Analyzing the Effect of Emerging Pedagogies on Students' Problem-Solving Ability in Mathematics at Secondary Level

Ishtiaq Ahmed[1] and Jam Muhammad Zafar[2]

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Abstract

The study aimed to analyse the "analysing the effect of emerging pedagogies on students' problem-solving ability in Mathematics at secondary level". The main objectives of the study were to investigate the effect of flipped classroom through project-based learning on students' problem-solving ability in Mathematics at the secondary level. In this chapter, the results and interpretation of the data were presented, which were collected through questionnaires administered to three respondent groups: 200 students, 100 Secondary School Teachers (SSTs), and 50 Head Teachers, for a total sample size of 350 participants. Finding the effect of flipped classroom through project-based learning on the problem-solving ability of the students in Mathematics at the secondary level was the aim of this research. The structured questionnaire consisted of 40 items broken down into 10 headings/indicators that included the areas of integration of flipped classroom model, project-based learning strategies, mathematical problem-solving skills, real-world application of mathematics, use of technology in Math learning, collaboration and peer learning, inquiry and critical thinking, motivation and engagement, teacher support and instruction, and administrative and resource support. These signals were: (1) flipped classroom model incorporation (most respondents 90% agreement (2) project-based learning strategies, 92 % agreement, (3) skills of solving mathematical problems, 93% agreement, (4) real-life application of Math, 92 % agreement. Favour this practice, indicating strong endorsement of "work on Math projects based on real-life problems".

Keywords: Emerging Pedagogies, Problem-Solving Ability in Mathematics, Flipped Classroom, Project-Based Learning at Secondary School

Introduction

Traditional lecture-based, inquiry-based learning, collaborative learning, flipped classroom, pedagogical methods, Mathematics, metacognition, the traditional, lecture-based teaching approach in Mathematics education has tended to be more standardised and passive, often failing to cater to diverse learning styles and needs. The consequence of this approach is the lack of engagement and understanding among students, a phenomenon prevalent in many classrooms worldwide. Indeed, student disengagement and a lack of critical thinking skills in Mathematics are significant concerns (Zafar & Akhtar, 2023; Naz et al., 2024; Zhang et al., 2024).

[1]*MPhil Scholar, Department of Education, National College of Business Administration and Economics (NCBAE) Sub-campus Rahim Yar Khan, Punjab Pakistan. Email: ishtiaqahmedla786@gmail.com*

[2]*Associate Professor, Department of Education, Khwaja Fareed University of Engineering and Information Technology (KFUEIT) Rahim Yar Khan, Punjab Pakistan. Email: dr.zafar@kfueit.edu.pk*

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The rapid development of teaching approaches and educational technology is accelerating the adoption of emerging pedagogies in Mathematics education. Modern pedagogical approaches are essential components of teaching Mathematics, along with problem-solving skills, which students need to succeed in rapidly developing societies. Modern educational methods, including flipped classrooms, problem-based learning, and collaborative learning, have demonstrated potential to enhance the mathematical and problem-solving abilities of secondary school students, according to Lone et al. (2011) and Bhutto and Zafar (2023). The transition depends on the implementation of technology, which enables interactive learning sessions and customised education methods. The educational progress signals an end to conventional instructor-led instruction while prioritising student participation, mathematical thinking, and real-world applications of Math content (Zafar et al., 2023; Abbas & Zafar, 2025).

Project-based learning (PBL) is an effective educational method that actively benefits Mathematics education at the Secondary school level. Through PBL, students address complex, realistic problems that require them to apply mathematical knowledge to discover solutions. Through this educational approach, students take part in an inquiry process and critical thinking, which leads to better knowledge retention and essential problem-solving abilities (Safari, 2015; Rittle-Johnson, 2017; Fyfi, 2021; Anjum & Zafar, 2022). Teamwork structures in PBL enable students to master communication abilities, which prepare them to tackle authentic issues and problems. Strategies that use real-life problems yield optimal results in Mathematics because students find it challenging to connect abstract topics to everyday experiences. The solution of practical issues shows students why Mathematics matters in their everyday lives and enables them to master their quantitative abilities.

New technologies provide additional value to current creation-focused educational methods. Educational technologies, including interactive simulations powered by AI and collaborative tools, allow students to receive personalised learning experiences that adapt to their individual learning needs. Rao et al. (2023) demonstrate that modern technology enables students to study mathematical ideas through personalised, dynamic, and engaging experiences. Students can use Khan Academy, Desmos, and GeoGebra to practice problems through interactive interfaces that provide immediate feedback and after-class resources. The tools facilitate both individual and collaborative learning by allowing students to communicate about Math problems in real time during online sessions.

Educational expertise requires proficiency, which enables faculty to effectively integrate these innovations into instructional materials, in concert with classroom diversity management and technological Utilization for academic advancement.

Emerging Pedagogies

Flipped Classroom

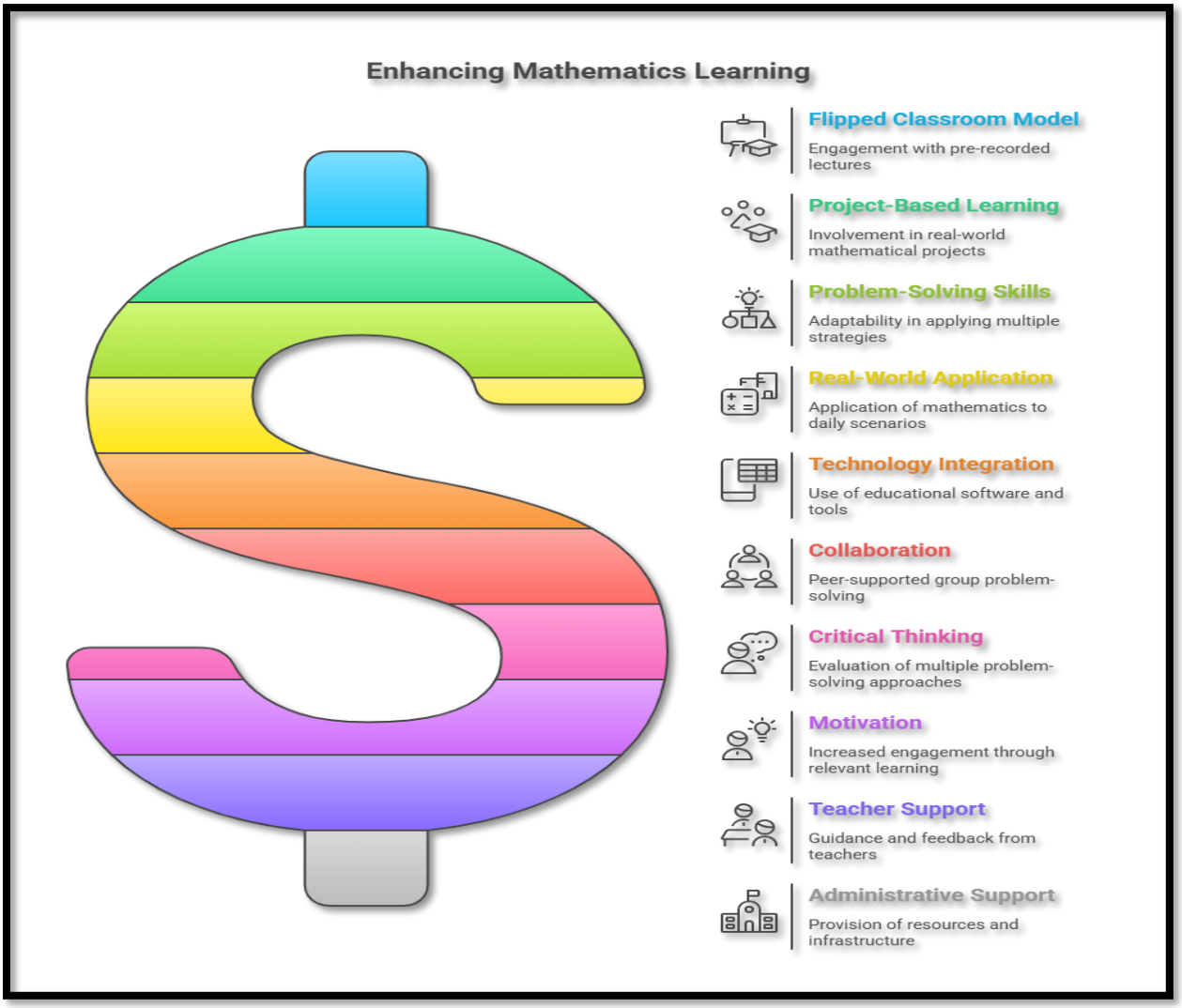
Project -Based Learning

1. Inquiry-Based Learning (IBL)
2. Collaborative Learning
3. Adaptive Learning (AI-Driven)

Problem-Solving Abilities in Mathematics - Secondary Level)

1. Analytical Problem-Solving
2. Creative Problem-Solving
3. Logical Reasoning
4. Computational Thinking
5. Real-World Application

Figure 1: Enhanced Mathematics learning



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Research Objectives

1. To test the efficiency of flipped classroom concept in improving the real-life equipping of students with Mathematics.
2. To determine how project-based learning was facilitate practical Mathematics knowledge.
3. To assess the common effect of the use of flipped classroom and project-based learning practices on the capacity of students to use Math in practical situations

Research Questions

1. How does the strategy of the flipped classroom impact the student academic capacity to apply mathematical concepts in real life processes?
2. What is the significance of project based learning and its effect on practical use of Mathematics?
3. How do flipped classroom and project-based learning increase on real-life application of Math concept when combined?

Significance of the Study

Traditional evaluation systems are often misaligned with the goals of emerging pedagogies. Flipped classrooms and real-world tasks promote critical thinking, collaboration, and problem-solving, but students are still assessed using multiple-choice or short-answer questions. Wasir et al. (2024) suggest reimagining assessment as part of the learning process. They advocate for performance-based assessments, portfolios, and project presentations that align with active learning strategies. Opportunity: Some countries and IB schools have begun embedding authentic assessments in their curricula, demonstrating measurable improvements in students' higher-order thinking skills and creativity. These pedagogies have been shown to improve a student's ability to solve problems, even so, incorporating them into the mainstream curriculum is very challenging.

Review of Literature

A literature review is a comprehensive summary and critical evaluation of existing scholarly work on a specific topic. It serves to contextualize a research problem, identify gaps in current knowledge, and demonstrate familiarity with the subject area, which helps in developing a theoretical framework and methodology for a new study. Essentially, it synthesizes what is already known about a topic to show how your research will contribute to it (Rao et al., 2023; Ahmad et al., 2023; Sadaf et al., 2024; Yousaf et al., 2025).

The Flipped Classroom Model and Project-Based Learning

In an era defined by rapid technological advancements and an increasingly globalized knowledge economy, the cultivation of robust mathematical problem-solving skills among secondary-level students has become a paramount educational objective (Albay, 2020; Ali et al., 2019; Hassan et al., 2024). This imperative arises from the recognition that mere procedural fluency is insufficient for navigating the complexities of modern challenges, necessitating instead a deeper conceptual understanding and the capacity for adaptive reasoning (Saleem et al., 2024). Contemporary educational paradigms, therefore, increasingly emphasize pedagogical approaches that foster critical thinking, creativity, and the ability to apply mathematical principles in novel contexts (Bosica et al,. 2021). This shift underscores the importance of investigating emerging pedagogies that move beyond traditional, teacher-centered instruction to student-centered learning environments (Montague et al., 2011; Naz et al., 2023; Arshad et al., 2025). Such approaches aim to equip students with 21st-century skills, including advanced problem-solving, by engaging them actively in their learning process (Wasir et al., 2024). Specifically, problem-based learning and inquiry-based learning represent two such innovative strategies that have garnered significant attention for their potential to enhance mathematical concept mastery and problem-solving capabilities across various educational levels. These innovative teaching strategies contrast sharply with traditional methods, which often prioritize rote memorization and algorithmic drills that may not effectively cultivate higher-order thinking or genuine mathematical understanding (Lone et al., 2011). Traditional instruction typically presents mathematical concepts in a highly structured, sequential manner, breaking down complex ideas into smaller, manageable components where learning progresses step-by-step (Myer's et al., 2024).

The idea of a Flipped Classroom is to replace the normal order of lesson and homework by having the students do the lecture content at home and the work at school. At home, students watch short videos to introduce themselves to the new material, while class time is spent doing exercises, discussing topics and putting what was learned to use (Bhutto & Zafar, 2023). Because of this

shift, students can work when it suits them and teachers can help students in ways that meet their specific needs.

Studies conducted lately suggest this model is effective in a Math classroom. Ahmad et al. (2023) completed a study in Saudi Arabia and discovered that no difference in academic success was present between traditional and flipped instruction, despite finding that students involved in the flipped workshops reported greater self-efficacy. Having this confidence is important in Math, as students usually struggle with stress and becoming disconnected).

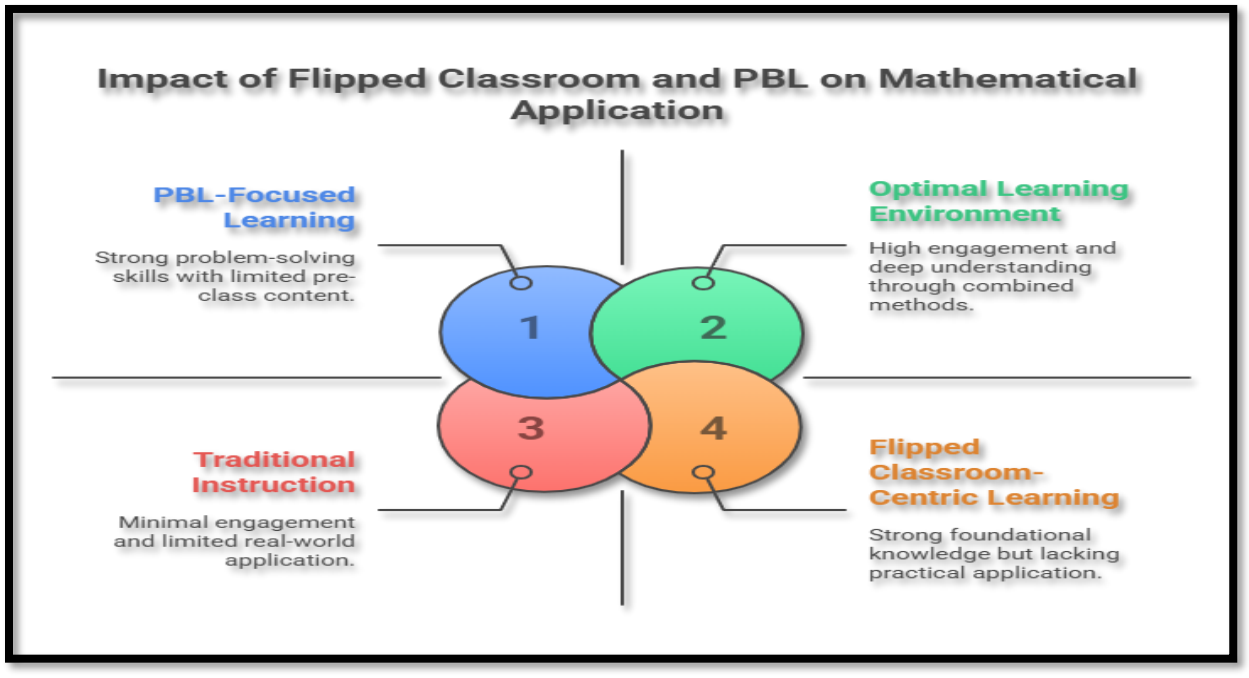
Effectiveness of Active Learning in STEM

The meta-analyses always show that active learning (flipped learning and PBL) contributed diversely with a significant level of student performance in Science, Technology, Engineering and Mathematics (STEM). According to one measurement, the failure rate was 1.5-fold as low and the exam score was increased by 6 percent with active learning procedures as contrasted to traditional lectures.

The Problem-Solving Approach in Mathematics

According to Atef, Seddiqi and Mubarez (2024), students who use problem-solving approaches through a flipped classroom tend to be more optimistic about their learning outcomes. In addition, students worked together and interacted, making it easier for one person to explain the ideas to the group.

Figure 2: Impact of Flipped Classroom



Theoretical Framework

Educational technology integration in secondary Mathematics classes requires specific theoretical approaches which support both content subject matter and student level characteristics. These educational standards provide teachers with helpful frameworks which show them how we can effectively use emerging pedagogies to improve student learning outcomes.

Technological Pedagogical Content Knowledge (TPACK): Educational practitioners blend technology-based approaches with pedagogical principles and Mathematics subjects according to TPACK teaching guidelines to achieve teaching effectiveness.
Technology Acceptance Model (TAM): TAM examines both utility perceptions and convenience evaluation while studying what drives teachers to adopt digital teaching tools for Mathematics education. (EURASIA JOURNAL)
Unified Theory of Acceptance and Use of Technology (UTAUT): The officials at UTAUT grew the TAM model through their integration of facilitating conditions and social influence to provide total technology acceptance assessments in education environments.

- Technological Pedagogical Content Knowledge (TPACK) was introduced in 2006 by Punya Mishra and Matthew J. Koehler.
- Technology Acceptance Model (TAM) was created in 1986 by Fred Davis.
- Unified Theory of Acceptance and Use of Technology (UTAUT) was launched in 2003 by Viswanath Venkatesh.

Conceptual Framework

Independent and Dependent Variables

Independent Variable (IV): The instructional strategy combining the flipped classroom and project-based learning (PBL) methodologies.
Dependent Variable (DV): The application of mathematical concepts to real-world problem-solving tasks by secondary-level students.

Methodology

"The research methodology is the procedure which is used by the researchers to gather data for resolving problems of investigation and design of the research comprises of the whole procedure which is conducted research" (Ahmad et al., 2022).

Table 1: Tools of responses

Sr. No	Tool	Purpose	Respondents	Statistical Techniques
1	Questionnaire *(Experimental Design)*	1. Analyzing the Effect of Emerging Pedagogies on Students' Problem-Solving Ability in Mathematics at Secondary Level	Head teachers ,SST and Secondary classes	Descriptive statistics: Percentage, mean score, standard deviation etc.
		2.To identify the Effect of Flipped Classroom Model through Project-Based Learning on Students' Problem-Solving Ability (*Real-World Application)* in Mathematics at Secondary Level	Head teachers ,SST and Secondary classes	Independent-Samples T Test;
2	Observation sheet (Experimental Design and Tasks for solve the problems and use it real -world applications)	1.To explore Effect of Flipped Classroom Model through Project-Based Learning on Students' Problem-Solving Ability (*Real-World Application)* in Mathematics at Secondary Level	Secondary classes (Math)	Pre-test Post -test Experimental &Control groups. And Solution

Data Collection and Analysis

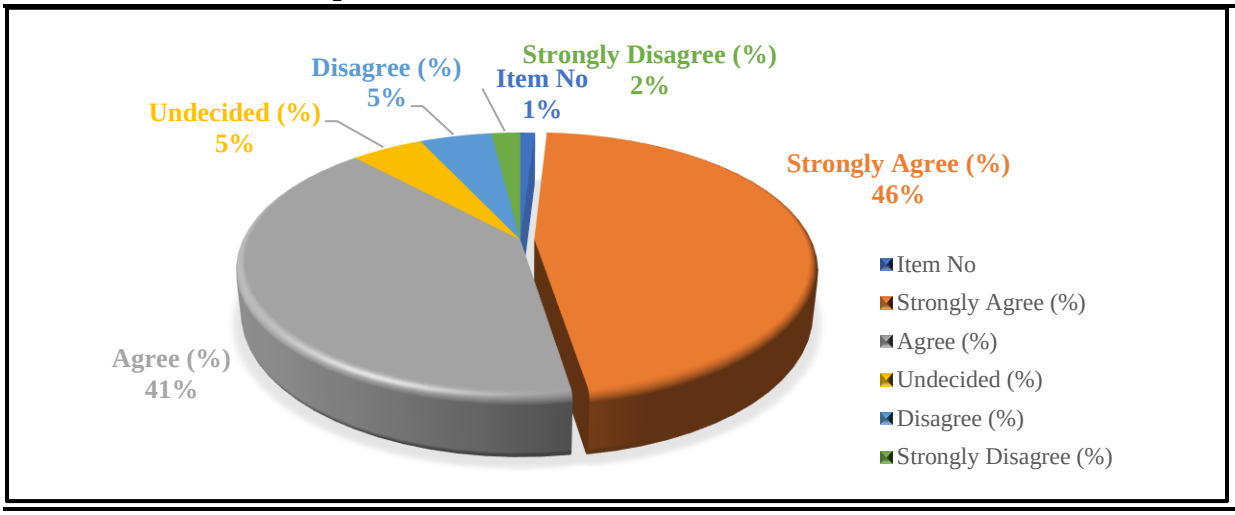
Research population from each Tehsil of South Punjab. Prior consent from the District Education Authorities is taken. The collected data were analyzed with the help of software Statistical Package SPSS findings for the research topic "analyzing the effect of emerging pedagogies on students' problem solving ability in Mathematics at secondary level". The formal authority letter for data collection was obtained from the supervisor at department of education NCBAE Lahore, Sub campus Rahim Yar Khan

All Secondary schools students, SSTs (Secondary School Teachers), and Head Teachers of South Punjab having three divisions namely Multan, Bahawalpur and Gera Ghazi Khan

Data Analysis

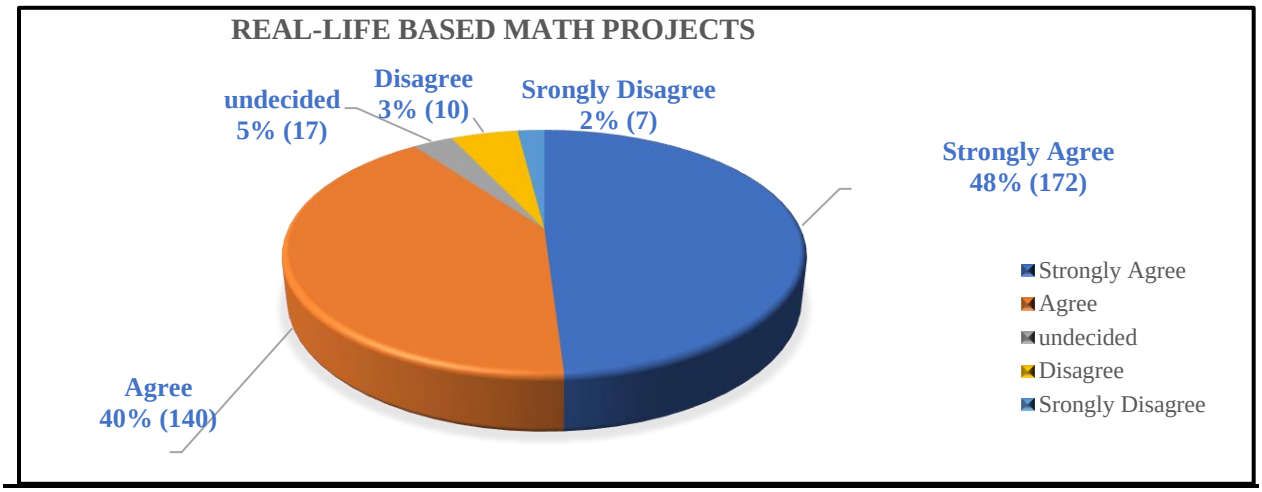
Responses of Sample

Figure 3: Indicator 1: Integration of Flipped Classroom Model: Engagement with pre-recorded video lectures prior to classroom instruction



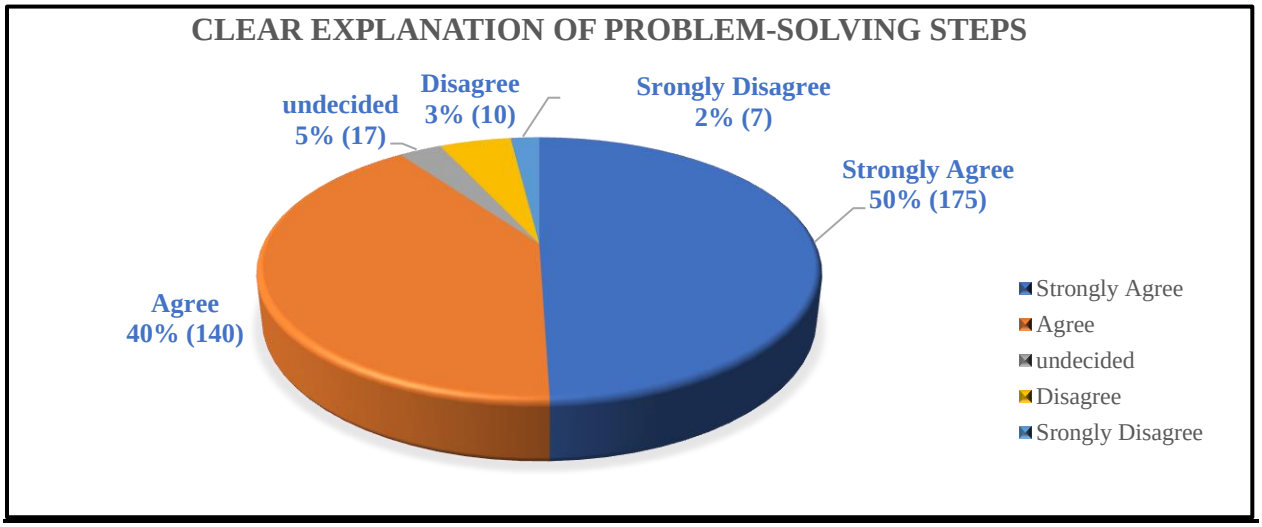
Out of the total respondents of 350, 200 students, 100 SSTS and 46 head teachers, 90% agreed that they view the video lectures of the teachers prior to the lessons. This implies that 100% of respondents demonstrated positive attitude to pre-class video activity that is the essential part of the flipped classroom concept.

Figure 4: Project-Based Learning Strategies: Involvement in mathematical projects rooted in real-world contexts



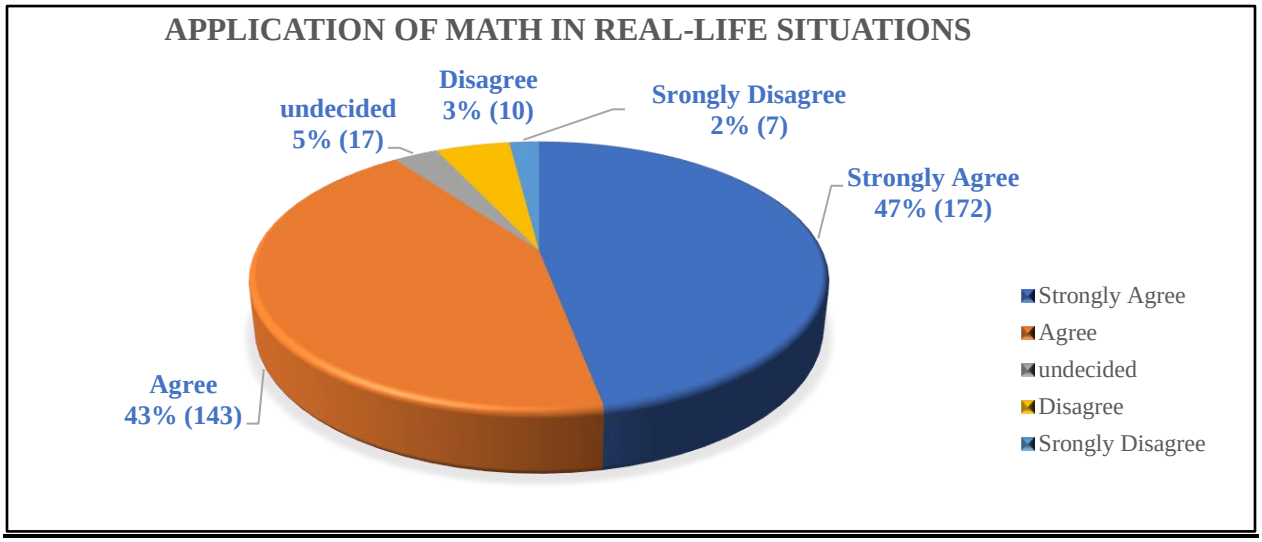
This means a total of 92% participants showed agreement, reflecting the strong integration of real-world applications within the Math curriculum under the project-based learning model These results confirm that students find real-life context highly relevant and engaging, which in turn supports deeper understanding and motivation in Mathematics learning.

Figure 5: Mathematical Problem-Solving Skills



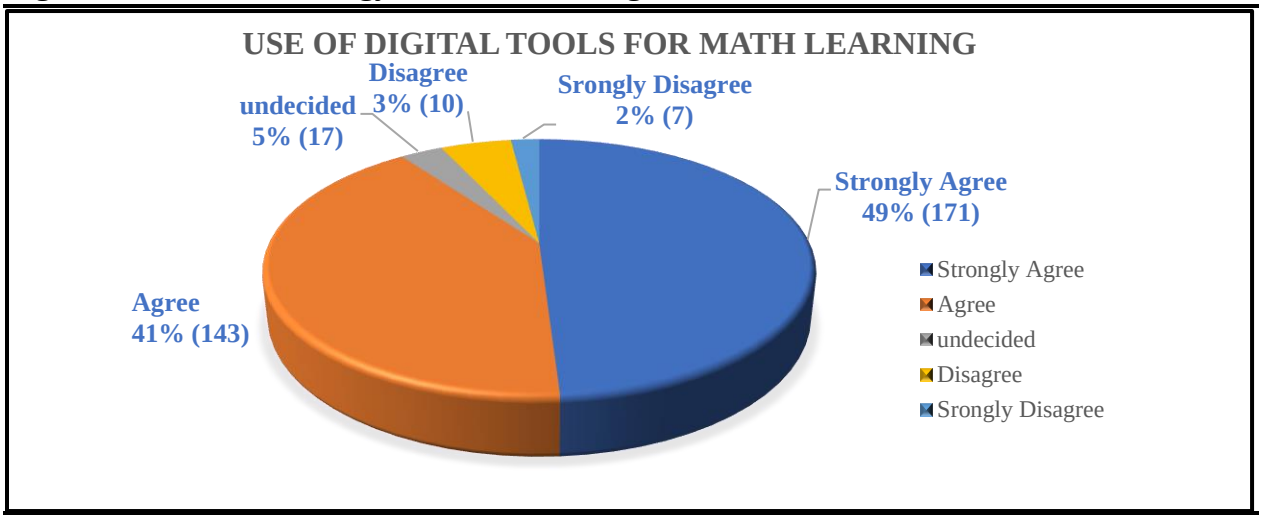
Summed up this gives 90 percent positive answers or in other words this shows clear development of mathematical reasoning and communicating ability by learners This indicates that not only the flipped method, as well as project-based learning is on its way of assisting students comprehend mathematical procedures, but it is also making them well articulate their problem-solving processes, which is of paramount importance in deep learning.

Figure 6: Real-World Application of Mathematics



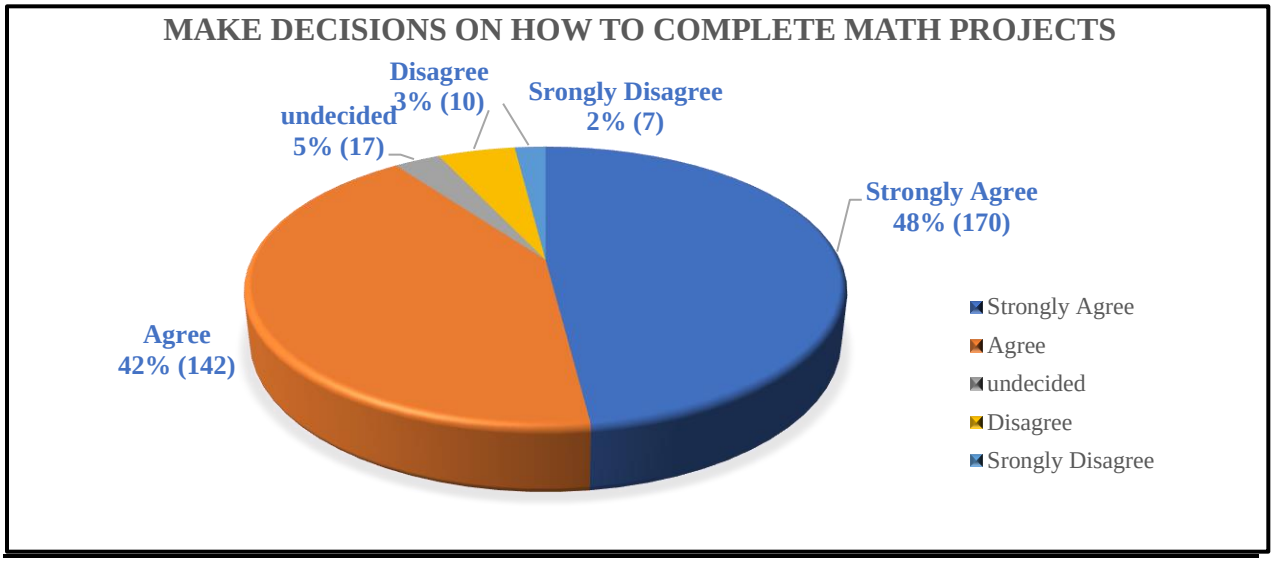
Of the 350 respondents (200 students, 100 SSTs and 50 head teachers) 47 percent said, strongly agreed and 43 percent said they apply Math skills to real life activities like shopping, budgeting or planning. This represents an overall 90 percent agreement which is a good demonstration of the fact that there is an effective closure of the gap between Mathematics study concepts and real life concepts.

Figure 7: Use of Technology in Math Learning



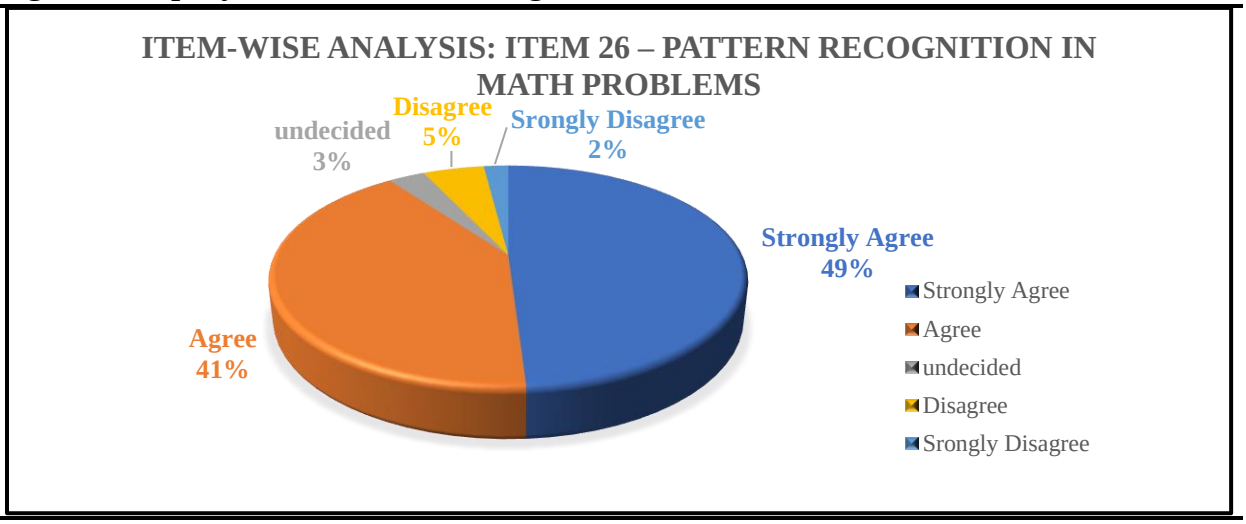
Of the 350 respondents (200 students, 100 SSTs, and 50 head teachers), 49 percent of them strongly based their answer on the 41 % agreement that they use digital tools through apps, videos, or software in learning Math. Forty percent of them also agreed to use digital tools in their Math learning .Such results favor the increased use of educational technology to promote students subject comprehension, visualization, and interaction in Math.

Figure 8: **Collaboration and Peer Learning**



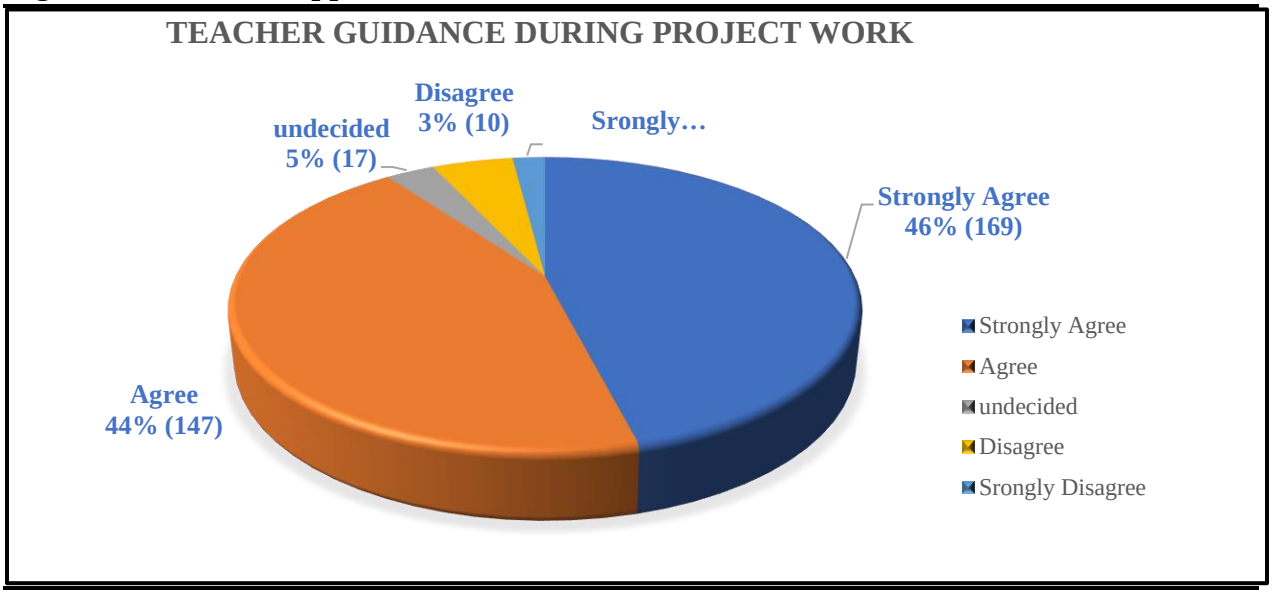
Among 350 respondents (200 students, 100 SSTs and 50 head teachers), 48 percent were strongly in agreement, and 42 percent were in agreement that they often request, or provide assistance to peers when working at Math problems. Such an amount makes 90 percent the same which indicates the effectiveness of collaborative learning encouraged by flipped and project-based teaching.

Figure 9: Inquiry and Critical Thinking



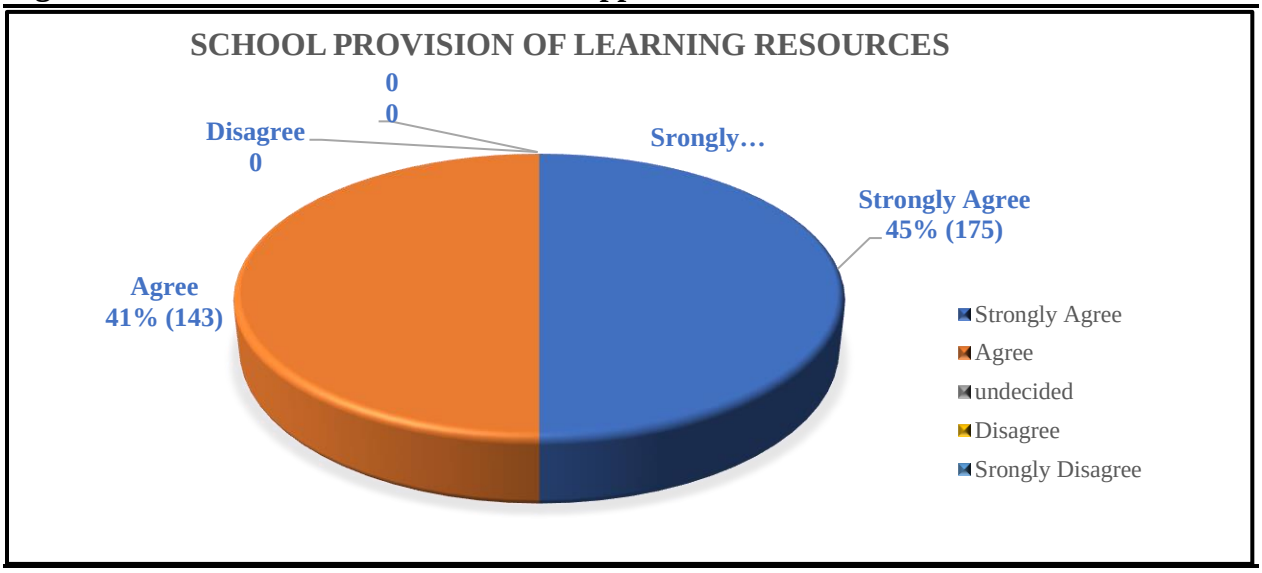
Of the 350 respondents (200 students, 100 SSTs, and 50 head teachers), 49 percent strongly agreed and 41 percent agreed that they are proactive in looking out to explore patterns and logical links in solving Math problems. This amounts to 90% concurrence, outlining that students are not only gaining critical and analytical thinking capacities but this is highly desirable in both the flipped classroom and project-based learning

Figure 10: Teacher Support and Instruction



Of all the 350 respondents (200 students, 100 SSTs and 50 head teachers), 46 percent strongly agreed and 44 percent agreed that teachers actively mentor them through the project work in Mathematics class. This translates into a total agreement of 90 percent, which indicates positive influence of teachers and instructional assistance in the process of project-based learning.

Figure 11: Administrative and Resource Support



My school gives me internet, learning devices or space. Of the total 350 respondents (200 students, 100 SST and 50 head teachers), 50 percent strongly agreed and 50 percent agreed that their school has the necessities including internet connection, computer machines, or even physical location that facilitates learning. That comes in 100 percent of total agreement, reflecting robust system of infrastructure support in most schools that make it easy to achieve flipped and project-based learning. There was great consistency on the positive answers, mean was 4.28.

Conclusion

Flipped Classroom (Pre-Class Videos)
Finding: 90% watch videos before class.
Action: Build a shared video bank. Track viewing weekly.

Project-Based Learning
Finding: 92% engage in real-world Math projects.
Action: Link projects to local problems. Use simple rubrics.

Problem-Solving Skills
Finding: 90% show better reasoning and explanation.
Action: Add 1 reasoning task in every assignment.

Real-World Math Use
Finding: 90% apply Math in shopping, budget, and planning.
Action: Start a student real-life Math diary.

Technology in Math Learning
Finding: 90% use apps, videos, or software.
Action: Use tools like GeoGebra for graphs and visualization.

Peer Collaborations
Finding: 90% help peers in Math tasks.
Action: Assign monthly rotating peer-tutor groups.

Inquiry & Critical Thinking
Finding: 90% explore patterns and logic.
Action: Add 1 pattern-finding question per lesson.

Teacher Instruction Support
Finding: 90% confirm strong teacher mentoring.
Action: Give milestone feedback in projects.

Admin & Resource Support
Finding: 100% agree resources are provided. Mean = 4.28 high support.
Action: Maintain stable internet and device access.

Findings and Discussion

Effect of Flipped Classroom through Project-Based Learning on Students' Problem-Solving Ability in Mathematics at Secondary Level" — integrating global perspectives, recent studies, my study's factors and indicators

1. **Global Shift in Math Pedagogy and Rationale for the Study**
   The world over, education systems have been experiencing a shift in education delivery that entails the move away of the traditional approach of passive yet lecturing kind of teaching to learner-oriented classroom settings. With the growing awareness of the relevance of problem-solving skills in Mathematics especially in the higher or secondary levels of education,

teachers and researchers have sought ways of revising the traditional teaching models that have been in use. One of the most noticeable and innovative methods is flipped classroom methodology along with the project-based learning (PBL). All these strategies stimulate in-depth comprehension, teamwork, and critical thinking, which are, usually, disregarded by the traditional approaches. As part of this study which was carried out in the setting of the Pakistani secondary schools, 350 respondents (200 students, 100 secondary school teachers [SSTs], and 50 head teachers) answered 40 items classified across 10 indicators. All indicators covered a major element of flipped-PBL approach, such as integration of video learning, cooperation in the group, correlation with the real life, inquiry thinking approach, and academic institution support. The needs and demands of problem-solving in the real world in the 21st century is promoted by such movements as 21 st century skills organized by organizations like UNESCO, OECD, and World economic forum, and therefore, the introduction of Mathematics education that would cater not only to the demands but also to the needs of real-world problem-solving. Thus, this paper can be used to contribute data on a developing country to the increasing amount of evidence adequation the flipped and project-based instructions.

2. **Integration of Pre-Class Video Learning and International Evidence**
   A highlighted feature of the flipped classroom was the use of video lectures recorded in advance, which was one of the discussed essential aspects. The study data indicated that 90 percent of the respondents have strongly agreed or agreed that they watched the video content prior to arriving at class, their mean score was 4.28 with standard deviations (SD) of 0.67.

3. **Project-Based Learning as a Core Driver of Skill Development**
   The other significant concern of the research was the project-based learning as an approach that helps to increase student comprehension of the concept of Mathematics in the real world. The answers to such indicators as interdisciplinary learning, decision-making in project activities, and teamwork showed percentages of agreement high enough (more than 88%), which strengthened the role of PBL. Students claim that now they can apply the ideas of Mathematics to their everyday lives, comprehend how this knowledge would be helpful in future jobs and obtain freedom to choose how to solve the tasks.

4. **Role of Technology, Collaboration, and Teacher Support**
   The third topic of interest involved the positive setting that was necessary to advance flipped-PBL models. Agreeable levels were determined in the indicators concerning technology usages (Apps, calculators, and software), peer support, and comments of the teachers. Respondents agreed that digital technologies supported their ideas of visualization of Math concepts, whereas collaboration activities gave access to mutual strategies.

5. **Implications of Findings and Pathways for Educational Reform**
   On the whole, the given research proves the efficiency of integrating flipped classroom strategies and project-based learning to enhance the problem-solving capacity of secondary school students. The findings reveal that students should be prepared to work with pre-class contents, use Math meaningfully, and take part in collaborative learning activities.

Recommendations

1. **Train Teachers in Flipped-PBL Pedagogy**
   Regular professional development workshops should be conducted to equip teachers with the skills to implement flipped and project-based learning strategies effectively.

2. **Ensure Availability of Digital Infrastructure**
   Schools should be provided with reliable internet, multimedia tools, and devices to facilitate video lectures and technology-based project activities.

3. **Develop Contextualized Video Content**
   Curriculum-aligned video lessons in local contexts and languages should be created to enhance students' understanding and relatability.

4. **Encourage Collaborative Project Work**
   Schools should design project tasks that promote teamwork, peer learning, and problem-solving to foster 21st-century skills.

5. **Incorporate Real-Life Applications in Curriculum**
   Mathematics curricula should include practical, real-world scenarios to make learning more meaningful and applicable.

6. **Adopt Flexible Teaching Timetables**
   Allow time within the school schedule for project completion, feedback sessions, and flipped learning activities.

7. **Provide Student Access Beyond the Classroom**
   Learning platforms and video content should be accessible at home to support student preparation before class.

8. **Use Formative Assessment Tools**
   Teachers should employ digital quizzes, peer reviews, and reflective journals to assess student progress regularly.

9. **Engage Parents in the Learning Process**
   Awareness programs for parents can help them understand the flipped-PBL model and support their children at home.

10. **Monitor and Evaluate Implementation**
    School administrators should regularly evaluate the effectiveness of flipped- PBL practices and make adjustments based on student feedback and outcomes

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