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Enhancing Engineering Students' Data Interpretation and Scientific Communication through AI Prompt Engineering and Video-Based Analysis

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ABSTRACT

A critical skill gap exists among final-year engineering students concerning the interpretation of complex data and its effective communication in scientific writing. Students frequently struggle to move beyond surface-level analysis of diagrams and tables, often overlooking crucial parameters, trends, or comparisons essential for robust academic reports. This study introduces and evaluates an innovative pedagogical approach designed to address this deficiency. The core objective is to enhance the capabilities of final-year engineering students in interpreting and explaining experimental and numerical data through the application of Artificial Intelligence (A.I.) Prompt Engineering. This method utilizes Gemini A.I., with lecturers defining specific learning outcomes based on data-rich videos generated by Veo 3 Gemini. Students are then tasked with constructing and refining targeted prompt sentences that align with the video content, guiding the A.I. to assist in identifying patterns, trends, and differences within the visual and quantitative data. Initial implementation of this approach yielded promising outcomes. Students who previously provided brief or incomplete interpretations demonstrated an improved ability to generate more comprehensive and structured explanations. Many exhibited enhanced skills in identifying trends, comparing variables, and highlighting key findings from both graphical and tabular elements embedded within or derived from the dynamic video content. Feedback collected from participants indicated that they found the approach intuitive and helpful in deepening their understanding of data presentation and analysis. These preliminary results support the viability of integrating A.I. Prompt Engineering into engineering curricula. This innovative teaching strategy, which combines AI-driven analysis with video-based learning, offers a dynamic and interactive experience that has the potential to significantly improve analytical thinking, scientific communication, and overall data literacy among engineering students, preparing them for the demands of their future careers.

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1. Introduction

The ability to interpret complex data and communicate findings is essential in engineering and academic research. However, engineering education faces a major challenge. A significant challenge in engineering education is that many students struggle with analyzing experimental or numerical data presented in diagrams, tables, and other visual formats [1]. They often approach discussions in technical reports and theses without depth, focusing on obvious results and ignoring subtle variations, trends, or comparative insights that are vital for thorough analysis. This leads to weak results and discussion sections, negatively impacting the overall quality of academic work.

Several factors contribute to this widespread problem. As students are new to their fields, they are still learning what precise language looks like and often fall short [2]. Further research shows that scientific writing can be inherently challenging, requiring clarity, conciseness, objectivity, and a logical flow of information, which many students struggle to master [3]. Common issues include problems with paragraphs and a general uncertainty about the writing process, often due to a lack of writing experience [4]. Nandiyanto *et al.,* found that a significant majority, 91.5%, of university students had difficulty with the various parts of scientific articles, like the abstract, introduction, results, discussion, and conclusion [5]. Students frequently report challenges with the introduction and discussion sections, which rely heavily on data interpretation and argumentation. Even when students have a partial understanding of the data, their inability to express this understanding means their analysis often remains superficial or poorly supported. This indicates that focusing solely on data interpretation mechanics may not be enough without also addressing communication. An approach that helps students structure their explanations and express their analytical thoughts could greatly help bridge this gap. The struggles students experience, such as missing critical parameters and providing shallow discussions, show that current teaching methods may not be adequate. There is a clear need for explicit, structured, and technology-enhanced methods to develop these essential skills, shifting from helpful additions to core components of engineering education.

In this changing environment, AI Prompt Engineering is becoming recognized as a helpful technique for guided learning [6-8]. Prompt engineering involves creating effective prompts for AI systems to get useful and accurate responses. As teachers increasingly incorporate AI tools into their classes, understanding prompt engineering fundamentals is key to maximizing AI's potential. Effective prompting principles include being specific and clear about desired outcomes, providing relevant context, especially in educational settings, using structured formats when appropriate, offering examples of desired results, and breaking down complex requests into simpler steps [9]. Alongside the rise of AI, video-based learning has proven effective in education [10,11]. Advanced AI tools like Google's Veo 3 Gemini can generate high-quality, data-rich video content from prompts, opening new possibilities for creating engaging learning materials [12-14].

Combining these three elements, which are data-rich videos from tools like Veo 3 Gemini, AI analytical capabilities from systems like Gemini A.I., and the interactive process of student-driven prompt engineering, can create a powerful learning environment. The video provides complex, dynamic scenarios for analysis. The AI supports processing and organizing information, and prompt engineering encourages students to think actively and critically engage with the material [15]. This active engagement with rich media, supported by AI, is likely to be more effective than passive information consumption or undirected use of AI tools. The visual storytelling aspect of advanced video generation can further enhance understanding by presenting data more contextually and memorably. The main goal of this research is to improve the abilities of final-year engineering students in interpreting and explaining diagrams, tables, and other data forms in their academic writing, especially in the results and discussion sections of technical reports and theses. This study

specifically introduces and assesses the use of A.I. Prompt Engineering with Gemini A.I. to help students systematically identify patterns, trends, and differences in visual and quantitative data. A unique part of this method is using data-rich videos from lecturers generated by Veo 3 Gemini as the main material for student analysis. This approach goes beyond traditional static data representations, using visual storytelling to enhance understanding and engagement.

This initiative aims to close an important skill gap in engineering education by providing a structured way for students to analyze data meaningfully and critically. It combines AI, prompt engineering, and video analysis into an engaging, interactive learning experience designed to improve both analytical thinking and scientific communication skills. The process requires students to think critically about video data, create precise prompts for AI analysis, and effectively interpret and communicate AI-generated insights. It also fosters a crucial skill for modern engineers: the ability to communicate effectively with intelligent systems.

2. Methodology

This study took an exploratory approach to evaluate the initial implementation of an AI-enhanced learning intervention. The goal was to improve data interpretation and scientific writing skills among final-year mechanical engineering students at Universiti Kebangsaan Malaysia. 30 participants were enrolled in a Finite Element course that required submitting significant technical reports or theses involving data analysis. Although the exact number of participants in this phase was not provided for a large-scale quantitative analysis, the focus was on observing qualitative changes in student work and gathering formative feedback on the intervention. The research design was mainly qualitative. It emphasized the depth of student experiences and the subtle improvements in their analytical and communication skills, with the possibility for future mixed-method expansion.

Once the Veo 3 Gemini videos were created, students had the main task of the intervention, which was to create and refine targeted prompt sentences for Gemini A.I. These prompts aimed to guide Gemini A.I. in analyzing the video content in line with the learning outcomes set by the lecturers. The process was iterative and driven by students:

i. Students carefully analyzed the data-rich video provided by the lecturer. This included observing phenomena, identifying potential data points, and understanding the context of the information presented.
ii. Based on their analysis and the learning objectives, students developed precise prompts for Gemini A.I. These prompts could ask the A.I. to identify specific trends in a segment of the video, compare variables across different conditions shown, explain a process, or extract quantitative data if visually represented.
iii. Students then submitted these prompts to Gemini A.I., which processed the information, potentially using the video content or transcripts/descriptions, to generate textual outputs.
iv. This process of prompt construction, submission, and evaluation of AI output encouraged students to think critically about what questions to ask, how to phrase them for the best results, and how to interpret the AI's response in the context of the video data.

This student-led prompt engineering phase is central to the intervention. The cognitive effort shifts from simply consuming information to actively eliciting and structuring it with an AI partner. Students are not just looking for answers; they are also learning the meta-cognitive skills of breaking down problems and effective inquiry.

This active involvement in framing the analysis helps them gain a deeper understanding of the data and the analytical process itself rather than just passively receiving pre-digested information. The intervention was based on established teaching principles. Students were guided implicitly or explicitly by effective prompt engineering principles outlined by educational technologists. This guidance includes crafting specific prompts, providing context derived from the Veo 3 video, potentially using relevant examples, and requesting output in a structured format appropriate for their reports. The four key components of an effective prompt are the main character (Task), the surrounding (Context), the camera shoot (Format), and the message (Tone). This offers a solid framework for guiding students in this process. While this initial phase was mostly qualitative, the framework allows for future inclusion of quantitative measures. These could include rubric-based scoring of report quality or pre/post-intervention assessments of specific data interpretation skills to provide a more complete evaluation. Table 1 delineates the structured workflow of the intervention, highlighting the collaborative roles of educators, students, and AI tools in fostering advanced analytical and communication skills.

Table 1
Structured Workflow for this Assignment

Phase/Component	Key Actor(s)	Primary Activity/Process	Desired Outcome/Skill Targeted
1. Learning Outcome Definition	Lecturer	Specifies analytical tasks and learning objectives based on curriculum requirements.	Clear, measurable learning objectives for data interpretation.
2. Video Content Generation	Lecturer, Veo 3 Gemini	Lecturer prompts Veo 3 Gemini to create dynamic, data-rich video scenarios relevant to learning outcomes.	Engaging, complex, and contextually rich data source for student analysis.
3. Video Analysis by Student	Student	Critically views and analyzes the Veo 3 Gemini video, identifying key data points, phenomena, trends, and relationships.	Deep understanding of the video content and initial identification of areas for analysis.
4. Prompt Construction & Refinement	Student	Develops specific, targeted prompts for Gemini A.I. to analyze aspects of the video; iteratively refines prompts.	Effective AI interaction skills, critical questioning, problem decomposition, and precise articulation of analytical needs.
5. AI-Assisted Output Generation	Gemini A.I.	Processes student prompts and video-related information to generate textual analyses, summaries, or explanations.	Structured data summaries, preliminary interpretations, or textual explanations based on student guidance.
6. Student Interpretation & Writing	Student	Critically evaluates AI-generated output, synthesizes it with own understanding, and integrates into academic report.	Improved analytical writing, enhanced data interpretation skills, ability to critically use AI-generated content.

3. Results

The initial implementation of the A.I. Prompt Engineering intervention yielded encouraging results, indicating a positive impact on final-year engineering students' abilities to interpret data and articulate their findings, as well as favourable student perceptions of the novel approach.

3.1 Exercise 1: Video-Based A.I. Prompt Engineering – "UKM is the Best University"

This exercise introduces students to A.I. Prompt Engineering through the analysis of a video generated using Veo 3 Gemini as shown in Figure 1 (a). The core of the activity is a short video featuring a Malaysian girl dressed in a red kebaya, confidently walking at KLCC while the camera tracks her movements. As she walks, she joyfully declares:

"…UKM is the best university and ranked among the top universities globally and in Asia…"

Although simple on the surface, this video is used as a dynamic educational tool. Students are required to observe and analyse key visual cues, interpret spoken messages, and consider the overall context and tone of the video. All parameters have been considered as shown in Table 2. Using these insights, students must construct a well-structured A.I. prompt that can instruct a language model (e.g. Gemini) to generate relevant outputs such as captions, summaries, interpretations, or scene re-creation. This exercise provides a practical introduction to AI Prompt Engineering, focusing on how slight alterations in video elements necessitate a complete re-evaluation and rewriting of the initial prompt (Figure 1 (b)). Therefore, if the video's content changes, for instance, the red kebaya becomes a blue blouse, or the ethnicity shifts from Malaysian to Chinese, or even the location changes from KLCC to a bustling market, the original prompt will no longer yield the desired, accurate output. Students must identify these "changing parameters" (e.g., clothing color, garment type, nationality, location, specific actions, time of day, lighting, and even the emotional tone or camera movement nuances) and then systematically develop a new prompt that precisely reflects these updated elements. This iterative process of observation, parameter identification, and prompt refinement is crucial for mastering effective communication with generative AI models and achieving targeted video generation.

This process challenges students to think critically and communicate with clarity and purpose, mimicking the skills they will need in engineering tasks where data interpretation and precision are vital. Through this activity, students develop critical thinking, observational, and descriptive skills that are essential for engineering tasks. These prompt engineering skills can be transferred to interpreting technical data such as describing relationships in graphs, identifying key values in tables, and comparing variable trends. This exercise encourages multimodal learning by integrating language, visuals, and context, while also strengthening A.I. literacy and students' ability to interact effectively with intelligent systems.

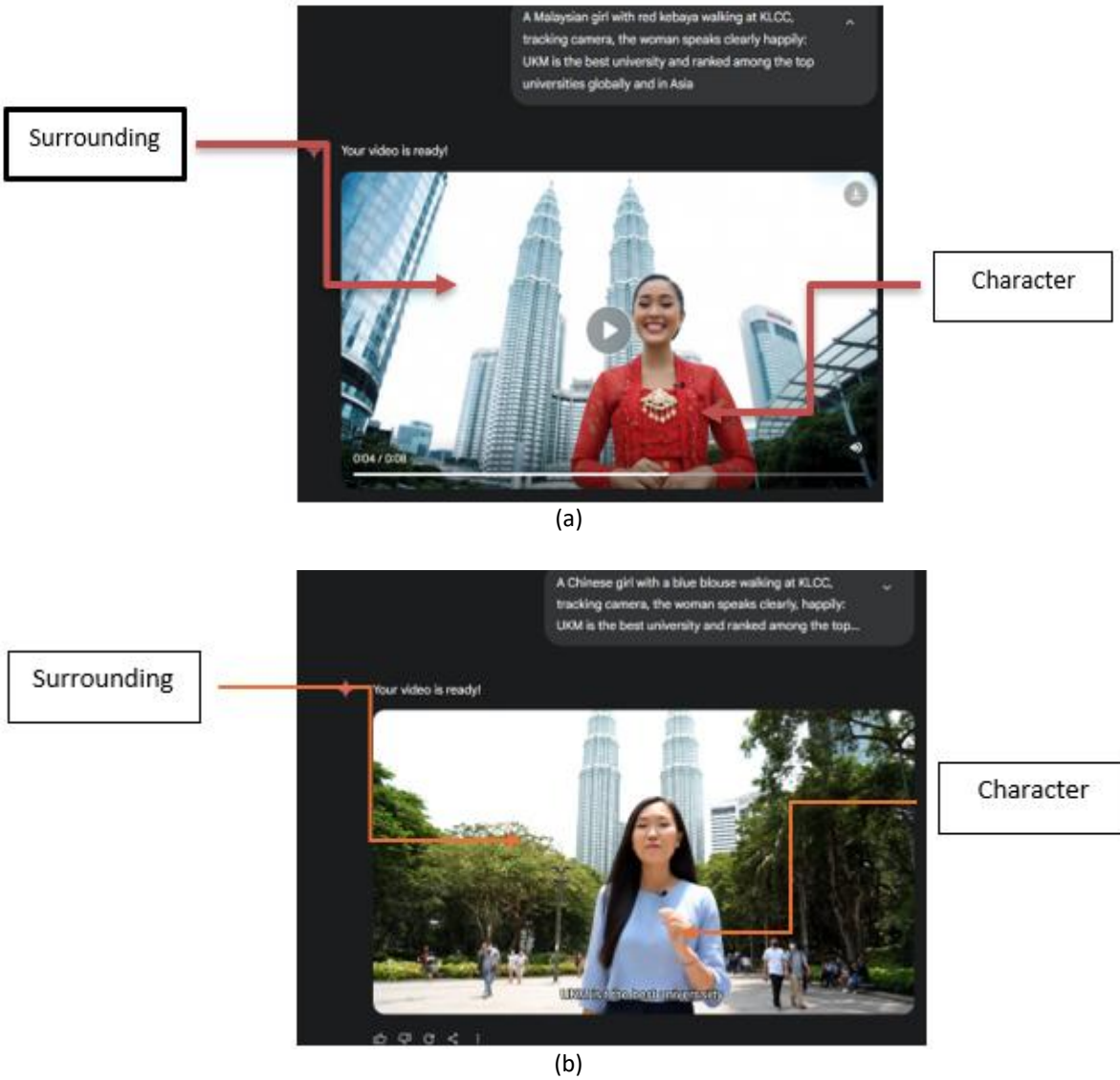


Fig. 1. Exercise 1 for students using video-based AI

Table 2
Key components of an effective prompt

Part	Factor	Parameter 1	Parameter 2
Part 1: Main Character	Character	Malaysian	Chinese
	Gender	Girl	Girl
	Dress	Red Kebaya	Blue Blouse
Part 2a Surroundings	Place	Walking at KLCC	Walking at KLCC
Part 2b Camera Shoot	Shooting	The camera tracks her movement	The camera tracks her movement
Part 3: Messages	Movement	As she walks, she joyfully declares	As she walks, she joyfully declares
	Message	"Speech"	"Speech"

3.2 Exercise 2: A.I. Prompt Engineering Based on Talkshow Video Analysis

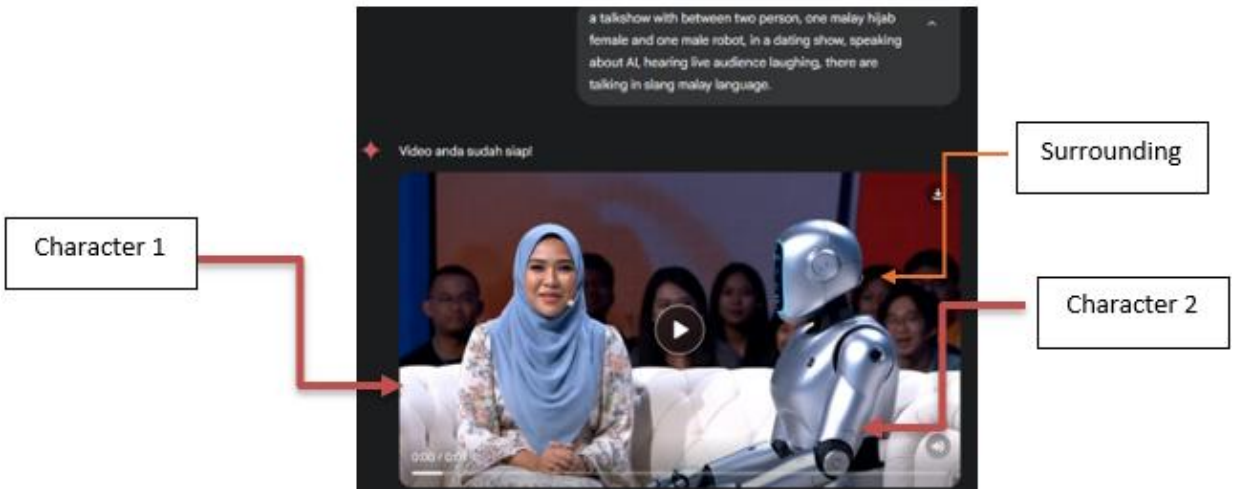
In this exercise, students are required to write an A.I. prompt based on a short prompt as shown in Figure 2:

"… a creative video featuring a talk show setting. The video presents a humorous conversation between two characters: a Malay woman wearing a hijab and a male robot, participating in a mock dating show. The interaction is lively, spoken in casual Malay slang, and accompanied by laughter from a live audience, creating a light and engaging atmosphere…"

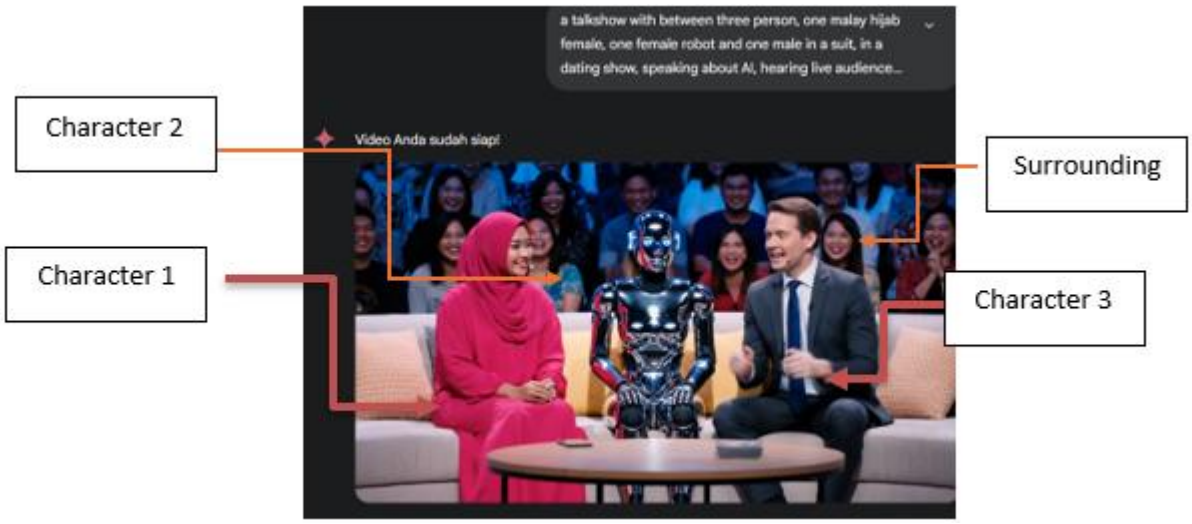
Students must observe and analyze various aspects of the video, including visual elements (such as gestures, expressions, and setting), spoken dialogue (with cultural and emotional nuance), and the overall context and tone as tabulated in Table 3. Based on this analysis, students are tasked with constructing a targeted and effective prompt that can guide an A.I. model (such as Gemini) to generate similar outputs, whether it be a caption, a dialogue script, a scene summary, or a tone-matching response.

This activity not only encourages students to explore the intersection of language, culture, and technology but also trains them to develop the critical thinking and descriptive skills required in engineering problem-solving, such as writing precise prompts for interpreting experimental data, graphs, or system behavior. By understanding how to engineer prompts from rich multimedia content, students gain the ability to apply these skills in real-world engineering contexts, where clear interpretation and communication of data are crucial.

Once students are trained to think critically and construct prompts based on visual narratives, they can transfer this skill to technical data interpretation. For example, they learn how to describe the relationship between temperature and time from a graph, interpret the highest and lowest values in a table, and identify contributing factors, or compare multiple variables and trends across different datasets. This innovation encourages multimodal learning, combining language, visuals, and data to foster a holistic understanding. It also strengthens critical thinking, creativity, and A.I. literacy, equipping students with practical skills for interacting with intelligent systems in engineering and beyond. By turning a local promotional video into an analytical exercise, this approach not only builds academic skills but also enhances students' connection to their institution and appreciation for its global standing.



(a)



(b)

Fig. 2. Exercise 2 for for students using video-based AI

Table 3
Key components of an effective prompt for exercise 2

Part	Factor	Parameter 1	Parameter 2
Part 1: Main character	Character	1. Malay women wearing a hijab 2. male robot	1. A Malay hijab female 2. One female robot 3. One male in a suit
Part 2: Surroundings	Place	Talk Show, Dating Show Audience laughing	Talk Show, Dating Show Audience laughing
Part 3: Messages		Malay Language Slang	Indonesian Language Slang

3.3 Qualitative Shifts in Student Work with AI Intervention

A key outcome observed was a notable improvement in the quality of students' data interpretations and explanations within their academic writing. Students who had previously tended to provide brief or incomplete analyses in their reports were, after engaging with the AI-guided process, able to generate significantly more comprehensive and well-structured explanations of the data presented in (or derived from) the Veo 3 Gemini videos. The positive student feedback is a crucial early indicator of the intervention's potential. An approach that students find both easy to use and beneficial to their learning is more likely to be embraced and lead to meaningful educational outcomes. Table 4 summarizes the qualitative shifts observed in student work and incorporates indicative student feedback, illustrating the practical impact of the AI-enhanced intervention on specific aspects of data interpretation and scientific communication.

Table 4
Qualitative shifts in student work with AI intervention

Aspect of Data Interpretation/Explanation	Typical Observation Pre-Intervention (Common Student Struggles)	Observed Improvement Post-Intervention (with AI-guidance)	Illustrative (Anonymized) Student Feedback Snippet
Comprehensiveness	Brief, incomplete, or superficial coverage of data points.	More detailed, thorough, and complete explanations of data and its implications.	"The AI helped me cover all the important aspects I usually miss."
Structure & Coherence	Disorganized presentation, weak logical flow between points.	Logically structured narratives, clearer connections between data, analysis, and conclusions.	"Using the prompts made me think about how to organize my results section much more effectively."
Identification of Trends	Focus on obvious trends only, missing subtle patterns.	Identification of both overt and more nuanced or complex trends within the data.	"Gemini pointed out a trend in the video I hadn't noticed, which was key for my discussion."
Comparison of Variables	Superficial or incomplete comparisons, lacking depth.	More nuanced and comprehensive comparisons between different variables or conditions.	"I could finally compare the different scenarios from the simulation video in a structured way."
Highlighting Key Findings	Key findings buried, overlooked, or not clearly stated.	Salient points and critical findings were more effectively emphasized and articulated.	"The prompts helped me focus on what was really important to say about the data."
Depth of Analysis	Descriptive rather than analytical, surface-level engagement.	Deeper analytical engagement, moving beyond description to interpretation and explanation.	"It wasn't just about describing the video; the AI helped me analyze *why* things were happening."
Critical Insight	Limited critical questioning or independent thought.	Emergence of more critical questions about the data and its limitations.	"Constructing the prompts made me think more critically about the data itself and what it really meant."

Rubrics and clear evaluation criteria were indeed utilized to assess student work in this section. These criteria specifically emphasized students' ability to observe and comprehensively analyze various facets of the video content, including visual elements (such as gestures, expressions, and setting), spoken dialogue (with attention to cultural and emotional nuance), and the overall context and tone. Students demonstrating proficiency in these areas were awarded higher marks, reflecting the structured assessment approach.

Traditional teaching often sees engineering students struggling with complex data interpretation, frequently providing only surface-level analyses of static information. This innovative study introduces an AI-guided pedagogical approach, leveraging Gemini AI and Veo 3 Gemini videos, to address this gap. Students learn AI Prompt Engineering, crafting specific prompts to guide the AI in identifying crucial patterns and trends within dynamic visual and quantitative data. This method fundamentally shifts the learning experience from passive consumption to active engagement, offering personalized and adaptive support that traditional methods cannot easily replicate.

While the study presents promising initial results, several limitations should be acknowledged. The findings are based on initial implementation and preliminary results, indicating that the approach is an early-stage exploration rather than a comprehensive, large-scale investigation. Future research should aim to conduct the study with a larger and more diverse cohort of final-year engineering students to enhance the statistical power and generalizability of the findings.

4. Conclusions

This study has introduced and provided an initial evaluation of an innovative AI-enhanced pedagogical approach designed to improve the data interpretation and scientific communication skills of final-year engineering students. The core methodology, involving student-led A.I. Prompt Engineering with Gemini A.I. based on data-rich videos generated via Veo 3 Gemini, has demonstrated promising early results. Students exhibited enhanced abilities to produce comprehensive, well-structured, and insightful analyses of complex data. They showed improvements in identifying trends, comparing variables, and highlighting key findings. Crucially, student feedback indicated that the approach was perceived as intuitive, helpful, and effective in deepening their understanding of data presentation and analysis. This positive reception underscores the usability and perceived value of the intervention, which are key factors for successful educational technology integration.

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