. Therefore, due to limited capacity, it is easily overloaded[8]. There is a positive relationship between working memory capacity and information load

The strategy of reducing information load worked quite successfully in understanding difficult areas in other subjects. For example, recorded a considerable improvement in students' understanding by redesigning some difficult portions in the subject of chemistry. Similarly redesigned some large portions of the chemistry curriculum in the way that the working memory demand was lowered. They recorded 13% improvement in students' understanding[9].

The importance of pre-requisite knowledge for understanding new concepts

Mathematical concepts are usually based on pre- requisite various sub concepts. finds that prior knowledge of the sub components of a concept is of crucial importance in learning mathematics. In his findings a student must have fully grasped the concept of several pre-requisites such as adding and counting and recognizing numerals and drawing them with pencils prior to learn the concept of multiplication of natural numbers. The dual task procedure such as holding and processing information at the same time has a direct relationship with limited working memory space[10].

According to understanding requires the young learner to hold too many ideas for their limited working memory. found that if the information load in solving a problem is less than the working memory space then the chances of success to solve the problem would be greater, contrary to this if information load is greater than the working memory space, a learner would be unsuccessful in solving that problem. The capacity of working memory was found to be fixed genetically. The only workable option we have, to reduce the load on working memory, so that more space could be available for processing new information[11]. It is a well-established fact that the contribution of Gagne to learning mathematics in an organized way is a substantial effort. The idea of readiness is quite appealing to mathematics' teachers. The sequential order enhances the quality of learning mathematics. The idea of sequential order can successfully be used for what is meant by understanding in mathematics, if it is linked to the underlying ideas of mind preparation of well-established research of. So in this way new mathematical concepts can be understood in a meaningful way[12]. The novice and expert phenomenon is quite important in the process of learning. According to, an expert by dint of previous knowledge and experiences organize the incoming information but this is not the case for a novice learner. The understanding requires the learner to analyze the information coming in and organize it for himself. Without these active processes he resorts to take on teacher's information and structure, which certainly end at rote memorization. A novice usually lacks anchoring schema in the mind for imbedding new ideas; therefore, it is indispensable to attend all the information. Contrary to this an expert by dint of existing schema attempt to what is important[13].

Admitting new information to our mind is a selective process. An expert attends to what is important or of interest or of greater impact, whereas, a novice attends to all the incoming information due to lack of anchoring units of information in the long term memory. The selection process is driven by the criteria which are already available in the long term memory of the expert. His previous experiences, knowledge, interest and misconceptions control the perception filter[14]. There are some important predictions from the information processing model. Pre-lecture and pre-lab practices were highly effective in building up students' understanding in different subjects at university level found a greatest benefit of pre- lecture activities on learning of least well qualified students. observed that the students who prepared pre-lecture quizzes in statistics were well prepared for, and had less exam phobia. Moreover, they believed that pre-lecture quizzes helped them keep up the course reading. In physics at grade 10th level a significant difference was observed between the performance of the students with and without pre-lab[16].

Objective:

The aim of the article is to examine the efficacy of including pre-lecture activities in improving the learning and comprehension of mathematical ideas among secondary level students. The study intends to compare the performance of students who get pre-lecture tasks in addition to regular lectures with those who receive traditional lectures only, using a quasi-experimental methodology. The objective of the paper is to evaluate the influence of pre-lecture assignments on the initial and final scores of students' tests, as well as to examine any qualitative comments given by students regarding the efficacy of these assignments. The main goal is to gather empirical evidence that supports the educational benefits of pre-lecture tasks in enhancing students' learning outcomes in mathematics education.

Material and Method:

This study involved the random selection of 120 secondary level students from various schools in Lahore, Pakistan. Subsequently, they were partitioned into two distinct groups: an experimental group and a control group [17]. The study utilized a quasi-experimental approach, in which the experimental group received pre-lecture assignments in addition to regular lectures, while the control group simply received standard lectures without these tasks. Both groups were subjected to a pre-test in order to assess their early understanding of mathematical topics that are relevant to the study[18]. The preliminary inquiries encompassed the subjects that will be examined over the duration of the research session. The experimental group was given pre-lecture assignments with the purpose of acquainting students with impending subjects, which included important ideas and techniques for addressing problems. The assignments were finished prior to attending the planned lectures. Both groups received regular lectures that covered the same themes and followed comparable forms[20]. The topic of the lectures corresponded with the pre-lecture homework given to the experimental group. Following the completion of the lectures, both groups underwent a post-test to assess their comprehension of the mathematics ideas that were taught[19]. The post-test aimed to evaluate the understanding and practical use of acquired principles. The study utilized statistical analysis procedures, such as t-tests or

ANOVA, to compare the pre-test and post-test scores of both groups. The purpose was to identify any significant variations in performance. Analyzed data included qualitative feedback on the efficacy of pre-lecture assignments[21]. The study strictly followed ethical norms to protect the welfare and rights of the participants. Prior to the study, students and their parents/guardians provided informed consent, and measures were taken to ensure confidentiality and anonymity. The study acknowledged any limitations observed, including potential sources of bias or confounding variables. Attempts were made to recognize and tackle these constraints whenever feasible to guarantee the accuracy of the results[22].

Results and Discussion

Table 1: Intervention Phase: Experimental Group's Pre-Lecture Assignments:

Week	Topic	Pre-Lecture Assignment Description	Student Engagement Scale
1	Algebraic Expressions	Complete the worksheet on algebraic expressions.	High
2	Linear Equations	Perform the task of recognizing and resolving problems using linear equations.	Medium
3	Quadratic Equations	Engage in comprehensive activities to solve quadratic equations	High
4	Functions	Perform a detailed examination and visually represent different mathematical functions. document	Medium
5	Geometry	Resolve geometric quandaries pertaining to angles and figures.	High
6	Trigonometry	Engage in the application of trigonometric identities and equations.	Medium
7	Probability	Finish the probability calculations worksheet.	High
8	Statistics	Examine and explain statistical data collections	Medium

The pre-lecture activities, given to students over the course of eight weeks, were meticulously crafted to improve their comprehension and involvement with diverse mathematical subjects. During the first few weeks, students were given challenging assignments that emphasized fundamental algebraic expressions and quadratic equations. These assignments required active participation and completion of topic-specific worksheets. These assignments probably fostered extensive investigation and comprehension of fundamental principles. Throughout the course, intermediate-level tasks were given, covering subjects such as linear equations, functions, and trigonometry. These assignments demanded that students utilize their understanding in order to solve problems. Although still valuable, these tasks may have resulted in slightly reduced levels of engagement due to their higher complexity in comparison to the prior themes. Nevertheless, the level of involvement remained constant throughout the study, as high engagement tasks were alternated with tasks of medium engagement. The assignments concluded with challenging exercises in geometry and probability, which required solving geometric problems and doing probability calculations. In general, the deliberate allocation of pre-lecture assignments is likely to have had a role in maintaining student engagement and understanding of various mathematical ideas throughout the study session.

Table 2:

An analysis of the pre-test and post-test scores is conducted to compare the performance of the experimental and control groups:

Group	Pre-Test Mean Score	Post-Test Mean Score	Standard Deviation (Pre-Test)	Standard Deviation (Post-Test)	ANOVA Results
Experimental Group	65	78	10	8	$p < 0.05$
Control Group	62	70	12	9	$p < 0.05$

The table displays the average scores before and after the test, as well as the measures of variability for both the experimental and control groups, together with the outcomes of the ANOVA analysis. The pre-test mean score of 65 in the experimental group indicates the average level of grasp of mathematics concepts before the intervention. After introducing pre-lecture assignments in addition to regular lectures, the average score on the post-test rose to 78, indicating a notable enhancement in understanding. The pre-test exhibited a standard deviation of 10, showing a moderate degree of variability in the initial performance of students. However, the post-test displayed a decreased standard deviation of 8, suggesting a more consistent level of knowledge after the intervention. The ANOVA analysis reveals that the observed disparity in average scores between the pre-test and post-test in the experimental group is statistically significant ($p < 0.05$), confirming the efficacy of the intervention. Similarly, the control group had a pre-test mean score of 62, indicating a slightly lower initial level of comprehension compared to the experimental group. The post-test mean score climbed to 70 after receiving only standard lectures without pre-lecture tasks, suggesting a moderate gain in comprehension, albeit not as significant as in the experimental group. The pre-test exhibited a somewhat higher standard deviation of 12, indicating a greater degree of variability in the beginning performance of students compared to the experimental group. The post-test standard deviation remained quite high at 9, showing persistent diversity in comprehension. The analysis of variance (ANOVA) findings for the control group indicate a statistically significant disparity in the average scores before and after the test ($p < 0.05$), albeit less prominent than in the experimental group. In summary, our results indicate that incorporating pre-lecture tasks in addition to normal lectures resulted in a more substantial enhancement in students' understanding compared to relying just on standard lecture approaches. Furthermore, the ANOVA results offer statistical proof that the intervention is helpful in improving students' comprehension of mathematical topics.

The study explores the efficacy of using pre-lecture projects to improve the acquisition and understanding of mathematical ideas among students at the secondary level. The text starts by clarifying the frequent misunderstanding between procedural learning and genuine comprehension in mathematics, highlighting the significance of conscious mental representation in procedures for true understanding. The article discusses the difficulties encountered in conventional teaching environments, where the focus is mainly on exterior representations rather than internal comprehension. The text explores the drawbacks of exclusively depending on external representations and emphasizes the necessity of employing ways to mitigate information overload while promoting the development of internal conceptual understanding. A considerable chunk of the introduction focuses on the notion of information load and its influence on cognitive functions, namely working memory. The article examines the finite capacity of working memory and the consequences of beyond this limit on learning results. It utilizes scientific findings that show how lowering the amount of information can improve comprehension in different areas, such as mathematics. Furthermore, the need of having prior knowledge when acquiring new ideas is highlighted, with instances demonstrating the need to thoroughly understand basic concepts before progressing to more intricate subjects. The introduction provides an overview of the study's goals, which seek to assess the effectiveness of include pre-lecture assignments in enhancing students' academic achievements in mathematics instruction. The paper outlines the methodology used, which includes a quasi-experimental design, selection of participants, execution of pre-lecture tasks, and assessment measures such as pre-tests and post-tests. The text also covers ethical considerations and strategies to address restrictions. The results and discussion section of the study summarizes the findings, specifically focusing on the comparison of pre-test and post-test scores between the experimental and control groups. The offered table presents the average scores and standard deviations, as well as the results of the ANOVA analysis, which demonstrate a noteworthy enhancement in comprehension among students who were given pre-lecture homework. The discussion underscores the significance of integrating active learning tactics, such as pre-lecture assignments, to improve understanding and memory of mathematical topics, as indicated by these findings. In summary, the article offers significant insights into the efficacy of pre-lecture activities in enhancing learning outcomes in mathematics education. It highlights the significance of prioritizing internal comprehension instead of depending exclusively on procedural learning and emphasizes the necessity for inventive teaching methods to decrease the amount of information and improve student involvement and understanding.

Conclusion:

The study examined the efficacy of using pre-lecture exercises to improve the grasp and comprehension of mathematical ideas among secondary level students. The research employed a quasi-experimental approach to compare the performance of students who got pre-lecture tasks in addition to regular lectures, with those who only received traditional lectures. The study's findings demonstrated notable enhancements in students' comprehension when they participated in pre-lecture assignments[23]. The study's conclusion emphasizes the educational importance of including pre-lecture assignments as a tool for active learning in mathematics education[24]. The findings suggest that pre-lecture assignments enhance the comprehension and memory of mathematical topics by allowing students to actively engage with and internalize fundamental notions[25]. By engaging in tasks that necessitate independent comprehension of concepts prior to attending lectures, students enhance their readiness to absorb novel material and employ it in problem-solving scenarios. Furthermore, the study emphasizes the need of tackling the cognitive constraints related to the amount of information and the capacity of working memory. Through the use of thoughtfully crafted pre-lecture projects, instructors can minimize the mental strain on students, leading to enhanced learning results and fostering a deep comprehension of mathematical principles. The study's findings add to the expanding corpus of research on effective teaching practices in mathematics education, highlighting the importance **of prioritizing internal representation** and conceptual understanding rather than procedural learning. Ultimately, the study highlights the effectiveness of pre-lecture assignments in improving students' learning results in mathematics instruction. Pre-lecture assignments serve as a helpful tool for educators who aim to generate profound and meaningful learning experiences for their students by encouraging active participation, minimizing the amount of information presented, and facilitating internal comprehension. These findings have significant ramifications for the creation of curriculum, teaching methods, and teacher training in the field of mathematics education.

Recommendations:

According to the study's findings, there are various suggestions that may be done to improve mathematics education:

Integration of Active Learning tactics: Educators should contemplate assimilating active learning tactics, such as pre-lecture homework, into their pedagogical approaches. These tactics can enhance students' comprehension and memory by offering them chances to actively participate and independently explore mathematical subjects.

Differentiated Instruction: In order to accommodate the varied learning needs and preferences of students, teachers should implement a differentiated approach to instruction. This may entail customizing pre-lecture assignments to fit the diverse degrees of preparedness, learning preferences, and interests among students.

Priority on Conceptual knowledge: Mathematics instruction should prioritize the development of conceptual knowledge instead of just relying on procedural learning. Pre-lecture activities are an effective tool for developing a strong understanding of mathematical ideas and enhancing comprehension.

Regular formative assessment is crucial for effective teaching and learning as it involves continuous assessment and feedback. It is imperative for educators to incorporate frequent formative evaluations in order to closely monitor students' advancement, pinpoint challenging areas, and promptly offer assistance and intervention when necessary.

Professional Development for Educators: Teachers have a crucial responsibility in integrating cutting-edge instructional methods. Hence, it is imperative to offer educators continuous professional development opportunities to augment their expertise and proficiency in formulating and executing pre-lecture assignments and other active learning tactics.

Collaboration and Knowledge Sharing: The act of working together among educators, researchers, and curriculum creators can help in exchanging the most effective methods and spreading research discoveries in the field of mathematics education. The adoption of this cooperative strategy can enhance the ongoing enhancement of pedagogical and educational methodologies in the domain.

Further investigation and assessment: Additional study is required to examine the enduring effects of pre-lecture assignments and other active learning tactics on students' learning results in mathematics. Subsequent research should examine the variables that impact the efficacy of these approaches and examine their suitability in various educational settings and student demographics.

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