Feasibility and Acceptance of Micro-Video as an Innovative Teaching Method in Engineering Education

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The Asian Conference on Education 2023
Official Conference Proceedings

Abstract
The growing interest in innovative teaching methods within higher education has prompted an exploration of micro-videos as a valuable intervention tool. Grounded in the Technology Acceptance Model (TAM) theory, this study investigates the effectiveness and acceptance of micro-videos as a teaching method in sustainable engineering education, while also identifying the factors that influence students' acceptance of this approach. The study was conducted in three stages. Firstly, semi-structured interviews were conducted with 30 engineering students to gather insights and formulate a TAM-based model for measuring student acceptance. Secondly, an experiment involving 425 year-2 engineering students from a university in China was conducted. The experiment incorporated a preview-test, micro-video viewing, post-view survey, and a post-test. Results indicated a significant 20% increase in post-test scores, indicating improved knowledge acquisition and confirming the effectiveness of micro-video pedagogy. Furthermore, the study found that the "quality of the framework" and "quality of the content" of the micro-videos had a significant impact on students' attitudes towards using this teaching method via structural equation modelling (SEM). This study provides important implications for the future development of innovative teaching methods. By understanding the feasibility and factors affecting acceptance, educators can harness the potential of micro-videos to enhance engineering education.

Keywords: Sustainable Engineering Education, Micro-Videom, Technology Acceptance Model (TAM), Experiment Intervention, Structural Equation Modelling (SEM)

Introduction

The 1987 Brundtland Report by the United Nations spotlighted sustainability as essential for current development without compromising future generations (United Nations General Assembly, 1987). This concept has since permeated global educational strategies, with an emphasis on integrating sustainability in engineering practices and education. As institutions shape future leaders, sustainability education becomes vital. With evolving societal needs, traditional educational methods often lag. Thus, modern pedagogies in sustainable engineering education, such as project-based learning (PBL) and service learning (SL), have emerged as solutions to instill sustainability principles effectively in students (Lozano et al., 2013; Tang, Law, Gary, Tsui and Lo, 2016; Mesa, Esparragoza, and Maury, 2017; Hou and Wu, 2020; Gutierrez-Bucheli et al. 2022).

With technological advancements, micro-video pedagogy, characterized by its brevity and efficiency, has gained prominence in the educational sector (Liu et al., 2022, Hou et al., 2023a). Its versatility spans various disciplines, proving useful on platforms like TikTok and YouTube. Despite its widespread application, the potential of micro-videos in engineering sustainability education remains untapped, and the student reception towards this teaching method is yet to be thoroughly examined. Hence, it is imperative to explore the integration of micro-video in sustainable engineering curricula and understand its impact on student engagement.

This research aims to address the knowledge gap surrounding the practicality of micro-videos as an instructional tool in engineering education, focusing on sustainable development within the built environment. The study will involve engineering students to assess the impact of micro-videos on their understanding of sustainability concepts. Using pre and post-engagement performance metrics and a Technology Acceptance Model framework, the research seeks to evaluate the pedagogical value of micro-videos and understand students' acceptance levels and influencing factors in the academic context.

This study aims to examine the effectiveness of micro-videos in facilitating engineering students' learning of the sustainable built environment knowledge and investigate the factors that affect students' acceptance of using micro-videos in their learning processes. Specific objectives are as follows:

(1) To investigate the effectiveness of the micro-video in enhancing students' learning outcome
(2) To identify the factors that influence students' acceptance and perceptions of the micro-video
(3) To verify the proposed theoretical model using questionnaire survey data

1. Literature Review

1.1 The Importance of Sustainable Engineering Education

Education for Sustainable Development (ESD) emerged in 1987 with the publication of the Brundtland report, establishing it as a significant field (Zaccai, 2012). ESD is defined as an educational approach that fosters the advancement of knowledge, skills, values, and attitudes to enable individuals to thrive in a more sustainable and just society (United Nations Educational, Scientific, and Cultural Organization, 2005). Nowadays, sustainable education can be synergistically integrated with various concepts such as "Sustainability in

Management Education (SME)" (Figueiró and Raufflet, 2015), "Environmental Sustainability Education (ESE)" (Kónya et al., 2021), and "Engineering Education for Sustainable Development (EESD)" (Gutierrez-Bucheli, Kidman, and Reid, 2022) to cultivate sustainability awareness among higher education students and incorporate sustainability principles into their learning experiences.

Among of these concepts, sustainable engineering education plays a vital role in addressing the challenges of sustainable development and securing a more sustainable future. Engineering is key to finding solutions for sustainable development problems (Davidson et al., 2010; Karatzoglou, 2013). The recognition by UNESCO of the influence of engineering on society, ethics, and individual values further underscores the significance of incorporating sustainability into engineering education (UNESCO, 2010).

One of the emerging issues in "engineering unsustainability" is the environmental impact of engineering activities. Depletion of natural resources, greenhouse gas emissions, and environmental contamination are just a few examples of the negative consequences resulting from engineering projects. Promoting sustainability awareness among engineering students and incorporating sustainable engineering education methods are vital steps in addressing these challenges. Universities and educational institutions have recognized this need and have implemented various approaches to advance engineering sustainability education (Juárez-Nájera et al., 2006; Pérez-Foguet et al., 2018). These approaches aim to cultivate a deep understanding of sustainable development principles and equip future engineers with the knowledge, skills, and values necessary to design and implement sustainable solutions.

1.2 Sustainable Engineering Education Approaches

Applying innovative teaching methods in engineering sustainability education is necessary for ensuring that students are equipped with the knowledge and skills to address current and future sustainability challenges (Hou et al., 2023a; b). Various teaching strategies have been developed and tested to enhance the effectiveness of sustainability education. Research shows that more than 22 distinct teaching strategies effectively strengthen sustainability education in various ways (Jeronen et al., 2017). However, as this field constantly evolves, new methods are emerging and being reformed.

Common and effective teaching methods in engineering sustainability education include project-based, service, experiential, interdisciplinary, and active learning, which fall into categories like project-based learning (PBL), service learning (SL), and general engineering sustainability education methods. These approaches enhance critical thinking, problem-solving skills, and sustainability comprehension in students. While pedagogical methods like flipped classrooms and problem-based learning can boost engagement, they may pose challenges such as time intensity, group dynamics, and resource demands (Gutierrez-Bucheli et al. 2022).

In light of these considerations, the incorporation of micro-video into engineering education programmes is appropriate, as micro-video can stimulate students' learning enthusiasm and initiative. (Wang, 2022; Liu et al., 2022; Tian and Tsai, 2021; Wang et al., 2019). Furthermore, with the development of video platforms, video resources are simple to locate, edit, and generate, while internet-based education has become commonplace for students due to its popularity. The subsequent section will therefore introduce the micro-video teaching procedure.

1.3 Micro-Video Learning and Its Feasibility for Engineering Sustainability Education

Micro-video, as a vehicle for micro-learning, is widely used in university teaching (Liu et al., 2022). There is no agreed-upon definition of micro-video, but a variety of explanations exist. Micro-video, which includes micro-films and micro-documentaries, can be recorded and viewed on multi-channel video terminals. Micro-videos can be as short as 30 seconds or as long as 20 minutes. Micro-videos range between 30 seconds and 20 minutes in length. Wistia, a video hosting and analytics company, has provided a definition of micro-videos - micro-videos are typically less than 60 seconds long and are distinguished by their brevity, simplicity, and singular concentration on a single topic or idea. The micro-potential of videos for education derives from their clear visual presentation and concise transmission of information.

Several disciplines have attested to the effectiveness of micro-videos as a teaching aid, including tertiary-level English (Wang, 2022), chemistry (Wang et al., 2019), and physical education (Huang and Yu, 2022). Micro-videos have been shown to substantially improve both student achievement and motivation, as demonstrated, for instance, by the work of Wu et al. (2022) in the field of pharmacology education. Furthermore, Li et al. (2021) demonstrated that the use of micro-videos in biochemistry education helped students develop problem-solving skills and innovate better. In addition, Gong (2021) found that the use of micro-videos in physical education studies increased students' interest in the subject and broadened their perspectives. Moreover, Wang et al., (2018) discovered that embedded real-time operating systems (RTOS) can benefit from micro-video. Micro-videos, in contrast to traditional teaching resources, leverage vibrant and visually engaging content to enhance classroom efficiency, encourage student participation, and make abstract concepts appealing in engineering sustainable development education (Wang, 2022; Liu, 2022).

According to research conducted by Huang and Yu (2022), students' propensity to utilize micro-videos for educational purposes is significantly influenced by the video's production value, the content's applicability to the course, and the platform's user-friendliness. Students' perception of micro-videos' usefulness for learning and their motivation to learn were also significant factors influencing their openness to using micro-videos in the classroom, according to research by Al-Rahmi et al. (2021). Other factors such as the length of the micro-video, the level of interactivity, and the availability of captions or subtitles may also affect students' willingness to use micro-videos for learning (Brame, 2016).

2. Research Methodology

2.1 Design of the Research Activities

To achieve the above objectives, a mixed-methods approach was utilised, combining both quantitative and qualitative research methods. The study is divided into two stages: experiment preparation (*Stage 1*) and experiment implementation (*Stage 2*).

In *Stage 1*, a micro-video was first developed for teaching "street canyon effect" using an animation development software. After that, the video was distributed among 30 students of various academic backgrounds. Students were encouraged to watch the video during the off-classroom time. In-depth interviews were then conducted with the 30 students to collect feedback. After the analysing the interview data, the micro-video was further verified based on the student feedbacks. At the same time, the interview results were examined to identify the factors that affect students' acceptance to use micro-video and proposed a TAM-based theoretical model.

In the *Stage 2*, an experiment, including a pre-view test and a post-view test, was implemented to test the effectiveness of the micro-video in facilitating students' learning. The pre-view and post-view tests results were analysed to examine the effectiveness of the micro-videos. A questionnaire survey designed based on the TAM-based model was distributed to the experiment participants for verifying the proposed theoretical model.

2.2 Micro-Video Development

An eight-minute micro-video introducing the "street canyon effect" in sustainable urban built environments was created with vibrant animation and sound effects to enhance student engagement. The video underwent feedback collection from 30 students through in-depth interviews, focusing on aspects such as video quality and the effectiveness of the micro-video pedagogical strategy, with the results categorized for data analysis. Table 1 provides the context of the respondents and their main concerns over the micro-video pedagogy.

Table 1: Respondents' background and concerns over the pedagogy

Academic background	**Frequencies (%)**
Undergraduate	50%(n=15)
Postgraduate	49%(n=14)
PhD	1%(n=1)
Students' concern over the micro-video pedagogy	**Frequencies (%)**
Quality of the micro-video content	83%(n=25)
Quality of the micro-video operation	60%(n=18)
Quality of the micro-video framework	33%(n=10)

2.3 Pre-view and Post-view Tests

The experiment focused on assessing students' comprehension of the "street canyon effects," involving pre-view and post-view tests. The tests, comprising seven questions each, were intentionally set at a slightly more difficult level post-viewing to highlight the micro-video's effectiveness. Students completed test-1 independently before viewing the video, followed by the experiment, and then completed test-2, all administered online with a 10-minute time limit. Figures 1a and 1b depict two examples of questions disseminated to students via an online platform.

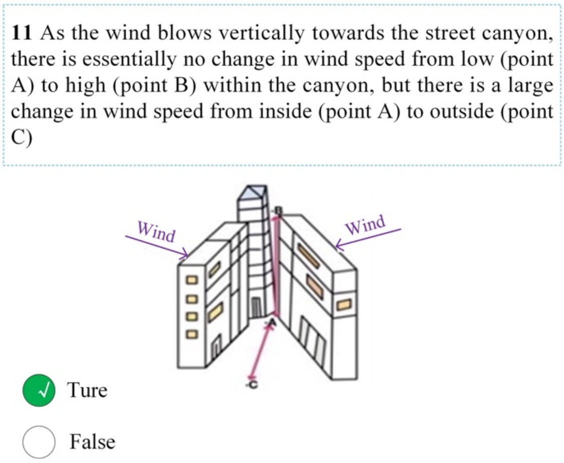


Figure 1a: A question designed in pre-view test

Figure 1b: A question designed in post-view test

Figure 1: Two example questions distributed among students through the online platform

2.4 TAM-Based Model Development

The Technology Acceptance Model (TAM) serves as a primary framework for assessing factors driving students' embrace of micro-video learning. TAM, introduced by Davis in 1989 (Davis, 1989), underscores two pivotal elements influencing technology adoption: perceived usefulness (PU) and perceived ease of use (PEU). PU gauges the potential benefits users anticipate from a technology, while PEU evaluates the anticipated ease of its operation. External elements, like technology characteristics, also impact adoption rates, as highlighted by Liu and Ye (2021). Research by Yang and Su (2017) showed that video production quality, rather than utilitarian factors, significantly influenced student engagement in MOOCs. Further, Brame (2016) emphasized the importance of aligning videos with learning objectives and ensuring technical quality to bolster student engagement. These theoretical insights align with feedback from 30 student interviews.

Therefore, based on previous literature and in-depth interviews, the quality of micro-video as an important factor that affect students' acceptance of the micro-video pedagogy was proposed to be added in the new model. The quality of micro-video is categorised into three components: quality of the micro-video contents (OC), quality of the micro-video framework (QF), and quality of the operation of the micro-video (QO). Figure 2 shows the major constructs of the TAM-based model, in which, QC relates to the micro-module content: the topic/knowledge selection in each video, QF refers to the structure and presentation of the knowledge, and lastly QO refers to students' experience with the online platforms.

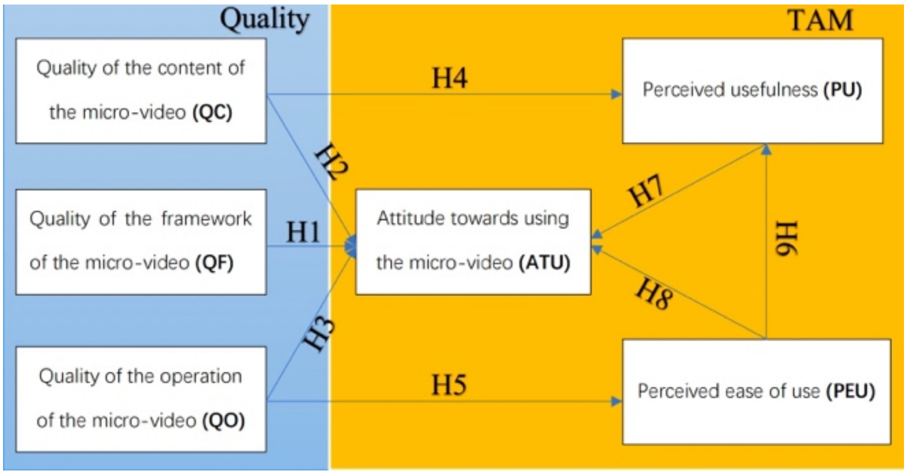


Figure 2: Proposed TAM-based model

The multiple lines shown in the proposed TAM-based model (Figure 2), are possible impact paths identified based on the literature review, in-depth interview, and the classic TAM model.

H1:The attitude toward using a micro-video is positively affected by the framework of the micro-video.
H2:The attitude toward using a micro-video is positively affected by the contents of the micro-video.
H3:The attitude toward using a micro-video is positively affected by the operation of the micro-video.
H4:The perceived usefulness is positively affected by the micro-video quality of content.
H5:The perceived ease of use is positively affected by the micro-video quality of operation.
H6:Perceived usefulness is positively affected by the perceived ease of use.
H7:The attitude towards using the micro-video is positively affected by the perceived usefulness.
H8:The attitude towards using the micro-video is positively affected by the perceived ease of use.

2.5 Questionnaire Survey Design and Data Collection

A TAM-based questionnaire with 36 seven-point scale questions was utilized to investigate eight hypotheses concerning the perceived quality of micro-videos in sustainable engineering education. The study, involving 425 engineering students, received ethical approval, and data analysis using SPSS 26 and SEM via SPSS and AMOS software provided insights into the relationships between variables, contributing to a comprehensive understanding of the factors influencing students' acceptance of micro-video pedagogy. . The survey obtained human subject ethics application review approval (No. HSEARS20221217003) from the first author’s university.

3. Results

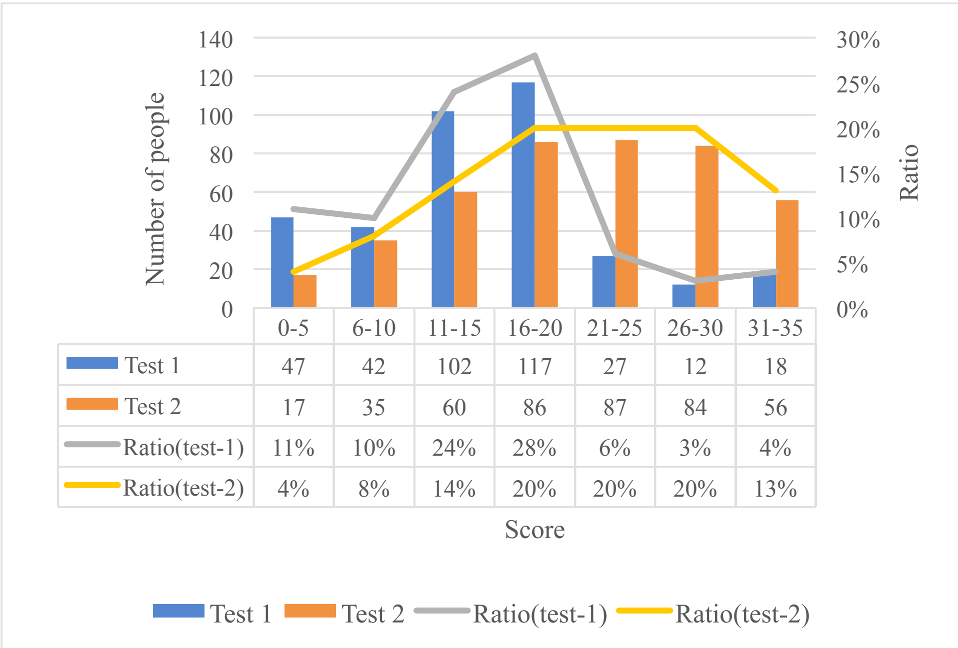
3.1 Effectiveness of the Micro-Video Pedagogy

The two online tests received 425 legitimate responses. Table 2 shows the background information of engineering student participants. The two tests received 425 valid questionnaires (>1 minute response time). The online platform automatically recorded the responses of the students and automatically calculated their scores.

Table 2: Background information of engineering student participants

Attributes	Distribution	Respondent% (n=425)
Major	Built Environment	27% (n=113)
	Engineering Management	32% (n=134)
	Civil Engineering	21% (n=91)
	Town & Country Planning	20% (n=87)
Grade	Undergraduate Grade 2	425 (100%)

The study analyzed the results of two tests, revealing a significant improvement in the correct response rate of students after viewing the micro-video. Test-2 showed a notable increase in the average score (22.8) compared to Test-1 (15.7), with a 7% higher rate of faultless scores, indicating the effectiveness of the micro-video pedagogical method in facilitating student learning and knowledge acquisition. Figure 3 displays the results and comparative analysis of the two tests.



	0-5	6-10	11-15	16-20	21-25	26-30	31-35
Test 1	47	42	102	117	27	12	18
Test 2	17	35	60	86	87	84	56
Ratio(test-1)	11%	10%	24%	28%	6%	3%	4%
Ratio(test-2)	4%	8%	14%	20%	20%	20%	13%

Figure 3: Graphical representation of the test results and their comparisons

3.2 Model Testing and Analytic Results

3.2.1 Reliability and Validity Tests

Cronbach's Alpha was used to determine the questionnaire's internal consistency in this study.

Cronbach's Alpha coefficients for the scale are all greater than 0.7 (PU:0.903; PEU:0.891; QC:0.921; QO:0.856; QF:0.912; ATU: 0.898), suggesting that the questionnaire has adequate internal consistency for use in the present study.

This study used the Kaiser–Meyer–Olkin sampling adequacy measure (KMO) and Bartlett's sphericity test to determine whether the data were suitable for factor analysis. KMO and Bartlett's test analysis results show that the KMO value of the questionnaire is 0.926, which is greater than the standard 0.70, Bartlett's Test of Sphericity is 6789.603, and the P value is 0.00, so it is suitable for factor analysis (Table 3).

Table 3: Test results of KMO and Bartlett's Test

KMO and Bartlett Test		
KMO		0.926
Bartlett test	Approx. Chi-Square	6789.603
	df	406
	P value	0.00

Regarding the factor loadings, as suggested by Hair (2019), items with factor loadings below 0.70 were removed from the model to improve the model and path strength, given that the averages and standard deviations were within the acceptable range. Table 4 shows that, except QO4, all variables had factor loading larger than 0.7. They can all be retained in the model. For QO4, its value is 0.694 and it can also be retained in the model.

Table 4: Results of Confirmatory Factor Analysis

Dimension	Observed variable	Factor loading	S.E.	C.R.	P	CR	AVE
PU	PU1	0.821				0.655	0.904
	PU2	0.860	0.058	18.693	***		
	PU3	0.817	0.062	17.391	***		
	PU4	0.808	0.062	17.114	***		
	PU5	0.734	0.053	15.020	***		
PEU	PEU1	0.830				0.672	0.891
	PEU2	0.817	0.058	17.178	***		
	PEU3	0.818	0.057	17.218	***		
	PEU4	0.814	0.060	17.096	***		
QC	QC1	0.772				0.667	0.923
	QC2	0.865	0.061	17.407	***		
	QC3	0.848	0.057	16.988	***		
	QC4	0.820	0.070	16.303	***		
	QC5	0.813	0.066	16.129	***		
	QC6	0.780	0.073	15.340	***		

QO	QO1	0.800				0.607	0.860
	QO2	0.785	0.061	15.179	***		
	QO3	0.831	0.054	16.144	***		
	QO4	0.694	0.065	13.131	***		
QF	QF1	0.887				0.676	0.912
	QF2	0.827	0.047	19.961	***		
	QF3	0.772	0.048	17.729	***		
	QF4	0.793	0.048	18.573	***		
	QF5	0.827	0.042	19.981	***		
ATU	ATU1	0.805				0.642	0.899
	ATU2	0.845	0.057	17.595	***		
	ATU3	0.761	0.054	15.332	***		
	ATU4	0.754	0.064	15.161	***		
	ATU5	0.836	0.059	17.339	***		

According to the theoretical assumptions, the path relationship of this model was constructed, as shown in the following Figure 4. In the present research, a TAM-based model incorporated six distinct variables, with each adopting a reflective measurement approach. It was imperative to validate that these indicators precisely represented the intended constructs. To determine the robustness and consistency of these indicators, various benchmarks were assessed. The results were promising, with the obtained Cronbach's alpha values surpassing the 0.70 threshold. Additionally, the composite reliability (CR) exceeded 0.60, and the average variance extracted (AVE) from the model surpassed the 0.50 benchmark (shown in Table 4). This implies that the model's indicators are both valid and reliable, meeting the established criteria for effective measurement. Additionally, for adequate discriminant validity, the bold numbers in Table 5 were greater than the corresponding non-bold numbers, indicating that the data achieved good discriminant validity.

Table 5: Correlation analysis and discriminant validity of the dimensions result

Dimension	1	2	3	4	5	6
PU	0. 809					
PEU	0.488	0. 820				
QC	0.358	0.413	0. 817			
QO	0.643	0.493	0.397	0. 779		
QF	0.276	0.302	0.431	0.298	0. 822	
ATU	0.516	0.497	0.458	0.477	0.442	0. 801

3.2.2 Analysis of the Measurement Model

The variables QC, QO, and QF served as independent variables, while PU and PEU served as intermediaries, and ATU served as the dependent variable in the structural equation model developed for this study. The overall model fitting was checked to make sure it was a good fit for the formal survey data. As indicated in Table 6, most indicators were satisfactory following model correction, and GFI and AGFI scores were just below the 0.9 threshold needed to pass evaluation. GFI and AGFI values were above 0.8, which is considered to be fine by Hair (2019). The proposed model can thus be leveraged for future similar data analyses.

Table 6: Structural equation model fit test results

Reference indicator	x^2/df	AGFI	GFI	TLI	NFI	CFI	RMSEA
Evaluation standard	1-3	>0.8	>0.8	>0.9	>0.9	>0.9	<0.08
Statistics	1.892	0. 855	0. 878	0.945	0.901	0.950	0.051
Model fit	yes	yes	yes	yes	yes	yes	yes

To estimate the regression coefficients, this study employs the maximum likelihood technique. The standard errors (SE) of the path coefficients are all positive and there is no outlying phenomenon, as shown in the Table 7. As the absolute value of the corresponding critical value C.R. is greater than 1.96, the regression coefficient value is statistically different from 0.05. When the critical ratio is greater than 1.96, the path coefficient is considered statistically significant at the $p<0.05$ level, and when it is greater than 2.58, at the $p<0.01$ level.

Table 7: Path coefficients and hypothesis test result

Path			Estimate	S.E.	C.R.	P
QO	←	QF	0.324	0.050	5.407	***
PEU	←	QO	0.526	0.060	8.529	***
QC	←	QF	0.440	0.049	7.548	***
PU	←	QC	0.200	0.048	3.716	***
PU	←	PEU	0.453	0.055	7.726	***
ATU	←	QC	0.167	0.054	2.908	**
ATU	←	QF	0.228	0.048	3.844	***
ATU	←	QO	0.104	0.063	1.607	0.108
ATU	←	PU	0.244	0.064	4.027	***
ATU	←	PEU	0.209	0.069	3.037	**

Note: *** means significant at the 0.001 level; ** means significant at the p<0.05 level

Based on the results of the fitting index test shown in the table above, the model fitting index is sufficient for path analysis and hypothesis testing between variables. The model fitting method used in this study is the maximum-likeness method, the non-parametric percentage Bootstrap is used to correct the bias, and the Bias-corrected test method is used to repeat the sampling 2000 times under the condition of a 95% confidence interval (Preacher and Hayes, 2004). In this study, the mediation effect of the structural equation model was analysed, and the specific results are shown in the following Table 8.

Table 8: Mediating effect test result

Parameter	Estimate	Lower	Upper	P
QF-QC-ATU (standardized)	0.073	0.016	0.147	0.011
QF-QO-ATU (standardized)	0.034	-0.017	0.105	0.196
QC-PU-ATU (standardized)	0.049	0.014	0.111	0.002
QO-PEU-ATU (standardized)	0.110	0.035	0.204	0.005

It can be seen from the Table 8 that the indirect influence coefficient of QF-QC-ATU (standardized) is 0.073, the confidence interval of the indirect effect does not include 0, and the p-value is less than 0.05. QC plays an intermediary role between QF and ATU.

4. Discussion - Leveraging Micro-Videos: A Modern Approach to Enhancing Sustainability Education

Micro-videos, with their concise and visually appealing format, have been recognized as a revolutionary tool in the realm of education. As evidenced by a plethora of studies, their rise in the academic domain isn't just a fleeting trend but a testament to their efficacy (Liu et al., 2022; Wang et al., 2019; Wang, 2022;). Particularly, in the context of facilitating sustainable education studies, students' acceptance of micro-video pedagogy is pivotal.

Drawing upon the findings from this empirical study, it is evident that the production quality, content relevancy, and platform's user interface play a significant role in students' inclination towards micro-videos (Huang and Yu, 2022). The findings suggest that when these elements are optimized, micro-videos can offer a richer, more engaging learning experience. This resonates with the broader implications of Al-Rahmi et al. (2021), where students' perception of the usefulness of micro-videos and their intrinsic motivation to learn emerge as critical drivers for their acceptance. It is not just about the video's contents; the surrounding elements, including its duration, interactivity, and the accessibility features like captions, also contribute to its acceptance (Brame, 2016).

Also, the dynamic nature of micro-videos caters to the modern student's learning preferences. Unlike traditional resources, micro-videos, with their vibrant visuals, encapsulate complex, abstract content in a manner that's both engaging and comprehensible. Their mobile-friendly design further amplifies their reach, catering to the on-the-go learning preferences of today's digital-native students (Wang, 2022; Liu, 2022). Furthermore, the inherent structure of micro-videos aligns seamlessly with sustainable education, which often grapples with intricate concepts that need real-world context. The flexibility of micro-videos allows educators to embed real-life instances, making the abstract notions of sustainability tangible.

5. Conclusion

This research explores the effectiveness of micro-video teaching in sustainable engineering education through the lens of the Technology Acceptance Model (TAM). Emphasizing the importance of video quality, the study suggests integrating micro-videos with traditional teaching methods for optimal educational outcomes. Micro-videos, offering real-time insights and engaging storytelling, bridge the gap in sustainable knowledge, democratizing education and transforming abstract concepts into tangible narratives. While the study focused on sustainable built environment, future research could enhance comprehensiveness by comparing micro-video teaching with other methods and exploring a broader range of topics within sustainable engineering. Longitudinal assessments and diverse domain studies could further enrich our understanding of the impact of micro-video pedagogy.

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