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Enhancing Energy Engineering Education through Universal Design for Learning: Student Perceptions of Choice in Engineering Communication

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1. Introduction

Despite sustained national attention and reform efforts, engineering education continues to experience persistent challenges related to student retention, degree completion, and equitable representation [1]. Many students, particularly those from historically underrepresented groups, leave engineering programs before graduation or disengage from core coursework early in their academic pathways [2]. These outcomes are often attributed to rigid instructional structures, narrowly defined assessments, and learning environments that privilege a limited range of communication styles and ways of demonstrating competence [3]. As a result, capable students may be filtered out not because of a lack of ability or interest in engineering, but because instructional practices fail to accommodate diverse learning needs, strengths, and identities. Addressing these systemic barriers requires pedagogical approaches that intentionally broaden access and participation without compromising academic rigor [4].

Universal Design for Learning (UDL) offers a framework for addressing these challenges by promoting flexibility in how students engage with content and demonstrate learning [5]. Grounded in principles of multiple means of engagement, representation, and action and expression, UDL aims to reduce unnecessary barriers while supporting learner variability. In this study, UDL was implemented in an undergraduate environmental engineering course focused on energy fundamentals. A key instructional strategy involved providing students with choice in how they presented their understanding of course concepts. Rather than requiring a single, traditional presentation format, students selected from multiple presentation modes, including short-form social media–style videos (e.g., TikTok), traditional slide-based presentations, infographic-style Instagram posts, or other approved formats. This flexibility was designed to allow students to leverage their strengths, communicate in personally meaningful ways, and engage more deeply with course material while meeting shared learning objectives.

This study is guided by the following research question: *What are student perceptions associated with UDL choice in presentation modes?* The contribution of this work lies in providing empirical insight into how UDL-informed assessment choices are experienced by engineering students, particularly within a technically rigorous environmental engineering context. By examining student perceptions of choice, engagement, and learning, this study contributes to the growing body of engineering education research seeking scalable, inclusive instructional strategies that support retention, persistence, and broader participation in engineering programs.

2. Background

Universal Design for Learning (UDL) is an instructional framework that emphasizes proactively designing courses to accommodate learner variability by providing multiple means of engagement, representation, and action and expression [6]. Rather than retrofitting accommodations, UDL focuses on removing structural barriers within curricula and assessments. Benefits of UDL include increased accessibility, student engagement, motivation, and persistence, particularly for diverse and underrepresented learners, while maintaining clear and rigorous learning objectives [7]. However, challenges to implementation include perceived increases in instructional workload, concerns about maintaining consistency and rigor, and difficulties aligning flexible assessments with accreditation or standardized evaluation practices [8]. Effective use of UDL therefore requires intentional design, transparent criteria, and faculty support.

In engineering education, UDL presents significant opportunities to address persistent issues related to retention, equity, and student engagement [9]. Traditional engineering courses often privilege narrow modes of problem-solving and communication, which can unintentionally exclude capable students. Applying UDL in engineering (through flexible assessments, varied instructional media, and student choice in demonstrating learning) can broaden participation while aligning with professional engineering practices that demand adaptability, communication, and collaboration [10]. By valuing multiple ways of thinking and expressing technical knowledge, UDL supports inclusive learning environments and prepares students for the diverse, interdisciplinary contexts of contemporary engineering work.

3. Methods

3.1 Intervention

The new curriculum intervention was implemented in an undergraduate environmental engineering course called “Fundamentals of Energy”. The student enrollment for this discipline specific engineering course was 9. The goal of this new curriculum intervention was to apply principles of Universal Design for Learning (UDL) by giving students a choice in selecting a presentation mode for each of the 3 class projects. Example presentation modes included, but were not limited to:

1. Create a 15-20 min Podcast + Upload to Podcast Host
2. Create a 3-min Rap Song + Upload to Instagram
3. Create a 60-sec SmartPhone Video + Upload to TikTok
4. Create a 5-min Voice-Narrated PowerPoint Video + Upload to YouTube

Students received bonus points for sharing/disseminating on social media: TikTok, Instagram, LinkedIn, YouTube, Twitter, Podcast Host, etc…

3.2 Data Collection and Analysis

Photovoice reflection prompts were used to allow students to share experiences via photo (e.g., pictures and images) and voice (e.g., personal narrative) [11]. By incorporating structured prompts, rubrics, and reflective components, photovoice enhances critical thinking, communication, and engagement, making engineering concepts more tangible and personally meaningful. Specifically, students were asked to respond to the following questions with 3 visuals and a 200 word narrative:

1. Prompt A (**Debrief Challenges**): What was the most challenging part of preparing and submitting the first stage of the project? Why? How did you handle it?
2. Prompt B (**Debrief Successes**): During the first project phase, where do you feel you contributed the most? What made this contribution valuable to the team or outcome?
3. Prompt C (**Communication Skill Development**): How did the process of working on the first project milestone impact your communication skills (e.g., teamwork, presentations, written reports)?
4. Prompt D (**Personal Growth**):Looking back on the first project milestone, where do you notice the most growth in yourself—technically, professionally, or personally?

Qualitative thematic analysis with two researchers was conducted using the following steps [12]: (1) both researchers independently familiarized themselves with the data through repeated reading and memo-writing; (2) each researcher conducted initial inductive open coding, assigning descriptive codes to meaningful segments of text; (3) researchers met to compare codes, discuss interpretations, and develop a shared codebook with agreed-upon definitions and examples; (4) the data were then re-coded using the shared codebook, with discrepancies resolved through discussion and consensus rather than statistical agreement; (5) codes were grouped into categories and synthesized into themes aligned with the research questions; and (6) themes were reviewed against the original data, refined collaboratively, and reported with representative excerpts to ensure credibility and transparency.

4. Preliminary Results

Based on the reflections provided in the sources, the following preliminary thematic analysis identifies the key patterns in the students' experiences during their renewable energy projects.

4.1 Bridging Theory with Real-World Context

This theme describes the transition from understanding renewable energy as abstract formulas to applying it within specific socio-economic and geographical constraints. Students realized that a "theoretically perfect" solution often requires adjustment to fit a local community's reality.

One student said, “The most challenging part of the project was achieving that our renewable energy proposals were **not only technically viable, but also realistic** from an economic and social point of view for a community like Villa de Leyva.”

Another student said, “Investigating the conditions of the place, its climate, the availability of resources, all that helped me better understand **how different energy matrices can be applied according to the characteristics of the territory**.”

4.2 Information Management

This theme highlights the technical struggle of locating recent, reliable, and localized data. Students frequently encountered obstacles when searching for specific energy consumption or environmental statistics for small municipalities, requiring them to diversify their research methods.

A student stated, “Often, access to complete, reliable and recent databases proved **more difficult than expected**, as most available sources lacked the necessary amount of files or provided obsolete and scattered information.”

Another student stated, **“I spent days searching** for energy consumption data from La Peña, a lot of official sources had nothing. It was like looking for a needle in a haystack - frustrating and overwhelming.”

4.3 Evolution from Confrontational to Collaborative Communication

Students noted a significant shift in how they communicated within their groups. They moved away from viewing arguments as a "competition" to be won and toward viewing communication as a tool for collective construction and consensus-building.

One response said, “I didn't feel that it was a confrontation of ideas, but rather sharing a point of view. That experience **allowed me to understand argumentation in a different way**, less focused on debating and more oriented towards building a clear and efficient idea collectively.”

Another response said, “I have come to understand that good communication is not based only on speaking or writing, but also on knowing how to **receive responses, resolve doubts and anticipate possible problems** to avoid them in time.”

4.4 Digital Creativity

This theme involves the use of modern digital tools and social media formats (like TikTok) to disseminate technical information. Students faced the challenge of making complex energy data engaging and accessible for a general audience.

One student said, “Our video had to be **creative enough to spark that interest** in the people who see it. For this, the video must have good digital content with truthful and pertinent information.”

Another student said, “Finally, we decided on TikTok, as we felt it was **a clear and dynamic way** to transmit the message. Personally, I took charge of recording and editing the video.”

4.5 Professional Responsibility

This theme centers on personal growth regarding time management and developing a professional work ethic. Students learned to manage academic stress and take personal initiative to ensure the team's success.

One student responded, “I discovered that I am more resilient than I thought. I survived the drought with quiet stubbornness. The real triumph was **controlling my resilience**.”

Another student responded, “I learned to **manage my time better**, fulfill group commitments and adapt to different ways of working. I was gaining confidence and learned to contribute in a more constant and organized way.”

4.6 Visual Summary

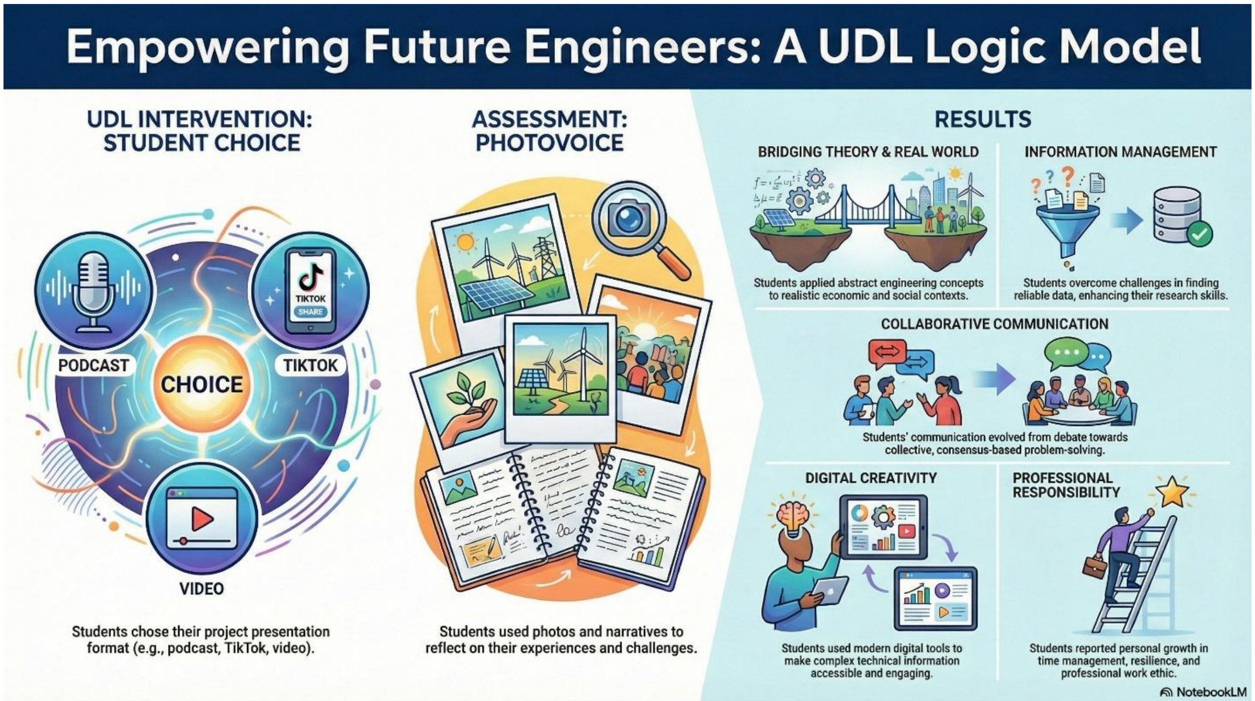

Figure 1. Source: NotebookLM

5. Conclusions

This study explored the research question: *What are student perceptions associated with UDL choice in presentation modes?* Findings suggest that providing students with choice in how they communicate engineering knowledge is perceived as both empowering and educationally meaningful. Students reported increased engagement, motivation, and ownership of learning when allowed to select presentation formats aligned with their interests, strengths, and communication preferences. The results indicate that UDL-based choice does not detract from technical rigor; instead, it supports deeper conceptual understanding by requiring students to translate complex energy concepts for diverse audiences using varied dissemination platforms.

The contributions of this study are threefold. First, it provides empirical evidence that UDL-aligned assessment flexibility can enhance student perceptions of learning and professional skill development in a technically focused environmental engineering course. Second, it demonstrates that nontraditional communication formats (e.g., short-form videos, podcasts, and social media) can serve as legitimate and effective vehicles for engineering knowledge dissemination. Third, the findings suggest actionable implications for engineering educators: instructors are encouraged to rethink rigid, single-mode assessments and instead design outcome-aligned choices that reflect the communication demands of contemporary engineering practice.

Departments and curriculum designers may also consider integrating UDL principles more intentionally to support retention, equity, and engagement without compromising disciplinary standards.

As a Work-in-Progress study, several limitations should be acknowledged. The small class size limits generalizability, and findings are based on student self-reported perceptions rather than direct measures of learning outcomes. Additionally, the study was conducted within a single course and disciplinary context, which may influence how students experienced choice and engagement. Instructor enthusiasm and course culture may also have shaped student perceptions.

Future research should examine UDL-based choice across larger and more diverse engineering cohorts, multiple institutions, and varied engineering disciplines. Longitudinal studies could explore how repeated exposure to UDL-informed assessments influences persistence, identity development, and communication competence over time. Further work may also investigate how different types of choice (e.g., collaboration structure, topic selection, or assessment pacing) interacts with student motivation and learning. Collectively, such efforts can strengthen the evidence base for UDL as a scalable and inclusive approach within engineering education.

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