Integrating Technology in Teaching Mechanics: A Distance Learning Perspective

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Abstract - *This study explores the integration of Google Meet and Google Docs in teaching mechanics to undergraduate Physics Education students during a twelve-week online learning period. Sixteen students participated in synchronous virtual lectures and completed twelve structured assignments submitted through Google Docs. Learning outcomes were examined using pre- and post-tests, revealing substantial improvement from a mean of 59.44 (SD = 1.59) to 84.81 (SD = 2.10), supported by a very large effect size (Cohen's d = 13.60). Assignment averages remained consistent between 81 and 87, demonstrating stable engagement throughout the course. Student satisfaction data indicated high perceived ease of use and learning effectiveness, though 50% of participants reported significant connectivity challenges. The integration of Tables 1–3 and Figures 1–3 within the narrative provides a comprehensive understanding of learning trajectories and contextual constraints. The findings show that well-orchestrated digital tools can support meaningful conceptual learning even in technologically uneven environments, offering insights for future online mechanics instruction in developing educational systems.*

Keywords: *Mechanics Instruction; Online Learning; Educational Technology; Google Meet.*

INTRODUCTION

Mechanics represents one of the most fundamental domains within physics, forming the conceptual basis for understanding motion, force, and energy, concepts that resonate across classical and modern physics alike (Bryce, 2009; Galili, 2018; Bao, 2019). For pre-service physics teachers, mastery of these concepts is essential not only for academic achievement but also for shaping their future pedagogical practice (Meltzer & Otero, 2015; Euler, 2024). Traditional instruction in mechanics typically relies on in-person demonstrations, real-time conceptual clarification, and a dynamic exchange of ideas. Yet the rapid shift toward online learning during the COVID-19 pandemic has challenged these long-standing assumptions and prompted educators to rethink how abstract physical concepts can be taught through digital platforms.

Globally, online instruction has expanded dramatically, accompanied by both enthusiasm and critique. Digital tools such as Google Meet and Google Docs have been widely adopted due to their accessibility, collaborative affordances, and compatibility across devices (Mishra, 2020; Ironsi, 2022). They offer possibilities for synchronous communication, real-time feedback, shared document editing, and the archiving of learning materials. Nevertheless, online instruction often unfolds within uneven technological landscapes. Issues of digital literacy, limited connectivity, disparate device availability, and varied home learning environments have been widely documented in international research (Lee, 2016; Khan, 2017; Panigrahi, 2018; Redmond, 2018; Lasekan, 2024). Such challenges are particularly acute in developing contexts, where online learning represents not only a pedagogical effort but also a logistical negotiation.

In Indonesia, many students experience unstable internet connections, bandwidth limitations, and disruptions that make synchronous learning difficult. Against this backdrop, evaluating the effectiveness of online tools in a Mechanics course becomes a complex but highly relevant endeavor. Beyond measuring cognitive outcomes, it becomes important to understand how students navigate the tensions between instructional design and infrastructural limitations. This study thus integrates numerical results, engagement data, and student perceptions into a cohesive narrative, supported by tables and figures positioned strategically throughout the manuscript. In doing so, it contributes both to local pedagogical practice and to broader global conversations about the resilience, limitations, and pedagogical potential of online physics instruction.

RESEARCH METHODS

This study adopted a quantitative design to examine changes in conceptual understanding, engagement, and satisfaction among sixteen third-semester students enrolled in an online Mechanics course. The twelve-week instructional period began with a pre-test assessing baseline knowledge. Weekly lectures were delivered synchronously through Google Meet, combining conceptual explanations, visual demonstrations, and interactive segments where students could pose questions or share reasoning. Assignments were completed through Google Docs, which provided opportunities for revision, feedback, and asynchronous participation when connectivity problems interrupted real-time engagement.

Recognizing the persistent technological constraints faced by students, the instructional approach incorporated several adaptive measures. Recorded versions of Google Meet sessions were made available for asynchronous review. Support materials were compressed to limit data consumption. Flexible submission timelines were introduced to ensure that disruptions in connectivity did not translate directly into academic penalties. Over time, these adaptations became integral components of the instructional design rather than peripheral accommodations.

Data sources included pre- and post-test scores, assignment averages across twelve sessions, and responses to a satisfaction questionnaire. Test scores were analyzed using means, standard deviations, and effect size calculations. Assignment data were summarized descriptively, and satisfaction results were analyzed to identify patterns in students' perceptions of the digital tools. Figures 1–3 complement Tables 1–3, helping to visualize distributions, trends, and response patterns. All tables and figures are placed explicitly within the Results section as indicated throughout the narrative.

RESULTS AND DISCUSSION

Before presenting the results in detail, it is helpful to acknowledge that the different strands of data collected, test scores, assignment performance, and student satisfaction, offer complementary perspectives on how learning unfolded in this online Mechanics environment. Each dataset captures a distinct aspect of student experience: the test results trace conceptual progression, the assignment scores mark steady academic engagement, and the satisfaction responses reveal the emotional and technological context in which students worked. The positioning of tables and figures throughout the next section is intentional, meant to guide the reader through a layered narrative that reflects not only what students achieved but also the circumstances under which these achievements emerged. With this framing, the presentation of results flows naturally into the interpretive discussion that follows.

Results

The clearest indicator of conceptual improvement appears in the comparison between pre- and post-test scores. As summarized in Table 1, students began the course with a mean pre-test score of 59.44 (SD = 1.59), suggesting relatively low but homogeneous prior understanding. By the end of the course, the mean post-test score had risen to 84.81 (SD = 2.10). This substantial increase is vividly illustrated in Figure 1, where upward trajectories appear consistently across all sixteen students. The effect size of Cohen's d = 13.60 underscores the magnitude of this gain, marking it as an exceptionally strong outcome rarely observed in introductory mechanics instruction.

Table 1. Pre-Test and Post-Test Scores

No.	Student ID	Pre-Test Score	Post-Test Score	Improvement
1	S01	58	85	27
2	S02	60	87	27
3	S03	62	88	26
4	S04	59	84	25
5	S05	61	86	25
6	S06	57	82	25
7	S07	60	85	25
8	S08	58	83	25
9	S09	61	87	26
10	S10	59	84	25
11	S11	60	86	26
12	S12	62	88	26
13	S13	58	83	25
14	S14	57	81	24
15	S15	60	85	25
16	S16	59	83	24

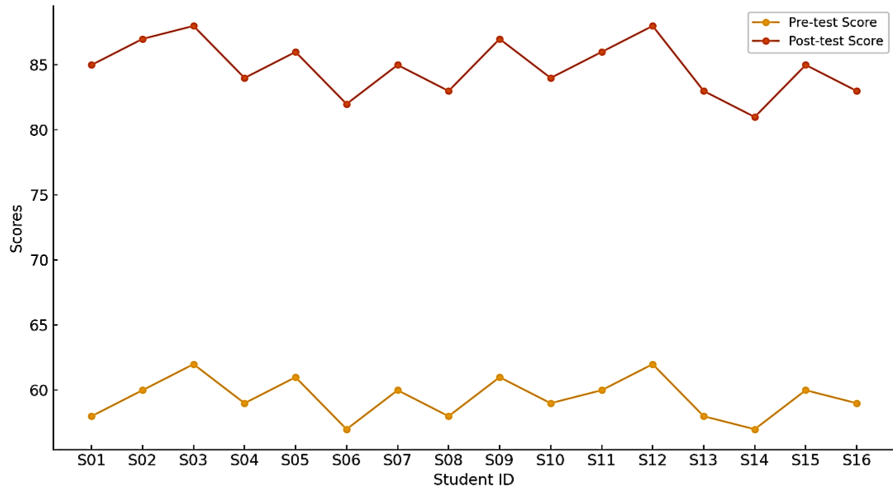

Figure 1. Comparison of Pre-test and Post-test Scores

Assignment data provides a second layer of evidence for student engagement. As shown in Table 2, assignment scores remained remarkably consistent throughout the twelve sessions, ranging from 81 to 87. This narrow range suggests that despite technological disruptions, students were able to maintain active participation and complete tasks reliably. Figure 2 reinforces this interpretation, presenting a distribution that clusters tightly around the mid-80s, reflecting sustained engagement rather than fluctuating or episodic participation.

Table 2. Average Assignment Scores for 12 Sessions

No.	Student ID	Average Assignment Score
1	S01	84
2	S02	86
3	S03	87
4	S04	83
5	S05	85

No.	Student ID	Average Assignment Score
6	S06	82
7	S07	84
8	S08	83
9	S09	86
10	S10	83
11	S11	85
12	S12	87
13	S13	83
14	S14	81
15	S15	84
16	S16	83

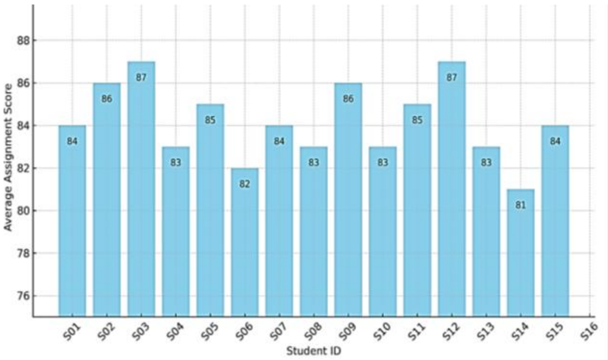

Figure 2. Average assignment scores across 12 sessions

The third dimension of the results concerns student perceptions. According to Table 3, satisfaction levels were high for ease of use (87%), learning effectiveness (90%), and instructor interaction (80%). These findings are visually reinforced by Figure 3, where satisfaction indicators rise prominently, though connectivity issues, reported by 50% of students, stand out as a persistent concern. This dual pattern suggests that while the tools supported meaningful learning, the infrastructure shaping students' access to them remained fragile.

Table 3. Satisfaction Metrics

Metric	Percentage (%)
Ease of Use	87
Learning Effectiveness	90
Interaction with Instructor	80
Internet Connectivity Issues	50

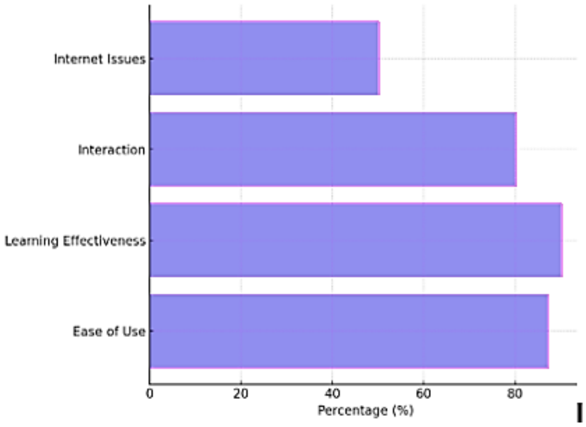

Figure 3. Satisfaction Metrics Overview

The third dimension of findings concerns student satisfaction. Table 3 presents high satisfaction levels regarding ease of use (87%), perceived learning effectiveness (90%), and instructor interaction (80%). Figure 3 visually mirrors these positive perceptions. At the same time, the data show that 50% of students experienced significant connectivity problems, introducing a counterpoint that contextualizes the otherwise encouraging results. This duality captures the complex reality of online instruction: learning can progress meaningfully even when technological conditions are unstable.

Discussion

Interpreting the findings across Tables 1–3 and Figures 1–3 provides a richer understanding of the dynamics of online mechanics learning. The substantial improvement in conceptual understanding aligns with research showing that synchronous online platforms, when paired with opportunities for review and reflection, can support robust learning in STEM disciplines (Ironsi, 2022; Redmond, 2018; Panigrahi, 2018). The magnitude of the effect size suggests not merely incremental improvement but genuine conceptual restructuring, indicating that the instructional design was well-suited to the complexities of mechanics.

The consistent assignment performance documented in Table 2 and illustrated in Figure 2 reveals the stabilizing role of asynchronous tools such as Google Docs. In many ways, asynchronous work provided continuity where synchronous instruction was disrupted. Students who missed parts of a Google Meet session could still engage deeply with the material afterward, mitigating the effects of connectivity issues. This hybrid pattern, synchronous immediacy complemented by asynchronous resilience, emerges as a pedagogical strength that may extend beyond the context of this study.

Satisfaction data from Table 3 and Figure 3 add an affective and contextual dimension to these interpretations. Students' positive perceptions suggest that the tools were not merely functional but supportive of their learning identities. Yet the high incidence of connectivity problems demonstrates the fragility of the digital learning environment in Indonesia. This tension situates the findings within broader discussions of digital equity and access. It suggests that technological integration alone does not guarantee effective learning; rather, it must be accompanied by infrastructural investment and attention to students' lived conditions.

Taken together, the results highlight that online mechanics instruction can succeed when technological tools are orchestrated thoughtfully and when instructors remain responsive to students' constraints. The study reinforces the value of hybrid learning structures that allow students to move fluidly between synchronous participation and asynchronous exploration. Furthermore, the findings emphasize the need for educational policy that strengthens digital infrastructure and expands training in digital literacy for both students and educators.

CONCLUSION

This study provides compelling evidence that integrating Google Meet and Google Docs into an online Mechanics course can produce significant conceptual gains, consistent engagement, and positive student perceptions. The dramatic rise in test scores, visualized in Table 1 and Figure 1, indicates that students were able to internalize and apply key mechanics concepts. The stability of assignment performance shown in Table 2 and Figure 2 reflects sustained engagement across the learning period, despite the complexities of remote learning environments. Meanwhile, the satisfaction data presented in Table 3 and Figure 3 show that students valued the accessibility and clarity afforded by the digital tools, even as they navigated persistent connectivity issues.

The study illustrates both the potential and limitations of online physics instruction in developing contexts. It demonstrates that thoughtfully implemented digital tools can expand learning opportunities, support conceptual understanding, and foster meaningful student–instructor interaction. At the same time, it underscores the need for infrastructure improvement and pedagogical adaptability to ensure equitable and effective learning.

Future research may extend these insights by incorporating qualitative methods, expanding sample sizes, or exploring similar interventions in other areas of physics. As online and hybrid learning continue to shape the future of education, findings from this study contribute to a broader conversation about how physics instruction can evolve to remain resilient, inclusive, and pedagogically rich.

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