TEACHING MATHEMATICS TO SCHOOL STUDENTS USING MODERN PEDAGOGICAL TECHNOLOGIES

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Abstract. This paper examines how modern pedagogical technologies can improve the teaching of mathematics in secondary schools. It reviews the theoretical foundations of technology-supported instruction and describes six practical approaches: dynamic mathematics software, the flipped classroom, problem-based learning, gamification, peer instruction, and digital formative assessment. Each approach is illustrated with a concrete classroom example. The paper also discusses typical obstacles and offers recommendations for teachers. The main conclusion is that technology is effective only when it serves a clear pedagogical purpose and keeps students actively thinking.

Keywords: mathematics education, pedagogical technologies, GeoGebra, flipped classroom, problem-based learning, gamification, formative assessment.

1. Introduction

Mathematics is often described by students as abstract, difficult, and disconnected from everyday life. Traditional lessons, in which the teacher explains a rule at the board and students copy and repeat it, can produce procedural skill but frequently fail to build deep understanding. Many students learn to follow steps without knowing why the steps work, and they forget them soon after the examination.

Today's students grow up with smartphones, video, and interactive applications. This creates both a challenge and an opportunity. If the classroom remains unchanged, attention and motivation decline. If digital tools and active methods are introduced thoughtfully, the same students can explore, test conjectures, and receive instant

feedback in ways that were impossible a generation ago. The aim of this paper is to show how modern pedagogical technologies can be used in school mathematics, and to explain each technology through specific, ready-to-use examples.

2. Theoretical Foundations

Modern technologies in mathematics teaching rest on several well-established ideas. Constructivism holds that students build knowledge actively rather than receive it passively. Papert (1980) extended this view by arguing that learners understand mathematical objects best when they can build and manipulate them, which is exactly what dynamic software allows. Vygotsky (1978) introduced the zone of proximal development: students learn most when tasks lie just beyond what they can do alone, with support from a teacher or peer. Collaborative and scaffolded activities are designed around this principle.

Pulya (1945) described problem solving as a cycle of understanding the problem, devising a plan, carrying it out, and looking back. Technology can support every stage of this cycle, for example by letting students visualize a problem, test a plan numerically, and verify the result graphically. Finally, research on assessment by Black and Wiliam (1998) shows that frequent, informative feedback is among the most effective ways to raise achievement. Digital tools make such feedback fast and practical even in large classes.

3. Modern Pedagogical Technologies with Examples

3.1. Dynamic mathematics software

Programs such as GeoGebra and Desmos connect algebra, geometry, and graphs in one interactive environment. Their main advantage is that students can change an object and immediately see the consequences.

Example 1: quadratic functions (Grade 9). The teacher prepares the function $y = ax^2 + bx + c$ with three sliders a, b, and c. Students are asked: What happens to the parabola when a changes from 1 to −1? When a approaches 0? How does c affect the

point where the graph crosses the y-axis? After five minutes of exploration, students formulate their own rules: the sign of a determines whether the parabola opens upward or downward, and c is the y-intercept. Only then does the teacher present the formal vertex formula $x = -b / 2a$ and the discriminant $D = b^2 - 4ac$. Because the rules were discovered rather than memorized, students retain them better and can explain them in their own words.

Example 2: geometry (Grade 8). In GeoGebra, students draw any triangle ABC, measure its three angles, and drag a vertex. The sum remains 180° in every position. Seeing the invariant across many cases builds the intuition that precedes a formal proof.

3.2. The flipped classroom

In the flipped classroom, students study new material at home through a short video or reading, and class time is used for practice, discussion, and individual help (Bergmann & Sams, 2012). This reverses the usual order and gives the teacher more time to work with students who struggle.

Example 3: the Pythagorean theorem (Grade 8). Before the lesson, students watch a seven-minute video showing that in a right triangle with legs a and b and hypotenuse c, $a^2 + b^2 = c^2$. They answer two check questions online. In class, the teacher first reviews the most common errors from the check questions. Students then work in pairs on tasks such as: A ladder 5 m long leans against a wall with its base 3 m from the wall. How high does it reach? (Answer: $\sqrt{(25 - 9)} = 4$ m.) The teacher moves between pairs, giving targeted help. Instead of spending twenty minutes lecturing, the lesson is spent almost entirely on thinking and problem solving.

3.3. Problem-based and project-based learning

In this approach, students learn mathematics by solving authentic problems that do not have an obvious single method. The problem comes first, and the necessary

mathematical tools are developed while solving it. This shows students why mathematics matters.

Example 4: the school garden (Grade 7). A group receives the task: "The school has a rectangular plot of 12 m by 8 m. Design a garden with flower beds and a path, and calculate how much fencing and soil you need within a budget of 500,000 soums." Students calculate the area ($12 \times 8 = 96$ m²) and the perimeter ($2 \times (12 + 8) = 40$ m), divide the plot into parts, compare prices, and present their plan to the class. Along the way they use area, perimeter, percentages, unit conversion, and estimation, and they practise communication and teamwork.

3.4. Gasification

Gamification applies game elements such as points, levels, badges, and friendly competition to learning tasks. Platforms such as Kahoot, Quizizz, and Blooket allow teachers to run quick quizzes with a live leaderboard. The goal is not entertainment alone, but regular low-stakes practice that students actually want to do.

Example 5: fraction fluency (Grade 6). At the start of the lesson, the teacher runs a five-minute quiz with questions such as $1/2 + 1/3 = ?$, $3/4 \times 2/5 = ?$, and which is larger, 5/8 or 2/3? Students answer on their phones, and a leaderboard appears after each question. The class then sees which question had the most wrong answers and the teacher reteaches that point immediately. To keep the activity healthy, the teacher emphasizes personal progress, for example by awarding a badge for improving one's own score, so that weaker students are not discouraged.

3.5. Peer instruction and collaborative learning

Mazur (1997) proposed a simple structure: the teacher poses a conceptual multiple-choice question, students vote individually, discuss with a neighbor, and vote again. Discussion typically raises the share of correct answers because students explain ideas to each other in familiar language.

Example 6: sign of a product (Grade 7). The teacher asks: "If $a < 0$ and $b < 0$, what is the sign of $a^3 \cdot b^2$?" Options: positive, negative, zero, cannot be determined. Many students first choose incorrectly. After two minutes of pair discussion, they notice that b^2 is always positive and a^3 is negative, so the product is negative. The teacher then asks one pair to explain the reasoning to the class.

3.6. Digital formative assessment

Formative assessment checks understanding during learning, not only at the end. Short digital forms, online quizzes, and exit tickets give the teacher a clear picture of the class within minutes.

Example 7: exit ticket on linear equations (Grade 8). In the last three minutes, students answer on a form: (1) Solve $3x - 5 = 10$. (2) Explain in one sentence what was done to both sides. (3) Rate your confidence from 1 to 5. If 40% of students solve the first problem incorrectly, the teacher plans a short review for the next lesson. If most are correct but confidence is low, the teacher adds more varied practice. In both cases, the next lesson is based on evidence and not on guesswork.

3.7. Combining technologies in one lesson

In practice, the technologies described above work best when combined. A single 45-minute lesson can use several of them without becoming overloaded. The following structure shows how this might look for the topic "Linear functions" in Grade 8:

Minutes 0–5 (gamified warm-up). A quick Kahoot quiz reviews coordinates and substitution, such as finding y when $x = 2$ in $y = 3x - 1$.

Minutes 5–15 (dynamic exploration). Students use sliders in Desmos for $y = kx + m$ and describe the effect of k and m on the line.

Minutes 15–25 (peer instruction). A conceptual question: "Two lines have the same k but different m. Will they intersect?" Students vote, discuss, and vote again.

Minutes 25–40 (problem solving). In groups, students compare two taxi tariffs, 2,000 soums plus 1,500 per km against 4,000 plus 1,000 per km, and find the distance at which the prices are equal (4 km).

Minutes 40–45 (formative assessment). An exit ticket with two questions and a confidence rating.

Such a lesson keeps students active at every stage, provides several moments of feedback, and shows how the same mathematical idea can be viewed through a graph, an equation, and a real-life situation.

Table 1. Summary of technologies and examples

Technology	Classroom example	Expected learning outcome
Dynamic software (GeoGebra, Desmos)	Moving sliders a, b, c in $y = ax^2 + bx + c$	Understanding of parameters and graph shape
Flipped classroom	Video on the Pythagorean theorem at home; problems in class	More class time for practice and feedback
Problem-based learning	Planning a school garden within a fixed budget	Transfer of area and perimeter to real life
Gamification (Kahoot, Quizizz)	Five-minute fraction quiz with live leaderboard	Higher motivation and quick fluency practice
Peer instruction	Vote on a concept question, discuss, vote again	Correction of misconceptions
Digital formative assessment	Exit ticket with three questions	Timely data for adjusting teaching

4. Challenges and Recommendations

Introducing modern technologies is not without difficulty. The most common obstacles are limited devices or internet access, insufficient teacher training, large class sizes, and the risk that technology becomes decoration rather than a learning tool. The following recommendations help to address them:

Start with the learning goal. Choose a tool only if it helps students understand something better than a traditional method would.

Begin small. Introduce one technology at a time, such as a single GeoGebra activity per week, and evaluate the result.

Plan for low-resource conditions. Use one shared computer or projector, group work on a single phone, or offline versions of the software.

Keep students thinking. Require explanations and justification, so that clicking does not replace reasoning.

Share and learn. Teachers benefit from exchanging ready-made materials and observing each other's lessons.

It is also important to evaluate whether a chosen technology actually works. Teachers can compare results on the same topic before and after introducing a new method, collect short student feedback, and track indicators such as homework completion, participation in discussion, and the number of common errors on tests. If a technology does not improve understanding, it should be adjusted or replaced. This reflective cycle of planning, teaching, evaluating, and improving turns the use of technology from a one-time experiment into a stable part of professional practice.

5. Conclusion

Modern pedagogical technologies can make mathematics lessons more visual, active, and personalised. Dynamic software helps students discover relationships; the flipped classroom frees time for practice; problem-based learning links mathematics to real life; gamification and peer instruction raise motivation and engagement; and digital formative assessment gives teachers the information needed to adjust their teaching. The examples in this paper show that such methods do not require expensive equipment, only careful planning and a clear pedagogical purpose. Technology does not replace the teacher; rather, it extends the teacher's ability to understand each student and to build lasting mathematical understanding.

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