AMC JOURNAL (DHANGADHI)
Year 8; June, 2025; Vol. 6; Issue 1; PP. 57-64 DOI: https://doi.org/10.3126/amcjd.v6i1.82108

Enhancing Flipped Pedagogy Using JavaScript

Bed Prasad Dhakal, PhD

Central Department of Education, Tribhuvan University
Email: bed.dhakal@cded.tu.edu.np
https://www.bedprasaddhakal.com.np
ORCID ID: https://orcid.org/0000-0002-1510-5046

Article History: Received on: May 5, 2025, Accepted on: June 25, 2025

Abstract

Integrating innovative pedagogy using digital tools can enhance students learning in mathematics education. So, this study investigates how to effectively use flipped pedagogy, focusing specifically enhanced by javascript mathematical simulations. Over a period of four months, we implemented and observed a pedagogical intervention of enhanced flipped pedagogy in a course "Differential Geometry", which is a third semester course of Master in Mathematics Education at Tribhuvan University, Nepal. Through a qualitative analysis rooted in design-based and grounded theory methodologies, this study placed emphasis on sixteen student's (five girls, eleven boys) perspectives, to design and refine enhanced flipped pedagogy. The finding of the study reveal two critical elements that support the successful implementation of enhanced flipped pedagogy: (a) well-structured and purposeful task formulation and (b) centralized digital learning platforms.

Keywords: Mathematics education, flipped pedagogy, Design-Based Research.

Introduction

As a faculty of mathematics education at Central Department of Education (CDED), University Campus (UC), Tribhuvan University (TU), I teach master's level students who are future educators in Nepal. So, our primarily responsibility is preparing master's level students as teacher to lead in increasingly technology-driven classrooms, where the rise of digital tools and artificial intelligence (AI) in education has rapidly changing the shift toward student-centric and learning-centric learning models. In this shift, flipped pedagogy is emerging as a transformative approach in school as well as higher education sector.

Flipped pedagogy traditionally involves students engaging with instructional videos before class, reserving in-class time for active learning (Weinhandl et al., 2020, Eltahir, 2017). However, this model often remains passive when limited to video consumption only, as I experienced. To address the limitations of this type of conventional flipped pedagogy, this article aims to investigate how JavaScript (JS)-enhanced Flipped Pedagogy (FP) can transform mathematics instruction, improve learner engagement, and support the development of higher-order thinking skills among future educators. So, I proposed an enhanced flipped pedagogy (EFP) that integrates video with JavaScript-based simulations, fostering deeper exploration, interaction, and discovery in mathematics learning.

In particular, I applied this approach in a course entitled "Differential Geometry (DG)", which is a third semester course of Master in Mathematics Education at TU. I hosted the course on my personal

Year 8; June, 2025; Vol. 6; Issue 1; PP. 57-64 DOI: https://doi.org/10.3126/amcjd.v6i1.82108

webpage: https://www.bedprasaddhakal.com.np/p/differential-geometry.html, which is based on google blogger, and followed by https://bpdhakal.com.np/, which is based on Moodle LMS. Both webpage combines YouTube videos, learning text furnished by HTML with interactive JavaScript(JS) simulations to support flipped learning for conceptual understanding and real-world modeling in mathematics education.

For this the research question of this study was "How does enhanced flipped pedagogy support student learning in mathematics?"

To answer the research question, this study is grounded in two key pillars: YouTube videos and JavaScript-enhanced instructional simulation. As in the literature, flipped learning redefines the traditional classroom dynamics, shifting direct instruction to pre-class activities and transforming in-class time into collaborative, problem-solving sessions as learning interaction (Weinhandl et al., 2020, Eltahir, 2017, Karabulut-Ilgu et al. 2018), which is enhanced by JavaScript (JS) simulations.

JavaScript(JS) is a free, versatile programming language that supports both 2D and 3D geometry, as well as computer algebra system (CAS) functionalities. Its platform-independent nature makes it ideal for educational use across devices and operating systems. Being JavaScript a flexible and accessible programming language, is added to this model by enabling interactive simulations that simulates and visualize mathematical concepts, which is embedded in web platforms, making them easily accessible and integrable into YouTube and HTML furnished flipped learning environments.

So, the model is named as "enhanced model of flipped pedagogy (EFP)".

It is believed that, together, YouTube videos and JavaScript simulation promote a dynamic interaction between content, learners, and digital tools as learning object. This synergy enhances mathematics education by allowing students to engage in flipped pedagogy with concepts construction actively, rather than passively consuming information from videos.

Methods

This study employed a combination of Design-Based Research (DBR) and Grounded Theory Approaches (GTA). As mentioned in literature, Design-Based Research (DBR) is a systematic and flexible research method that can effectively minimize the gap between researcher and participate in formal education (Creswell et al., 2018; Denzin and Lincoln, 2018; McKenney and Reeves, 2014), which is usually to answer a common dichotomy: those who are primarily involved in teaching are often not engaged in research, and those who do research, but do not involve in classroom teaching.

A core feature of DBR is the collaborative research design and testing of iterative interventions, which can be learning resources, activities, assessments, or technological tools (Anderson & Shattuck, 2012). In this study, DBR facilitated the iterative development and refinement of instructional design for enhanced flipped pedagogy, through YouTube videos and JavaScript based interactive simulation. For this intervention, the pre-class materials included YouTube based video lectures and JavaScript simulations through web pages: https://www.bedprasaddhakal.com.np/p/differential-geometry.html, and https://bpdhakal.com.np/ allowing students to constructively engage with learning content at their own learning pace. The first one was extensively used for resource purpose, while the later one was extensively used of activities purpose.

Year 8; June, 2025; Vol. 6; Issue 1; PP. 57-64 DOI: https://doi.org/10.3126/amcjd.v6i1.82108

The study followed four iterative design cycles while developing the content, videos and simulation, incorporating student feedback to refine instructional strategies (resource and activities) and support student's independent learning. The researcher himself documented lesson reports to capture successes and challenges, and multiple design cycles were used to improve learning resources and learning activities in the web.

Phase 1: Students were provided with YouTube videos and JS worksheets on the webpage. These videos and JS worksheets were created by the researchers and extended by further reading texts in HTML furnished form. According to the content, students had to exercise with given activities and solve given problems as pre-class activities.

Phase 2: Students were given Videos and JS based learning worksheets that are included with questions. Students used Moodle LMS through https://bpdhakal.com.np/ webpage to solve these questions and write their constructive answers and reasonable justifications to elaborate in the following class.

Phase 3: Students were provided with Videos and JS worksheets, which are created with questions or learning assignments. In addition, JS worksheets were designed for students to check their answers in MCQ formats- i.e. particularly using Moodle Lesson tool indicated whether their provided answer or solution was correct. The students were instructed to present constructive understandings and suggestions.

Phase 4: Students were provided with Videos and JS worksheets, including open questions in Moodle LMS using Forum tool. The students had to deal with these open questions to present their solution and argumentation in following live class.

The Grounded Theory Approaches (GTA) is used in the analysis of student activities in their natural learning environments. GTA was used to analyze student interactions and feedback. The data analysis began with identifying initial patterns from informal classroom-based conversations.

The study is conducted over four months (May–Sept 2024) time duration while teaching a semester course at Tribhuvan University, Nepal. The course is "Differential Geometry (DG)", which is a third semester course of Master in Mathematics Education. The participants of this study involved sixteen students (five boys, 11 girls), who were reading this third semester of a master's program in mathematics education. The content focused on this study, are from the topics of the course such as curves in space, surfaces, fundamental forms, and non-intrinsic properties.

Data collection included over 160 informal, natural classroom-based conversations with sixteen students (5 girls, 11 boys) during live classes. Open coding yielded 67 initial codes, which were refined to 49 through comparison and observation. Axial coding linked these codes to causes, action strategies, and consequences, centered around two core phenomena. This process led to the identification of two essential categories for effective student learning in video and JavaScript-enhanced flipped pedagogy, which are (a) Clear task definition and design and (b) Unified learning environments.

Results

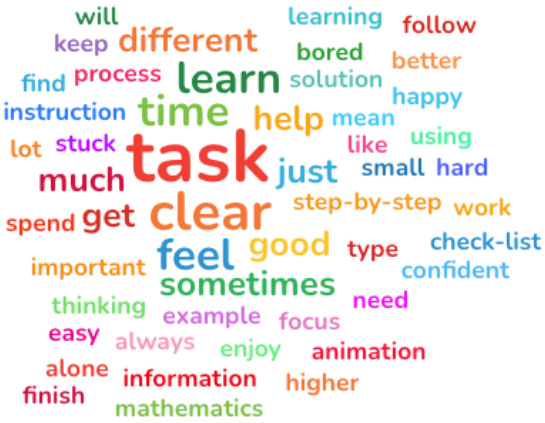
To explore emerging themes from the study, I employed an inductive coding approach. A total of 17 quotations related to the participants' experiences were extracted and categorized based on informal

Year 8; June, 2025; Vol. 6; Issue 1; PP. 57-64 DOI: https://doi.org/10.3126/amcjd.v6i1.82108

classroom conversations. These quotations were then visualized using a word cloud tool, which highlighted frequently occurring and prominently emphasized terms across the data set.

Figure 1:

World cloud of 17 quotations



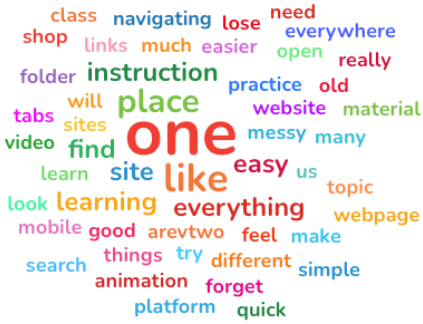
Words such as clear, instruction, task emerged as dominant, indicating a shared emphasis on task clarity. Based on this lexical pattern, the theme "Clear task definition and design" was inductively derived, reviewing the quotations. This theme captures the participants' collective perception of the importance of well-defined instructions in enhancing their engagement and understanding during the activity.

This indicated that students emphasized the need for clear, detailed task instructions to support automated independent learning through enhanced flipped pedagogy. Based on the follow up discussion, they preferred step-by-step guidance, sample solutions to avoid mechanical repetition and maintain smooth engagement.

To further uncover students' perceptions regarding the enhanced flipped pedagogy learning experience, another group of 32 quotations were collected from conversations and reflections related to learning automation. These quotations were again visualized through a word cloud, which revealed recurrent terms such as one place, everything together, smooth, no confusion, and easy access. Based on the frequency and prominence of these words and re-review of quotations, the theme "Unified learning environment" was identified.

Figure 2:

World cloud of 32 quotations



Based on the follow up discussion, students appreciated having all resources consolidated in one location, a single source webpage. For example, one student remarked that

> It is easy to follow because everything was in one place—notes, videos, interactive file, and quizzes.

Another student said similar version, as she mentioned that

> I didn't have to search or ask repeatedly; the site guided me step by step.

These sentiments suggest that the integration of instructional materials across the two platforms contributed to a smooth and coherent learning experiences, however, student preferred to have them in single web environment, such as through single URL. During the course delivery two integrated learning platforms were used, one is hosted in google blogger and another in Moodle LMS respectively by the sites https://www.bedprasaddhakal.com.np/p/differential-geometry.html and https://bpdhakal.com.np/. The theme "Unified learning environment" thus encapsulates students' positive reception of an organized and centralized learning space that minimized confusion and enhanced their sense of learning through single site.

From the data, it is resulted that students preferred centralized platforms that housed all learning materials—videos, JavaScript files, quiz, discussions, questions, assignments and instructions. May be, fragmented resources across multiple sites (in this study two sited were used) have led them to confusion and can reduced motivation. So, a unified platform was found as a key to efficient and independent automated student learning through enhanced flipped pedagogy.

Discussion and Findings

The study revealed that enhanced flipped pedagogy enhances student engagement, understanding, and learning automation. The two identified categories are task clarity, and centralized resources, which are crucial for designing effective enhanced flipped pedagogy.

In a literature, it is mentioned that, the flipped learning model is an effective instructional approach that significantly enhances student learning, primarily by shifting towards a more student-centered methodology and leveraging technology (Eltahir, 2017). This view is justified in this study as a student mentioned in a talk that

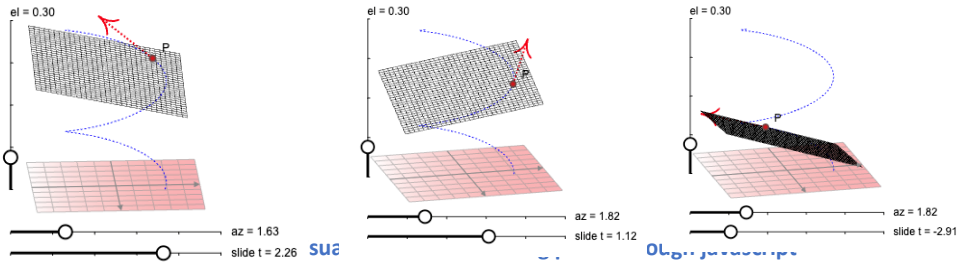
> "In my learning experience, the webpage is really effective! It's been great because it actually me to learn on my own, which I love. Plus, using interactive things definitely helped me learn and understand better, for example osculating plane."

It can be said that, this enhanced flipped pedagogy not only supports conceptual learning but also prepares students for real-world problem solving by simulating authentic mathematical scenarios. By combining video instruction with interactive JavaScript simulations, student have enjoyed rich, student-centered learning experiences that align with the demands of 21st-century education, working with digital tools. This view is also mentioned in a literature that enhanced flipped learning model is built on constructivist cum connectivist learning theory, which emphasizes that students actively construct knowledge through interactions with their environment, including friends, instructors and tools, based

Year 8; June, 2025; Vol. 6; Issue 1; PP. 57-64 DOI: https://doi.org/10.3126/amcjd.v6i1.82108

on their current and prior knowledge and authentic experiences (Koohang et al., 2011; Eltahir, 2017). This kind of essence is also articulated in a student response that

> "Honestly, this semester became a lesson learn. It's not just about understanding the concepts; it pushes us to actually learn mathematics. The videos and interactive things in website are brilliant – they make the math feel so real, and interactive, like we're feeling actual problems. For example, the applet of osculating plane, and I feel like I'm genuinely building my knowledge that as it differs as the point moves along the curve."



The students opinion can be justified by the text in the web. For example, the figure through the webpage illustrates the concept of an osculating plane in 3D space, which is a fundamental concept in differential geometry for understanding the local behavior of a space curve. The three panels show different snapshots of an interactive visualization, developed in JavaScript.

As the student explained, the space Curve (Blue Dotted Line) represents a three-dimensional curve, where Point P (Red Dot) specific a moving point on the space curve where the osculating plane is being calculated and displayed by simulation. The osculating Plane (Gridded Surface is the flat surface shown, which is based on the given point P on a curve, described as having "three-point contact" with the curve at P, meaning it contains the tangent line at P and also captures the direction of the curve's instantaneous bending. In the figure, tangent Vector (Red Arrow) originates from point P and lies within the osculating plane, indicating the direction of the curve at that exact point. The best I learn is as t changes, the point P moves along the curve, and consequently, the osculating plane recalculates and changes its orientation to remain the "best fitting" plane at the new position of P on the curve.

The three panels demonstrate how the osculating plane changes its position and orientation as the point P moves along the blue curve, showcasing its dynamic relationship with the curve's instantaneous curvature.

By the explanation, it can be seen that the three panels demonstrate how the osculating plane changes its position and orientation as the point P moves along the blue curve, showcasing its dynamic relationship with the curve's instantaneous curvature, which is the benefits of design based research (Anderson and Shattuck, 2012; Wang and Hannafin, 2005; McKenney and Reeves, 2014, 2013).

Learning is an individual process. So, it depends on learner's cognitive structure. To ensure optimal learning, it is essential to provide students with readily accessible resources, doable activities and in-need guidance throughout the task completion process. It is said that effective task design plays important role in fostering conceptual understanding, maintaining student engagement, and optimizing the overall learning experience in mathematics education (Weinhandl et al., 2020). This study also

found that the structure and clarity of instructional tasks significantly influence a student's ability to independently navigate the learning process and enhance a meaningful understanding of the content. The provided webpages with videos and JS simulations enabled students to grasp the intended objectives of a task, thereby minimizing confusion and promoting efficient problem-solving strategies. It is found that breaking down complex tasks into smaller, structured steps can reduce cognitive overload, making the learning process accessible for students with varying levels of mathematical proficiency.

From the discussion it is also seen that enhanced flipped pedagogy support student learning in mathematics through unified learning environment, which is also exemplified by literature, for example, it is said that student enjoy the discussion-based and interactive nature of the classroom if flipped pedagogy is used (Weinhandl et al., 2020). This study also found that providing a unified learning resources for flipped pedagogy helped student remember material better and often needed. Enhanced flipped pedagogy with JavaScript in addition offered a powerful model because it transformed the passive video consumption into active exploration through simulation, which supported independent learning, and fostered deeper understanding.

> Fo example, student said that "….the applet of osculating plane, .. I feel like I'm genuinely building my knowledge that as it differs as the point moves along the curve."

So, this study provides a foundation for further research, and pedagogical innovation in this promising area enhanced flipped pedagogy, particularly for the educational innovation in mathematics education.

References

Anderson, T. and Shattuck, J. (2012). Design-Based Research: A Decade of Progress in Education Research? Educational Researcher, 41(1):16–25.

Creswell, J. W., Creswell, J. D., Creswell, J. W., and Creswell, J. D. (2018). Research design: qualitative, quantitative, and mixed methods approaches. SAGE, Los Angeles London New Delhi Singapore Washington DC Melbourne, fifth edition.

Denzin, N. K. and Lincoln, Y. S., editors (2018). The SAGE handbook of qualitative research. SAGE, Los Angeles London New Delhi Singapore Washington DC Melbourne, fifth edition.

Eltahir, M. E. A. B. (2017). Instructional Design Model for Applying Flipped Learning in Higher Education Institutions. European Journal of Social Sciences Education and Research, 11(1):58.

Karabulut-Ilgu, A., Yao, S., Savolainen, P., and Jahren, C. (2018). Student Perspectives on the Flipped-Classroom Approach and Collaborative Problem-Solving Process. Journal of Educational Computing Research, 56(4):513–537.

Koohang, A., Riley, L., Smith, T., and Schreurs, J. (2011). E-Learning and Constructivism: From Theory to Application. Interdisciplinary Journal of E-Learning and Learning Objects, 5.

McKenney, S. and Reeves, T. C. (2013). Systematic Review of Design-Based Research Progress: Is a Little Knowledge a Dangerous Thing? Educational Researcher, 42(2):97–100.

McKenney, S. and Reeves, T. C. (2014). Educational Design Research. In Spector, J. M., Merrill, M. D., Elen, J., and Bishop, M. J., editors, Handbook of Research on Educational Communications and Technology, pages 131–140. Springer New York, New York, NY.

Wang, F. and Hannafin, M. (2005). Design-based research and technology-enhanced learning systems. Educational Technology Research & Development, 53:1042–1629.

Weinhandl, R., Lavicza, Z., Hohenwarter, M., and Schallert, S. (2020). Enhancing Flipped Mathematics Education by Utilising GeoGebra. International Journal of Education in Mathematics, Science and Technology, 8(1):1.