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Leveraging AI-Generated Supplemental Videos to Enhance Undergraduate Engineering Education

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Leveraging AI-Generated Supplemental Videos to Enhance Undergraduate Engineering Education

Abstract

One of the greatest challenges and opportunities facing higher education today is the use of artificial intelligence (AI) and its impact on education. This research, focused on civil and environmental engineering education, delves into the positive impacts AI can have on student learning and how faculty can leverage its vast and growing capabilities in their pedagogy. As part of an NSF-funded project, "plug and play" educational videos were developed with the goal of exposing undergraduate students to emerging skillsets needed to meet the needs of society and be a successful engineer in an evolving and data-driven profession. As a team of engineering faculty, translating technical knowledge in the areas of systems level thinking and data analytics, to an engaging educational video, without expertise in video or media production presented a unique challenge. This work presents the transition in educational video production from a time-intensive, human-driven process to the use of AI platforms that can generate high-quality visual and audio content much more efficiently. This shift in media production demonstrates a positive use of AI that all engineering educators can use to improve learning outcomes in their courses and provides a new approach to engage Gen Z students, who are very digitally oriented. The goal of this research effort is to showcase strategies and lessons learned in embracing AI to enhance student learning through creating and implementing supplemental educational videos at Manhattan University, a primarily undergraduate focused institution. Survey data focused on student satisfaction ratings and reactions to traditionally created vs AI generated content as well as feedback on faculty perception and comfort level around utilizing AI as an educational tool is presented.

Introduction

One of the greatest challenges and opportunities facing higher education today is the use of artificial intelligence (AI) and its impact on education. The excessive use of AI technology by students has raised concerns regarding the impact on students' academic and real-life performance [1]. This coupled with academic integrity issues associated with AI has created a negative stigma for many educators [2]-[5]. Despite the negative perceptions surrounding students' use of AI, there are many positive impacts AI can have on student learning and different ways faculty can leverage its vast and growing capabilities in their pedagogy [6]-[12]. Although the emergence of generative AI tools, like Chat GPT, Copilot and Gemini, have been the focus of much attention in this space, there are many other applications of AI in higher education. A review of publications from 2016 – 2022 identified the following most common usages codes of AI in higher education; (1) Assessment/Evaluation, (2) Predicting, (3) AI assistant, (4) intelligent tutoring system and (5) managing student learning [13].

One particular area of opportunity for the implementation of AI tools in engineering education is to assist in the creation of educational multimedia content. The use of multimedia content has proven to be an effective educational tool and the development and implementation of this type of content is on the rise [14]-[17]. This research effort follows the transition in educational video production from a time-intensive human based strategy to the use of AI platforms capable of producing high-quality visual and audio content in a fraction of the time. The educational video created demonstrates a positive use of AI that all engineering educators can use to improve learning outcomes in their courses and provides a new approach to engage the digitally oriented Gen-Z students.

This research aims to showcase strategies and lessons learned in leveraging AI to enhance student learning by creating and implementing educational videos at Manhattan University, an undergraduate-focused institution. The effectiveness of the AI generated multimedia content is assessed relative to traditionally developed multimedia content through the implementation of a multiple-choice technical assessment and survey focused on student perception and satisfaction. In order for AI to be an effective tool in higher education faculty must be willing to embrace and implement these technological capabilities into their current pedagogy. Survey data was collected from engineering educators from various disciplines to better understand current faculty perception and usage of AI as an educational tool. The preliminary results reported herein provide valuable insights from the study participants that contribute to a better understanding of effective engineering education through the use of AI.

Background

The educational videos implemented in civil engineering undergraduate courses at Manhattan University were developed as part of an NSF-funded project to expose students to emerging skillsets required to meet the needs of society and be a successful engineer in an evolving and data-driven profession. Given the limitations of many institutions to add credits above the current ABET accreditation requirements, the research team set out to develop “plug and play” educational videos that could be integrated as supplemental material in existing required courses. As a team of engineering faculty, translating technical knowledge in systems-level thinking and data analytics into engaging educational videos, without expertise in video or media production, presented a unique challenge. The growing capabilities of AI have transformed how engineering educators create unique, innovate, and engaging educational content for their students.

The application of educational videos in higher education extends far beyond the “plug and play” model presented in this project. There is a growing demand for educational multimedia as many educators have found themselves recording content and delivering material outside of the traditional face-to-face classroom environment. This transition was rapidly accelerated by the COVID-19 pandemic when many educators had to shift to a fully online delivery mode [18]. Despite the return to in person learning many educators are now utilizing educational multimedia content more than ever. The research presented provides strategies and lessons learned from implementing AI to more efficiently and effectively create video content that may otherwise be outside of the typical skillset of engineering educators.

Methods

Two educational videos were created on the topic of systems-level thinking applied to civil engineering infrastructure. One video (Video A) was created using traditional production methods and the other video (Video B) was created using AI. The educational content, herein referred to as the "script", was identical for both videos and was developed by a team of civil engineering faculty with over a decade of teaching experience. AI was not utilized in either scenario for the purpose of generating the technical information presented in the videos.

The videos created were each approximately 8 minutes in length. The videos have a documentary style with a narrator speaking while relevant videos and images are shown. For the benefit of the student, text is occasionally overlaid to emphasize key concepts. The production of Video A was a collaborative effort between faculty and student researchers that heavily relied on the expertise of senior-level communication majors. Video B was generated using the AI platform Synthesia™. Figure 1 shows a still image taken from both videos.

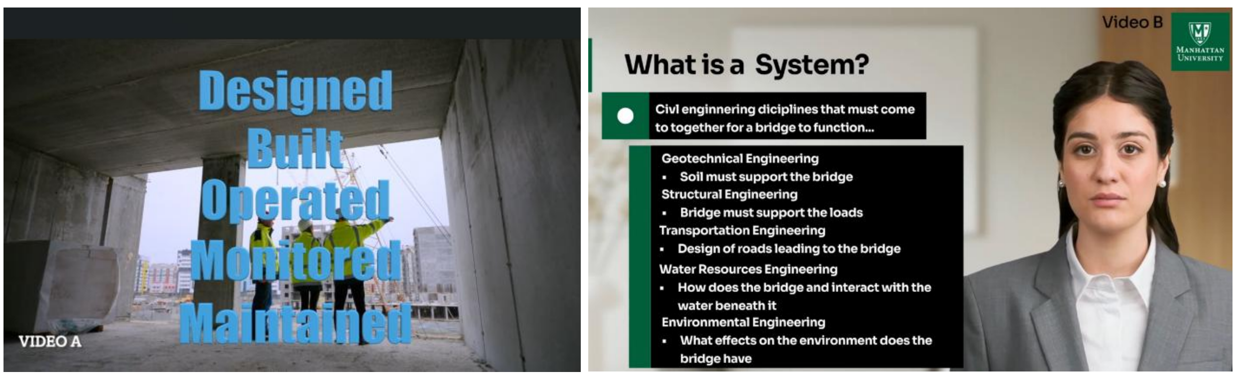


Figure 1: Still Images of traditionally (Video A) and AI (Video B) generated videos

Video A

Due to the engineering faculty's limited proficiency and experience in video production, undergraduate senior-level communications majors were tasked with the primary responsibility of creating multimedia content for the traditionally-produced engineering educational video. These students, well-versed and experienced in current standards and practices in video production, were brought on to ensure a high level of production quality. The video production process included the following traditional steps:

- Developing the Script
- Identifying and Organizing Footage
- Rough Cut of the Footage (matching the approximate timeline of the script)
- Audio Recording
- Final Cut of the Footage (matching the audio recording)
- Review and Final Edit

Developing the Script: The first step in creating the educational videos was to develop the technical content (or the script). As previously mentioned this was created by members of the research team that are not only well versed in the technical area but also have extensive teaching experience in higher education. The script was reviewed and edited by faculty with complimentary expertise in the subject matter. The final script served as the basis of the narrative content for the videos.

Identifying and Organizing Footage: Once the script was finalized, the research team developed the visual elements for the video. These elements consisted of still images and short video clips that related back to the content in the script.

Rough Cut of the Footage: The visual elements appeared on the screen for varying periods of time with an average duration of 10 seconds. Therefore, the developed 8-minute video required the curation of over 50 independent elements. The intention of the visual elements was to use images and short clips that were directly related to the narration of the video. The visual elements would constantly change to keep pace with the different topics being discussed and the engage audience. Next, text would be added over selected elements as a means to draw students' attention to key points made during the video. To bring all these elements together, extensive video editing was needed to assure smooth transitions and visual appeal.

Audio Recording: The script was narrated and recorded using professional equipment provided by the communications department. This process required numerous takes, ultimately taking over one and half hours to produce eight minutes of narration.

Final Cut of the Footage: Once the audio was recorded, it was added to the video, and a final cut was produced. The rough cut was refined by further trimming clips, ensuring smooth transitions between scenes, and focusing on pacing, timing, and flow of the narration.

Review and Final Edit: The draft video was then reviewed by the research team, leading to additional edits to both the visual elements and the narration.

Creating the video, from technical content development through final production, took 6 weeks. This was much longer than the research team had anticipated at the onset of the project. In order to obtain an acceptable level of production value, an extensive amount of time and effort was put into identifying appropriate visual elements. The editing process was also very time intensive and required in depth knowledge of the video editing software; therefore, relied on the experience of the communication students. Not including the technical content development and faculty review, it took approximately 40 hours to complete from start to finish.

Video B

Artificial intelligence enabled video production has made significant strides over the past few years. Using an AI platform would ideally allow the educational content to be produced without requiring extensive knowledge in video production or require access to expensive video editing and audio equipment. A new civil engineering undergraduate research assistant, who has no experience in video production, was tasked with creating the AI generated video. The intention was to create the same style video as before to provide a direct comparison.

After extensive research on available AI tools, a platform called Synthesia™ was selected and used to create the video. One of the major benefits of this platform is the ability to allow the user to create and implement a “human” avatar as part of the video (see Figure 1). The user can even opt to record themselves, allowing the software to create a personalized avatar.

The video production process still followed the steps outlined in the creation of Video A, however many of the previously labor-intensive efforts were done by the AI platform. Only script development and review/final edits were done manually by the research team.

The AI platform was provided the same technical script that the human creators of Video A received. Once the script was imported, the software was able to generate the rough-cut footage. AI not only selected the images, short video clips and visual text but also performed the required editing needed to create the video. The major concern during this stage was that the AI generated visuals would not be relevant or accurately paired with the technical content of the script. In our experience, the platform was able to accurately select the visual elements for the large majority of the script. The platform did allow for edits to be made by the user so the content can be altered and changed at any point in the video.

Using the imported script, the AI platform was also able to effortlessly generate the narration of the video. The user has the option to select from a number of different stock voices or even use their own. In this case a stock narration voice and avatar were selected. The use of the avatar meant that not only was the video narrated but in many scenes the avatar also appears in the video, simulating the presence of a professor speaking in class (see Figure 1). The visual presence of the narrator was not a part of the original video (Video A) due to video production limitations.

The process of having the AI platform generate the rough cut footage and audio recording from the written script provided took roughly 10 minutes. The research team was very impressed with the initial video produced but elected to make some final edits. The final editing process was done manually by the research team however it required little no to video production knowledge as the process is guided and simplified by the software. Including the final edits the video creation utilizing the AI platform took approximately 5 hours and no in-depth knowledge of video production to compete. It should be noted that for many educational applications this final editing process may not be necessary and in this case was done in order to create a comparable video to what had already been produced.

Video Implementation and Assessment

Sophomore civil engineering students were divided into a control and experimental group. Both groups were asked to watch an educational video on systems level thinking in civil infrastructure. The control group was shown the traditionally produced video (Video A) while the experimental group was shown the AI generated video (Video B). A technical assessment and series of survey questions related to satisfaction and perception of the video were developed by the research team. Learning outcomes were measured by having students take the multiple-choice technical assessment before (pre-test) and after watching (post-test) their assigned video. The assessment questions presented in Table 1 were intended to assess student knowledge of key systems level thinking concepts. After completing the learning assessment students were asked to watch the other video and compare the two, i.e the experimental group was shown the human produced video and the control group was shown the AI generated video. After watching both videos, survey data focused on student satisfaction ratings and reactions to traditionally created vs AI generated content was collected.

Table 1: Assessment Questions

Question	Multiple Choice Response				
1. What is the primary goal of systems thinking in civil infrastructure?	a) To minimize construction costs	b) To optimize the performance of isolated components	c) To understand the interdependencies of various system components for informed decision-making	d) To focus solely on environmental impacts	e) I don't know
2. Which engineering disciplines must collaborate in the construction of a bridge, according to systems thinking?	a) Structural, Geotechnical, Environmental, Water Resources, and Construction Management	b) Electrical, Mechanical, and Aerospace	c) Structural, Software, and Chemical	d) Water Resources, Software, and Geotechnical	e) I don't know
3. Why is systems thinking crucial when designing infrastructure in a city like San Francisco?	a) To avoid overspending on unnecessary components	b) Because isolated designs will not suffice when considering impacts from events like earthquakes	c) To ensure the aesthetic appearance of structures	d) To focus only on structural stability without considering other factors	e) I don't know
4. The New York City Subway System illustrates the interdisciplinary nature of civil engineering. Which of the following is NOT a key discipline involved?	a) Geotechnical engineering	b) Structural engineering	c) Environmental engineering	d) Chemical engineering	e) I don't know
5. Which of the following best describes the role of construction management in interdisciplinary projects like One World Trade Center?	a) Ensuring the project adheres to safety standards, timelines, and budgets	b) Designing the foundation of the building	c) Conducting environmental impact assessments	d) Handling public relations	e) I don't know
6. Which of the following is an example of a constraint in systems-level decision-making in civil engineering?	a) Transportation schedules	b) Aesthetic preferences	c) Technological, economic, and design constraints	d) Public opinion	e) I don't know
7. In mathematical optimization of civil infrastructure systems, the objective function could be described as:	a) Minimizing all construction efforts	b) Maximizing or minimizing a function subject to constraints	c) Only maximizing profits	d) Ignoring constraints for simplicity	e) I don't know
8. What does the future of civil infrastructure heavily rely on, as suggested in the video?	a) Individual expertise without interdisciplinary collaboration	b) Systems thinking to ensure resilient and adaptable infrastructure	c) Focusing solely on cost-cutting measures	d) Eliminating the need for technological advancements	e) I don't know

Faculty Surveys

A separate survey was developed to gage faculty perception and comfort level around using AI as an educational tool, as well as the use of educational multimedia content. Survey responses were also collected from fulltime faculty members who have been teaching in higher education for at least five years. The faculty respondents represent the following engineering disciples; civil, environmental, computer, electrical, chemical and mechanical engineering.

Results and Discussion

Video Implementation and Assessment

The central hypothesis of this study is that AI-generated educational videos are as effective as traditionally produced videos in enhancing student learning outcomes. To test this, surveys were administered in the fall 2024 semester to students enrolled in a sophomore level course "Introduction to Civil Engineering." In order to evaluate the learning outcomes the pre-test and post-test responses of the control (n = 25) and experimental group (n = 22) were compared. Both the control and experimental group were assumed to be homogeneous groups in terms of their performance as the students enrolled are predominately first semester sophomore civil engineering majors. Students were assigned an assessment score from 0-100 based on their correct responses to the multiple-choice questions. Figure 2 and Figure 3 present a box and whisker plot comparing the pre-test and post-test scores of the control and experimental groups, including and excluding outliers. From the box and whisker plot presented in Figure 2 it can be seen that both groups increased their median scores from 87.5 to 100. Both groups also showed the same improvement in the first quartile score from 75 to 87.5. When removing the outliers, Figure 3 shows the overall performance of the group that watched the AI video is better than those that watched the traditional video as indicated by the improvement in the first quartile performance to 96.9 for the experimental compared to 87.5 for the control group.

Figure 2: Box whisker plot for assessment scores including outlies

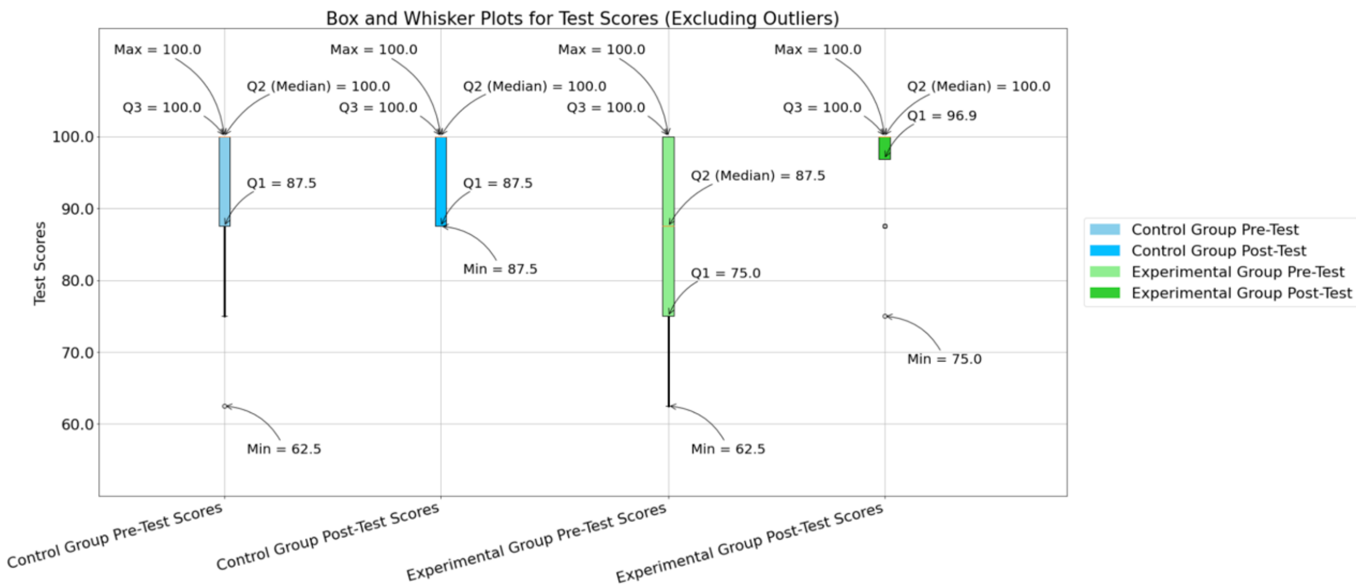


Figure 3: Box whisker plot for assessment scores excluding outliers

The preliminary results showed that both the experimental and control group showed similar levels of improvement on the technical assessment after watching their assigned video, which supports the hypothesis that the AI generated content was as effective as the traditionally produced content in regards to improving student learning outcomes. The results also demonstrate that educational multimedia content in general is an effective tool in engineering education and provides an alternative strategy to engage students outside of traditional in person lectures. Given the promising results from initial implementation additional surveys, videos and assessments will be conducted to increase the sample size and further validate these initial findings.

After completing the learning assessment all student participants (n = 42, students who did not watch both videos were removed from the data set) were asked to watch the other video and answer a series of survey questions comparing the two videos. The students were asked if they preferred Video A, Video B or did not observe a difference in four main categories: visual presentation (ie, images, video clips, transitions, text), narration style, ability of the video to teach the technical content and the ability for the video to hold their attention. The student survey results are summarized in Figure 4. The students indicated a preference for the AI generated video over the human produced video in all categories except the ability to teach the content, where the student preferences were equally divided between the two.

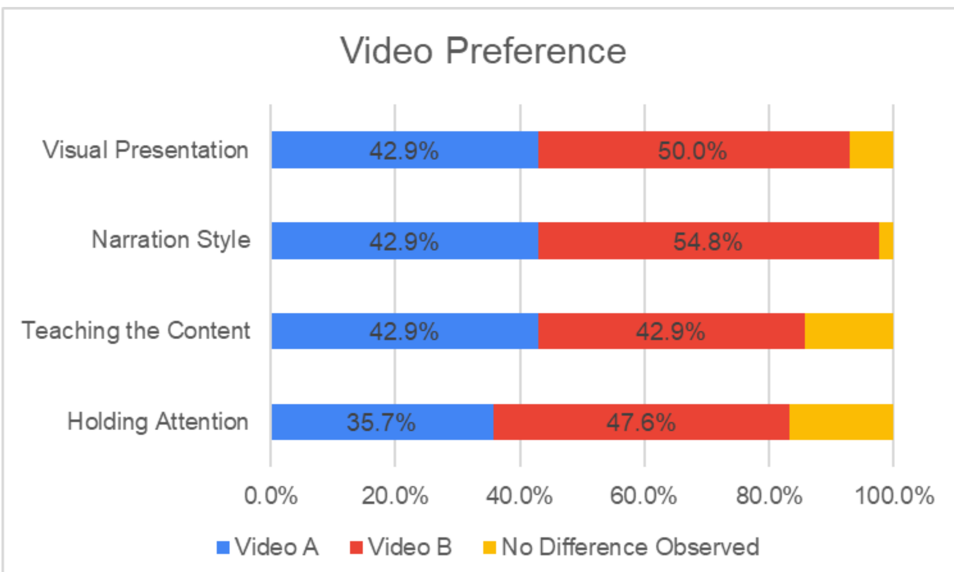
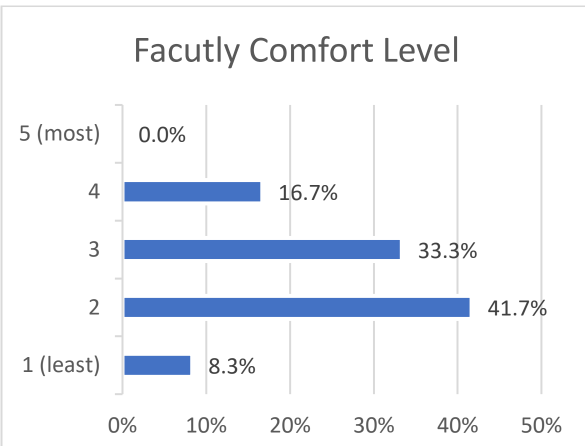


Figure 4: Video Preference Survey Results

The student survey results show great promise for the utilization of AI in the creation of supplemental educational videos. In general, the preference for the AI video was not expected by the research team as significantly more time and effort were put into the development of Video A. In particular the ability of Video B (AI generated) to hold the student's attention over Video A should be noted. It was also very interesting to see that the AI narration style received the most positive response of all categories. This was the one area that the research team was concerned with at the onset of the AI video production but the ability of the technology to accurately replicate human speech was clearly reflected in the student feedback. Utilizing this technology proved to be an effective way to engage Gen Z students and provides engineering educators a new strategy that can be integrated into their current pedagogy.

Faculty Survey Results

Preliminary survey data was collected from a diverse group of higher education engineering faculty (n=12), who provided a range of perspectives. As part of the survey, faculty were asked to rate their comfort level with using AI tools specifically related to their role as an educator on a scale of 1-5, with 5 being the most comfortable. Faculty were also asked to approximate how often they are using these tools. The results are shown in Figure 5. Faculty who self-identified as utilizing AI as an educational tool selected the following usage areas: generating assignments/assessments, enhancing instructor created content and other. No faculty reported using AI tools for the purpose of grading or creating educational multimedia content.



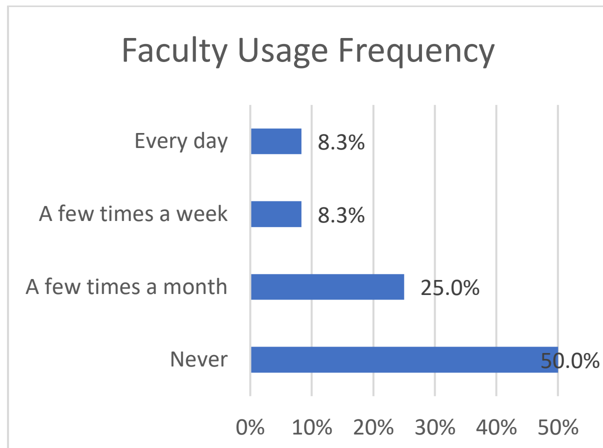


Figure 5: Faculty comfort level and usage frequency of AI as an education tool

The survey results indicate that there are still many engineering educators that are hesitant to embrace educational AI tools. Only 16% of faculty surveyed are regularly using AI as part of their current pedagogy. Faculty comfort levels around using these tools were also found to be relatively low, with only 16% reporting high level of comfort. The lack of comfort and perhaps experience with AI as an educational tool likely plays a role in the low usage frequency observed. Techniques and applications, like those presented here, can expose educators to emerging uses of AI that they may have not been aware of. This exposure and guidance can help increase faculty comfort in utilizing AI technology making it more likely for them to implement this technology as an educational tool.

Faculty also provided feedback regarding the creation and implementation of educational videos/multimedia content. 75% of faculty reported having created and implemented recorded educational content in one or more of the courses they have taught. 83.4% of faculty agree or strongly agree that the use of educational videos/multimedia content can have a positive impact on the learning outcomes in the courses they teach. Despite this only 33% of faculty would give the same rating to their knowledge level of educational video production and only 8.3% have used AI platforms to create this content.

The results clearly indicate that faculty are regularly using educational multimedia content in the courses they teach and an even larger majority agree that this content can have a positive impact on student learning outcomes in their courses. As expected, engineering faculty are not very knowledgeable in the area of video production. The disconnect here is apparent. Faculty agree multimedia content is beneficial for students but understandably do not have the skill set needed to produce high-quality content. AI tools have the ability to revolutionize the utilization of engaging and impactful video and multimedia content in engineering education. This research effort proves AI generated content is just as capable of improving learning outcomes and even more effective at engaging students. The AI platforms eliminate the need for the user to be well versed in video production and greatly expands the ability of engineering educators to create and utilize multimedia content in their courses.

Conclusion

Advancements in AI capabilities have transformed the ability of engineering educators, who have little to no knowledge in video production, to create high-quality and engaging educational content. The traditional human based approach of creating supplementary educational videos was found to be time intensive and required in-depth knowledge of video production. This limited the ability of most engineering educators to leverage this type of content in their courses. AI enabled video production software was found be an effective tool in producing educational multimedia content. Overall, the time and effort required to create a short 8-minute video was reduced by 88% using an AI platform. For engineering educators this AI automation allows for the ability to produce engaging and effective educational video content that would not have been possible to create only a few years ago without extensive knowledge in video production.

Although AI proved to be a powerful tool in creating multimedia content this would be meaningless if AI generated videos were unable to achieve the same standard of educational outcomes. Student learning outcomes were evaluated using technical assessment questions which were implemented before and after the students were exposed to the educational videos. The AI generated video (Video B) was found be as effective at increasing student learning compared to the traditionally produced video (Video A). This was demonstrated through a comparison of preliminary survey data on overall learning assessment performance (pre and post implementations) across groups. Student survey results showed great promise for the utilization of AI in the creation of educational multimedia content as the students actually showed a preference towards the AI generated content.

Faculty survey data showed that AI is not regularly being used by most engineering faculty for educational purposes with half of the respondents reporting that they are not currently using AI in their courses. Many of the faculty surveyed indicated low levels of comfort towards utilizing AI as an educational tool. Despite the majority of faculty indicating that they have used recorded content in their courses, when it came to video production most felt that they did not have a strong knowledge base in this area. AI platforms can provide a solution to this lack of expertise that may hold faculty back from creating and implementing educational videos that they strongly feel would improve student learning. It is clear from this research effort that AI capabilities in multimedia production can change the way engineering content is delivered and enhance the undergraduate engineering education experience for students today.

Acknowledgements

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