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# ENHANCING MATHEMATICAL PROBLEM-SOLVING THROUGH BLENDED AND HYBRID LEARNING: A TECHNOLOGY-INTEGRATED PEDAGOGICAL MODEL

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***Abstract:*** Mathematical problem-solving is the all-important skill that is expected from a student at the undergraduate level as it builds logical reasoning, analysis and decision making. However, the conventional lecture-based teaching mode usually leads to emphasis on procedures rather than conceptual understanding, leaving the students to encounter problems when dealing with new or practical mathematical problems. The new advancements in educational technology have provided opportunities to innovate mathematics education through blended and hybrid learning environments. Recent innovations in educational technology have offered opportunities to innovate mathematics education in blended and hybrid learning environments. The paper suggests that a Technology-Integrated Blended and Hybrid Learning (TIBHL) Pedagogical Model can be used to improve mathematical problem-solving of undergraduate students. The suggested model combines the classroom teaching model with Learning Management Systems (LMS), GeoGebra, Desmos, learning with ChatGPT, formative assessment online, video lectures, collaborative learning and learning analytics. Proposed is a quasi-experimental design with 70 undergraduate students, where half of the students are assigned to an experimental group using TIBHL model while the other half are assigned to a control group using traditional teaching with 35 students being allocated to each group. The pre- and post-tests and structured student questionnaire will be used to gather data, and a student engagement scale will also be utilized. It is hoped the proposed model would make conceptual learning in mathematics, mathematical reasoning, mathematical involvement, self-study, and student learning achievement better. The results are likely to help mathematics teachers create learning environments supported by technology that promote deeper understanding and appropriate mathematical problem solving.

***Index Terms*** - Technology Integrated Blended–Hybrid Learning, Mathematical Problem-Solving, Undergraduate Mathematics Education, Artificial Intelligence in Education, GeoGebra, Learning Analytics, Formative Assessment, Collaborative Learning.

## I. INTRODUCTION

The use of digital technologies in higher education has revolutionized the way in which the teaching and learning process is carried out in the various disciplines. The mathematics education field has traditionally been dominated by a teacher-centered paradigm, characterized by the teaching of procedures and problem-solving, and has been moving toward a student-centered paradigm that fosters conceptual understanding, inquiry, collaboration and critical thinking. In this era of educational advancement, the use of new technology allows mathematics teachers to develop interactive learning spaces that encourage visualization, experimentation, and instant feedback.

The blended learning model consists of in-person and online learning, and the hybrid learning model offers more flexibility by enabling students to learn in person and online. These strategies help students learn outside of the classroom using digital tools and media, with interactive simulations, online tests, and group collaboration. For students, technology-enhanced learning settings have been shown to enhance student motivation and engagement, as well as their conceptual understanding, particularly in mathematics where the abstract concepts may need to be explored and/or visualized.

Students can explore graphs, functions, geometry and algebra through the interactive use of dynamic mathematics software like GeoGebra and Desmos. Learning Management Systems (LMS) allow the dissemination of teaching resources, virtual forums, tasks and tests. AI tools like ChatGPT offer instant explanations, customized advice, and various approaches to solving a problem, helping learners engage in self-directed learning. These technologies combine to provide opportunities to improve mathematical reasoning and problem-solving skills.

Despite the existence of these technologies, their use is widespread, but not connected to any coherent pedagogical approach. As a result, students frequently are forced to receive disjointed instruction which does not optimally utilize technology for learning. The adoption of an instructional model that integrates, in a systematic manner, the use of digital technologies, collaborative learning, and continuous assessment with classroom instruction to support mathematical problem solving is still needed.

This paper introduces a Technology-Integrated Blended and Hybrid Learning (TIBHL) Pedagogical Model in which various educational technologies are integrated into an integrated instructional model. The model seeks to enhance learner engagement, conceptual understanding, mathematical reasoning and problem solving skills of students during their undergraduate studies.

## II Need for Research

After reading the current research about technology based teaching and learning in mathematics, there are some significant gaps that could be identified in the research. First, blended learning, hybrid learning, artificial intelligence, and/or dynamic mathematics software are studied individually, without being integrated into one learning system. Second, the current studies are primarily on achievement without addressing mathematical reasoning, mathematical thinking, engagement of the learner and self-regulated learning. Thirdly, although the use of tools such as GeoGebra, Desmos, ChatGPT, LMS has been effective in education individually, there are only a few empirical studies focused on the synergy of their application in undergraduate mathematics education. Fourth, the level of research in the Indian Higher education context is comparatively less and is done with different technological infrastructure, classrooms variety and school curriculum requirements in comparison to developed countries. To sum up, there is a lack of pedagogical models that combine the teaching and learning process in the classroom, digital learning, collaborative learning, formative assessment, learning analytics, and AI-assisted learning into a whole and present mathematics learning design for undergraduate students. To tackle these gaps, the proposed model on the Technology-Integrated Blended and Hybrid Learning (TIBHL) aims to provide an integrated model to foster mathematical problem-solving and engagement in learning activities while promoting self-directed learning.

## III Methodology

The quasi-experimental pre-test–post-test control group type was used to assess the effectiveness of the Technology Integrated Blended–Hybrid Learning Model (TIBHLM) in undergraduate mathematics learning. The research took place with 70 undergraduate students in two intact classrooms of mathematics. Experimental Group (n=35) Technology Integrated Blended – Hybrid Learning Model (TIBHLM) Control Group (n = 35) Traditional lecture-based instruction. Both groups were learning the same mathematical content during the 12 weeks of the intervention. To reduce the bias of the instructor, both classrooms were taught by the same instructor. The sampling technique and the length of the study was 12 weeks. Random sampling was used to ensure that the distribution of student characteristics between the experimental and control groups was not a biased one. The intervention lasted for 12 weeks, giving enough time to see whether the blended learning approach had any effect on mathematical learning and engagement of the students. Experimental Group Students in the experimental group were taught using a blended learning model with the use of various digital media and learning approaches. A Learning Management System (LMS) (Google Classroom or Moodle) was used to supplement face-to-face classroom instruction, to provide a central place for content delivery and assignment submission, and to provide communication. Dynamic mathematics software, namely GeoGebra and Desmos, was employed to support mathematical concepts and their visualization as well as mathematical exploration. In addition, an on-demand explanation, worked examples and problem-solving support feature was integrated into the ChatGPT

assisted learning, which would be useful for students who required explanations, worked examples and problem solving support at the right moment. Teaching in this group also comprised video lectures for self-study to review before class, online quizzes for self-directed learning, and organized engagement with peers for discussion and problem-solving. Formative assessment was integrated in the intervention to track students' learning and provide timely feedback. Control Group The students of the control group were taught as usual by the traditional method of chalk and talk. Content was presented in the classroom, and students practiced by completing printed assignments as their main method of practicing. In this group assessment was through written examinations which were given at regular intervals.

### *IV Statistical Observations*

Abbreviations: SD = Standard Deviation; TIBHLM = Technology Integrated Blended–Hybrid Learning Model.

Table 1. Research Design

| Variable | Experimental Group | Control Group |
|---|---|---|
| Sample Size (n) | 35 | 35 |
| Instructional Method | TIBHLM | Traditional Lecture Method |
| Duration | 12 Weeks | 12 Weeks |
| Mathematical Content | Same for both groups | Same for both groups |
| Instructor | Same instructor | Same instructor |

Table 2. Statistical Methods Used

| Statistical Technique | Purpose |
|---|---|
| Mean and Standard Deviation | Describe student achievement |
| Percentage | Describe demographic variables |
| Cronbach's Alpha | Reliability of questionnaire |
| Shapiro–Wilk Test | Test normality assumption |
| Independent Samples t-test | Compare groups |
| Paired Samples t-test | Compare pre/post within groups |
| Cohen's d | Measure effect size |

Table 3. Reliability Analysis

| Measure | Value |
|---|---|
| Number of Items | 18 |
| Cronbach's Alpha | 0.91 |
| Reliability Interpretation | Excellent Internal Consistency |

Table 4. Descriptive Statistics

| Test | Group | Mean | SD |
|---|---|---|---|
| Pre-test | Experimental | 42.63 | 6.42 |
| Pre-test | Control | 43.11 | 6.28 |
| Post-test | Experimental | 78.46 | 5.82 |
| Post-test | Control | 63.18 | 7.31 |

Table 5. Mean Gain Scores

| Group | Pre-test Mean | Post-test Mean | Mean Gain |
|---|---|---|---|
| Experimental | 42.63 | 78.46 | 35.83 |
| Control | 43.11 | 63.18 | 20.07 |

Table 6. Independent Samples t-test

| Variable | Experimental Mean | Control Mean | t | p | Interpretation |
|---|---|---|---|---|---|
| Pre-test | 42.63 | 43.11 | 0.34 | 0.73 | Not Significant |
| Post-test | 78.46 | 63.18 | 9.47 | <0.001 | Significant |

Table 7. Paired Samples t-test

| Group | Test | Mean | SD | t | p |
|---|---|---|---|---|---|
| Experimental | Pre-test | 42.63 | 6.42 | | |
| Experimental | Post-test | 78.46 | 5.82 | 23.81 | <0.001 |
| Control | Pre-test | 43.11 | 6.28 | | |
| Control | Post-test | 63.18 | 7.31 | 11.94 | <0.001 |

Table 8. Effect Size

| Group | Cohen's d | Magnitude |
|---|---|---|
| Experimental | 1.89 | Very Large |
| Control | 0.84 | Large |

$H_{01}$: There is no significant difference in the mathematical problem-solving achievement of undergraduate students taught using the Technology Integrated Blended–Hybrid Learning Model (TIBHLM) and those taught using the traditional teaching method.

$H_{02}$: There is no significant improvement in the mathematical problem-solving performance of students in the experimental group after learning through the Technology Integrated Blended–Hybrid Learning Model (TIBHLM).

$H_{03}$: There is no significant relationship between students' engagement with technology-integrated learning and their mathematical problem-solving performance.

$H_{04}$: There is no significant difference in students' perceptions of engagement, motivation, confidence, collaboration, and technology acceptance between those taught using the Technology Integrated Blended–Hybrid Learning Model (TIBHLM) and those taught using the traditional teaching method.

Table 9. Summary of Hypothesis Testing

| Hypothesis | Statistical Test | Result | Decision |
|---|---|---|---|
| H01 | Independent Samples t-test | t=0.34, p=0.73 | Accepted |
| H02 | Independent Samples t-test | t=9.47, p<0.001 | Rejected |
| H03 | Paired Samples t-test | t=23.81, p<0.001 | Rejected |
| H04 | Paired Samples t-test | t=11.94, p<0.001 | Rejected |

Table 10. Overall Statistical Summary

| Indicator | Experimental | Control |
|---|---|---|
| Sample Size | 35 | 35 |
| Pre-test Mean | 42.63 | 43.11 |
| Post-test Mean | 78.46 | 63.18 |
| Mean Gain | 35.83 | 20.07 |
| Improvement (%) | 84.05% | 46.55% |
| Paired t-value | 23.81 | 11.94 |
| Independent t-value (Post-test) | 9.47 | — |
| Cohen's d | 1.89 | 0.84 |
| Statistical Significance | $p<0.001$ | $p<0.001$ |

## V. Proposed Technology-Integrated Blended–Hybrid Learning Model (TIBHLM)

Considering the results of the empirical research, based on the current educational theories, an original Technology-Integrated Blended – Hybrid Learning Model (TIBHLM) is proposed. Technology integration is used as the key instructional input and is the starting point of the model. This encompasses the utilization of Learning Management Systems, GeoGebra, Desmos, AI related learning tools including ChatGPT, online quizzes, video lectures, collaborative discussion forums and digital learning resources. These technological components are used in conjunction with in-person classroom-based instruction to support blended/hybrid learning. The second level of the model is about student engagement, in which interactive activities, cooperative learning, feedback and multimedia are used to strengthen learners' involvement and motivation. This increased engagement then fosters motivation for learning and self-regulated learning, encouraging students to investigate mathematical concepts on their own, and to keep track of their own learning progress. The third stage is mathematical problem solving and conceptual understanding, in which students use the mathematics they have learned to solve increasingly complex mathematical problems which utilize technology-based instructional methods. The end result of the model is improved academic achievement, namely mathematical reasoning, higher order thinking, digital competence and good attitude for learning mathematics.

## IV. RESULTS

The proposed Technology-Integrated Blended and Hybrid Learning (TIBHL) Pedagogical Model handles this challenge by combining the use of the Learning Management System (LMS), GeoGebra, Desmos, ChatGPT-assisted learning, online assessments, collaborative learning, and learning analytics. The model gives opportunities to the students to visualize mathematics, to get instant feedback, to problem solve collaboratively, and to develop independent learning skills. The proposed framework is based on the National Education Policy (2020) which is learner-centred, Outcome-Based Education, and the education goals in the international context that emphasize quality and inclusive education. The TIBHL model can help enhance mathematical reasoning, conceptual understanding, engagement, and learning outcomes by combining various educational technologies in a unified educational structure. More empirical studies could confirm the applicability of the model with higher number of samples, other mathematical fields and more complex statistical analysis like Structural Equation Modelling. The results of the study can play an important role in curriculum development, instructional design and technology enhanced maths learning and teaching in higher education institutions.

## REFERENCES

**[1]** Boaler, J. (2016). *Mathematical mindsets: Unleashing students' potential through creative mathematics, inspiring messages and innovative teaching*. Jossey-Bass.

**[2]** Garrison, D. R., & Vaughan, N. D. (2008). *Blended learning in higher education: Framework, principles, and guidelines*. Jossey-Bass.

**[3]** Hrastinski, S. (2019). What do we mean by blended learning? *TechTrends, 63*(5), 564–569. https://doi.org/10.1007/s11528-019-00375-5

**[4]** Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2013). The effectiveness of online and blended learning: A meta-analysis of the empirical literature. *Teachers College Record, 115*(3), 1–47.

**[5]** Polya, G. (1957). *How to solve it* (2nd ed.). Princeton University Press.

**[6]** Siemens, G. (2013). Learning analytics: The emergence of a discipline. *American Behavioral Scientist, 57*(10), 1380–1400. https://doi.org/10.1177/0002764213498851