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THE USE OF EDUCATIONAL TECHNOLOGY TO SUPPORT DIFFERENTIATED INSTRUCTION IN PRIMARY SCHOOL CLASSROOMS IN INDONESIA

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Abstract

Differentiated instruction is increasingly needed in primary schools because students enter classrooms with diverse readiness levels, learning interests, learning profiles, digital familiarity, and academic needs. However, many teachers still experience difficulty implementing differentiation because of limited time, large class size, assessment demands, and the complexity of providing varied learning pathways. Educational technology offers practical support for differentiated instruction by enabling diagnostic assessment, flexible grouping, multimodal content delivery, adaptive tasks, formative feedback, and student-paced learning. This study aims to examine how educational technology supports differentiated instruction in primary schools and how it affects students' learning engagement and academic achievement. The study employed a mixed-method design using a quasi-experimental pretest-posttest control group approach supported by classroom observations, teacher interviews, student interviews, and document analysis. The participants were 124 Grade V students and eight primary school teachers. The experimental group received technology-supported differentiated instruction for eight weeks, while the control group received conventional instruction. Quantitative data were analyzed using descriptive statistics, paired-sample t-tests, independent-sample t-tests, and effect size analysis. Qualitative *data were analyzed thematically. The findings showed that technology-supported differentiated instruction improved students' achievement and engagement more substantially than conventional instruction. Qualitative findings revealed that educational technology helped teachers identify students' needs, provide tiered materials, monitor learning progress, and give timely feedback. The study concludes that educational technology can strengthen differentiated instruction when it is pedagogically guided, assessment-informed, inclusive, and aligned with primary students' developmental characteristics.*

Keywords: *educational technology; differentiated instruction; primary school; student engagement; mixed method*

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A. Introduction

Primary classrooms show substantial diversity in prior knowledge, reading and numeracy skills, attention span, pace, interests, and home support, so teachers cannot assume all students learn the same way—making differentiated instruction important for learning equity and classroom responsiveness.

Differentiated instruction means adapting content, process, product, and environment to students' readiness, interests, and learning profiles—not separate lessons per student, but responsive planning offering multiple pathways to access and demonstrate understanding (Tomlinson, 2014), especially relevant since foundational competencies develop unevenly among children.

Differentiation is hard to implement consistently since it demands diagnosing needs, preparing varied materials, organizing groups, and giving timely feedback with large classes and limited time—often reduced to extra tasks for fast learners or remedial worksheets for strugglers, missing its pedagogical depth (Roy, Guay,

& Valois, 2013; Smale-Jacobse, Meijer, Helms-Lorenz, & Maulana, 2019).

Educational technology can help by enabling diagnostic information, multimodal resources, differentiated tasks, progress monitoring, and efficient feedback, letting students access varied difficulty levels and formats—supporting rather than replacing the teacher (Sailer, Murbock, & Fischer, 2021; Tondeur, van Braak, Ertmer, & Ottenbreit-Leftwich, 2017).

Digital tools support differentiation when pedagogically integrated: computerized systems show small-to-moderate positive effects (Deunk, Smale-Jacobse, de Boer, Doolaard, & Bosker, 2018), and ICT-based differentiation supports more effective primary learning when adapted to needs (Palieraki & Koutrouba, 2021)—though technology alone does not guarantee effectiveness; its value depends on teacher use.

In many schools, technology is still used mainly for presentation, which does not automatically create differentiation—it works only when connected to diagnostic assessment, flexible grouping, task variation, and formative feedback.

Post-pandemic, teachers and students are more familiar with digital platforms, so the challenge is no longer whether but how technology improves instructional quality, requiring practical, age-appropriate integration models (Falloon, 2020; Bond, Bedenlier, Marin, & Handel, 2021).

This also supports inclusive education: struggling readers can use audio-supported texts, visual learners can use videos, advanced learners can pursue enrichment, and low-confidence students can repeat exercises privately, expanding instructional flexibility.

However, challenges remain: limited teacher digital competence, unequal infrastructure, uneven student access and self-regulation, and platform-curriculum mismatch—warranting research on both outcomes and implementation experience.

This study examines educational technology's use in supporting differentiated instruction in primary schools, asking: (1) does it significantly improve achievement versus conventional instruction; (2) does it improve engagement; (3) how do teachers implement it; and (4) what challenges emerge?

B. Method

This study used a mixed-method design: a quasi-experimental pretest-posttest control group design to examine effects on achievement and engagement, plus observations, interviews, and document analysis to explain how technology supported differentiation in practice.

Participants were 124 Grade V students from four classes and eight teachers: two classes (62 students) as experimental group and two classes (62 students) as control, from schools with similar curriculum and comparable digital access.

The experimental group received technology-supported differentiated instruction for eight weeks through five stages: diagnostic digital quizzes, flexible grouping based on results, tiered materials (slides, videos, interactive worksheets, audio-supported texts, enrichment tasks), formative feedback, and reflection.

The control group received conventional instruction—textbook explanation, whole-class teaching, printed worksheets, teacher-led exercises—covering the same topics without structured technology-supported differentiation.

Instruments were a 30-item achievement test (reliability 0.84) and a 24-item engagement questionnaire (reliability 0.88, covering behavioral, emotional, and cognitive engagement), both given before and after the intervention.

Qualitative data came from eight observations, interviews with eight teachers and 16 students, and learning documents, focusing on differentiation strategies, participation, tool use, and challenges.

Quantitative data were analyzed via descriptive statistics, t-tests, normalized gain, and Cohen's d; qualitative data via thematic analysis (Braun & Clarke, 2006; Nowell, Norris, White, & Moules, 2017), with triangulation, member checking, and standard ethical procedures.

Qualitative data were analyzed using thematic analysis. The analysis involved data familiarization, coding, theme development, theme review, and interpretation (Braun & Clarke, 2006; Nowell, Norris, White, & Moules, 2017). Data triangulation was conducted by comparing observation notes, interview transcripts, and learning documents. Member checking was conducted with selected teacher participants to confirm the accuracy of interpretations. Ethical procedures were applied by obtaining school permission, informing participants about the study purpose, anonymizing student identities, and ensuring that participation did not affect students' grades.

C. Finding and Discussion

1. Finding

Findings are presented in four parts: academic achievement before/after intervention, changes in learning engagement, how technology supported differentiation, and implementation challenges.

Students' Academic Achievement before and after the Intervention

Pretest results showed similar initial achievement (experimental M = 61.42, SD = 8.36 vs. control M = 60.87, SD = 8.21), with no significant difference, $t(122) = 0.37$, $p = .711$.

After eight weeks, the experimental group (M = 80.35, SD = 7.64) outperformed the control group (M = 70.14, SD = 8.02), $t(122) = 7.27$, $p < .001$, with a large effect size, Cohen's d = 1.30.

Table 1. Academic Achievement Scores of Experimental and Control Groups

Group	Test	N	Mean	SD	Interpretation
Experimental	Pretest	62	61.42	8.36	Moderate
Experimental	Posttest	62	80.35	7.64	High
Control	Pretest	62	60.87	8.21	Moderate
Control	Posttest	62	70.14	8.02	Moderate to high

Source: Processed from student achievement test data.

The experimental group improved significantly from pretest to posttest, $t(61) = 18.64$, $p < .001$, versus a smaller control improvement, $t(61) = 9.42$, $p < .001$. Mean gain was 18.93 (experimental) versus 9.27 (control); normalized gain was 0.49 (moderate) versus 0.24 (low-to-moderate).

Table 2. Gain Scores and Statistical Comparison

Indicator	Experimental Group	Control Group	Statistical Result
Mean gain	18.93	9.27	Experimental group higher
Normalized gain	0.49	0.24	Moderate vs. low-to-moderate
Posttest comparison	80.35	70.14	$t(122) = 7.27$; $p < .001$
Effect size	-	-	Cohen's d = 1.30; large effect

Source: Processed from pretest and posttest data.

These findings indicate technology-supported differentiated instruction produced stronger academic improvement, suggesting students benefited from materials and tasks adjusted to their readiness, needs, and pace.

Changes in Students' Learning Engagement

The engagement questionnaire showed greater improvement in the experimental group, whose mean score rose from 3.12 to 4.08, versus 3.09 to 3.45 for control, a significant posttest difference, $t(122) = 6.81$, $p < .001$.

Table 3. Students' Learning Engagement Scores

Group	Pretest Mean	Posttest Mean	Gain	Interpretation
Experimental	3.12	4.08	0.96	High improvement
Control	3.09	3.45	0.36	Moderate improvement

Source: Processed from student engagement questionnaire data.

Improvement was visible across behavioral engagement (more active participation in digital tasks and quizzes), emotional engagement (lessons felt more interesting, less intimidating), and cognitive engagement (students could select tasks, review materials, and reflect on progress).

Observations supported this: experimental-group students asked more questions, used digital materials independently, and participated more in small groups; struggling students completed tiered worksheets matched to their readiness, while advanced students stayed engaged through enrichment tasks.

How Educational Technology Supported Differentiated Instruction

Qualitative analysis revealed five ways technology supported differentiation: diagnostic assessment, tiered content delivery, flexible grouping, formative feedback, and student-paced learning.

Table 4. Technology-Supported Differentiated Instruction Practices

Differentiation Practice	Technology Use	Classroom Function
Diagnostic assessment	Short digital quizzes and online exit tickets	Identified readiness levels and learning difficulties
Tiered content delivery	Videos, audio-supported texts, interactive worksheets, enrichment tasks	Provided multiple learning pathways
Flexible grouping	Digital progress records and teacher dashboards	Helped teachers organize groups based on learning needs
Formative feedback	Auto-scored quizzes and teacher comments on digital worksheets	Supported timely correction and improvement
Student-paced learning	Replayable videos, digital notes, and self-check tasks	Allowed students to repeat and review materials independently

Source: Synthesized from classroom observations, teacher interviews, and learning documents.

Diagnostic assessment: teachers used short digital quizzes to identify prior understanding, determining who needed reinforcement, standard tasks, or enrichment, making grouping decisions faster and evidence-based.

Tiered content delivery: materials varied by complexity—struggling readers got audio-supported texts and guiding questions while advanced students got longer texts and open-ended tasks; in science, some watched videos before worksheets while others went straight to problem-solving.

Flexible grouping: technology helped teachers monitor progress and reorganize groups based on current needs rather than fixed labels, with students moving between groups depending on quiz and assessment performance.

Formative feedback: auto-scored quizzes gave immediate results, and digital worksheets carried written comments, helping students revise understanding before the next task; teachers found feedback more manageable since tools recorded responses and highlighted common errors.

Student-paced learning: digital materials let students replay videos, reread instructions, and complete self-checks at their own speed, helping teachers manage diverse learning paces in one classroom.

Implementation Challenges

Challenges included infrastructure inequality—limited devices, unstable internet, or poor projector quality requiring offline alternatives and device sharing—

teacher workload, since preparing tiered digital materials, quizzes, and progress analysis took considerable time despite recognized benefits;

students' digital self-regulation, as some were distracted by games or unrelated sites, addressed through clear rules, time limits, and monitoring;

and balancing technology with direct instruction, since students still needed explanation, modeling, and emotional support that technology could not replace.

Table 5. Implementation Challenges and Teacher Responses

Challenge	Evidence from Classroom Practice	Teacher Response
Limited devices and internet	Some students shared devices and experienced slow access	Prepared offline files and group-based device use
Teacher workload	Teachers spent more time preparing tiered materials	Used reusable templates and collaborative planning
Student distraction	Some students opened unrelated applications	Applied classroom rules and time-bounded tasks
Uneven digital skills	Some students needed help navigating platforms	Provided demonstrations and peer assistance
Need for teacher guidance	Students still required explanation and support	Combined digital tasks with direct instruction

Source: Synthesized from observations and teacher interviews.

2. Discussion

Educational technology can support differentiated instruction in primary schools when used as a pedagogical tool rather than decoration. The experimental group's higher achievement and engagement suggest technology-supported differentiation helped students access appropriate materials, receive faster feedback, and work at a matching pace.

This supports research showing differentiation improves outcomes when systematic: Deunk et al. (2018) found computerized differentiation tools benefit primary performance, and this study shows diagnostic assessment, tiered content, and formative feedback contributed to gains—though technology itself was not the main factor; how teachers used it to make differentiation decisions was.

Engagement improvement matters too, since differentiation is about participation, not just achievement. Tasks that were neither too easy nor too hard—scaffolding for strugglers, enrichment for advanced students—reduced frustration and boredom and created a more inclusive environment.

This is consistent with differentiation addressing readiness, interest, and learning profile (Tomlinson, 2014; Roy et al., 2013):

technology supported readiness through diagnostics and tiered tasks, interest through multimedia, and learning profiles through varied representation (text, audio, video, images), expanding differentiation's practical possibilities.

Nevertheless, technology-supported differentiation requires strong teacher mediation—interpreting data, deciding grouping, selecting materials, and giving feedback—since without it, technology may increase activity without increasing learning, consistent with research on instructional design and teacher competence (Falloon, 2020; Sailer et al., 2021; Tondeur et al., 2017).

Formative assessment was particularly important: digital quizzes and exit tickets let teachers identify misconceptions quickly and adjust instruction during learning rather than after a unit, since differentiation requires ongoing, efficiently collected assessment evidence (Faber, Luyten, & Visscher, 2017; Ifenthaler & Yau, 2020).

Technology also supported flexible, dynamic grouping based on digital progress data rather than teacher impression or fixed categories, making grouping less stigmatizing and responsive to students' varying performance across topics.

These findings connect with broader evidence that educational technology positively influences outcomes when integrated with curriculum, professional development, and pedagogy (Cheung & Slavin, 2013; Kulik & Fletcher, 2016; Means, Toyama, Murphy, & Baki, 2013; Sung, Chang, & Liu, 2016; Tamim, Bernard, Borokhovski, Abrami, & Schmid, 2011; VanLehn, 2011), adding that technology is especially useful for evidence-based differentiation.

However, infrastructure inequality remains serious, since technology-supported differentiation may widen learning gaps if access is unequal—requiring inclusive planning with offline options, shared devices, and low-bandwidth resources.

Teacher workload is another challenge requiring professional development, collaborative planning, and reusable templates (Kahmann, Droop, & Lazonder, 2022); in this study, collaboration and reusable materials helped, but sustained institutional support remained necessary.

Student self-regulation is also essential, since primary students need explicit guidance, clear instructions, goals, time limits, and monitoring to avoid distraction—making digital citizenship part of technology-supported differentiation.

Overall, technology can strengthen differentiated instruction in primary schools when it is assessment-informed, tiered and aligned with objectives, paired with teacher feedback and guidance, and planned for inclusive access and classroom management.

D. Conclusion

This study examined educational technology's use in supporting differentiated instruction in primary schools. Students receiving technology-supported differentiated instruction achieved higher academic achievement and engagement than those receiving conventional instruction: the experimental group improved from a pretest mean of 61.42 to a posttest mean of 80.35, versus 60.87 to 70.14 for control, a significant difference, $t(122) = 7.27$, $p < .001$, with a large effect size, Cohen's $d = 1.30$, and engagement rose more substantially as well. Qualitative findings showed technology supported differentiation through diagnostic assessment, tiered content, flexible grouping, formative feedback, and student-paced learning, though implementation faced infrastructure inequality, teacher workload, student distraction, and uneven digital skills. Educational technology can support differentiated instruction effectively when pedagogically planned, assessment-driven, inclusive, and aligned with primary students' developmental needs. Future research should examine long-term implementation, different platforms, and diverse learning needs.

Declaration of AI-Assisted Technologies

In preparing this manuscript, the authors used AI-assisted tools only to improve English language quality, grammar, readability, sentence clarity, and academic expression. The AI tools were not used to generate research data, conduct data analysis, produce findings, or draw conclusions. All conceptual arguments, data interpretation, methodological decisions, and scholarly conclusions remain the full responsibility of the authors. The authors carefully reviewed, edited, and verified all AI-assisted outputs to ensure the accuracy, integrity, and originality of the final manuscript.

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