MORE THAN NOVELTY: STUDENTS' PERCEIVED PEDAGOGICAL VALUE OF A 360° ENGINE VISUALIZATION EXPERIENCE

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Abstract

Digital technologies are increasingly being incorporated into higher education, opening new possibilities for the teaching of contents that are difficult to address through conventional resources alone. In engineering education, one of the challenges lies in helping students understand complex technical systems in a more visual and accessible way. In this context, a screen-based 360° engine visualization was designed to support visual exploration of the engine and its components. Specifically, the aim of the present study was to analyse students' post-experience perceptions of the utility, novelty and relevance of this educational resource and to examine the pedagogical value attributed to it in comparison with the usual course resources. A second aim was to compare this pattern in two universities in which the experience was implemented in the same way: the University of Cádiz (Spain) and Tecnológico de Monterrey (Mexico). To this end, 40 post-experience questionnaires were analysed, corresponding to 20 students from each university. The instrument included three items assessing the perceived utility, novelty and relevance of the technological resource, using a seven-point Likert scale, together with an open-ended question aimed at capturing students' qualitative perceptions of the experience and its added value. Results indicate a clearly positive evaluation in the three dimensions considered. In both institutions, the resource was assessed very favourably, suggesting that it was perceived not merely as an attractive addition, but as a meaningful support for learning. This interpretation was reinforced by the qualitative responses, which highlighted the role of the experience in making the engine easier to visualise and understand, as well as more engaging from an educational perspective. Although students from Tecnológico de Monterrey tended to provide slightly higher scores, no statistically significant differences were found between the two universities. Overall, the findings suggest that screen-based 360º visualization constitutes a valuable educational innovation in engineering teaching across two academic contexts. In particular, students attributed to it a pedagogical value that went beyond the usual course resources. The contribution is therefore centred on students' appraisal of the resource after use. The study may be of interest to teachers and researchers involved in the design and assessment of digital educational innovations in higher education, especially in disciplines dealing with complex technical contents.

Keywords: Engineering education, 360º visualization, perceived pedagogical value, student perception, educational innovation.

1 INTRODUCTION

Engineering education has traditionally relied on expository methodologies and the unidirectional transmission of knowledge [1]. This approach has been criticized for inadequately addressing the diverse competencies required of modern engineers, such as communication, teamwork, leadership, and interdisciplinary collaboration [2]. In response to these challenges, the strategic integration of advanced technological resources has emerged as a pivotal trend in the evolution of engineering education. Innovative tools, including virtual and remote laboratories, computer simulation platforms, 3D printing technologies, intelligent sensors powered by the Internet of Things (IoT), and immersive reality environments, are not mere adjuncts to traditional pedagogy. Instead, they represent transformative elements that have the potential to reshape teaching and learning processes, fostering a more dynamic, interactive, and competency-driven educational paradigm [1]. Disciplines that address complex technical content, such as mechanical engineering, have traditionally structured their curricula around lectures, exams, and laboratory experiments. This conventional approach prioritizes the development of technical expertise and problem-solving skills [2]. However, the advent of digital technologies offers ground-breaking opportunities to not only reinforce these foundational competencies but also integrate a forward-looking

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perspective on technological innovation, aligning education with the demands of specialized systems and products emerging in the context of the Fourth Industrial Revolution [3]. Moreover, these advanced tools contribute to reducing costs, enhancing accessibility, and increasing affordability, while enabling personalized and adaptive learning experiences that cater to diverse learner needs [4].

Numerous studies (e.g., [5] – [9]) have extensively documented the benefits of emerging digital technologies in enhancing the teaching-learning process. However, these investigations have predominantly focused on pre-university contexts or introductory undergraduate courses. In recent years, a notable shift has occurred, with an increasing body of academic research, such as [10], [11] and [12], exploring the impact of these tools in advanced courses that involve more intricate conceptual frameworks. This emerging focus highlights the potential of digital technologies to support deeper cognitive engagement and foster the mastery of complex disciplinary content. The aim of the present study was to analyse students' post-experience perceptions of the utility, novelty and relevance of a 360º visualization experience of an engine, designed as a central pedagogical tool to illustrate its key characteristics and the impact of each feature on the device's performance. A differentiating aspect of this research, compared to similar studies in the area, and under equivalent conditions at the University of Cádiz (UCA, Spain), and the Tecnológico de Monterrey (TEC, Mexico). This cross-institutional approach incorporated faculty with diverse technical and pedagogical expertise, as well as students with varying academic profiles, providing a broader perspective on the educational effectiveness of the proposed innovation.

2 METHODOLOGY

2.1 Sample

The study included 40 participants, 20 participants from each university selected at random from the participating courses. The students participated voluntarily after signing an informed consent form regarding the experimental procedure, which guaranteed the confidentiality of participants' data in accordance with the ethics committee from both universities. All participants collaborated voluntarily, reported normal vision, and indicated no colour blindness.

2.2 Stimuli

The educational resource consisted of a screen-based 360° engine visualization designed to support the understanding of mechanical systems through visual exploration. Students accessed the resource via a website on their laptops and could observe the engine from multiple perspectives, facilitating spatial comprehension and the identification of structural and functional components (see Figure 1).



Figure 1. Examples of perspectives for engine visualization.

2.3 Procedure

The experimental procedure was structured as a post-experience evaluation, designed to capture students' perceptions following their interaction with the proposed educational resource. The study was implemented under comparable instructional conditions. In both contexts, the activity was integrated into regular course sessions related to mechanical systems or engineering fundamentals. Students first participated in the screen-based 360° engine visualization, which allowed them to explore the engine and its components from multiple perspectives. The activity was conducted using the same technological

setup, instructions, and duration in both institutions in order to ensure procedural consistency. The complete activity took about 60 minutes.

Immediately after completing the experience, participants were asked to complete a post-experience questionnaire via Qualtrics. For the purposes of this paper, the analysis focused on three post-experience seven-point items assessing the perceived utility, novelty and relevance of the technology, together with one open-ended question concerning the added value of the experience compared with the usual course resources. Other questionnaire sections were not analysed in the present contribution.

Table 1. Questionnaire items analysed in this paper.

Quantitative items	*Qualitative item*
1. I consider the application of technology to have utility. *(Considero útil la aplicación de la tecnología).*	4. What did the screen-based 360° experience provide that was not provided (or was provided to a lesser extent) by the usual course resources (e.g., lectures, digital notes, practical sessions, etc.)? *(¿Qué te aportó la experiencia en 360° en la pantalla que no te aportaron (o te aportaron en menor medida) los recursos habituales de la asignatura (por ejemplo: clases teóricas, apuntes digitales, prácticas, etc.)?).*
2. I consider the application of technology to be novel. *(Considero novedosa la aplicación de la tecnología).*	
3. I consider the application of technology to be relevant. *(Considero relevante la aplicación de la tecnología).*	

2.4 Statistical treatment

After compiling and analysing the database containing participants' questionnaire responses, the analysis was conducted according to the procedures outlined in Table 2. The analysis combined quantitative and qualitative approaches to examine students' post-experience appraisals of the resource and the added value attributed to it in relation to the usual course resources in the two institutions. All analyses were conducted using IBM SPSS Statistics version 26.0.

Table 2. Statistical analysis phases and corresponding results.

Phase	*Statistical analysis*	*Results*
Phase 1. Overview of the post-experience evaluation.	Descriptive statistics	Overall description of students' post-experience assessments of utility, novelty and relevance in Cádiz and Monterrey.
Phase 2. Normality of evaluation variables.	Shapiro-Wilk test	Assessment of the normality assumption to guide test selection.
Phase 3. Significant differences between institutions.	Mann-Whitney U test	Detection of statistically significant differences between Cádiz and Monterrey in the three evaluation variables.
Phase 4. Qualitative appraisal of added value.	Brief thematic analysis	Identification of the main themes through which students described the added value of the experience compared with the usual course resources.

3 RESULTS

Results are presented in four phases. First, descriptive statistics are reported for the three evaluation variables in the two institutions. Second, normality is assessed in order to inform test selection. Third, between-university differences are examined using the Mann-Whitney U test. Fourth, the qualitative responses are analysed to identify the main forms of pedagogical value attributed to the experience in relation to the usual course resources.

3.1 Phase 1. Overview of the post-experience evaluation

To obtain an overview of the post-experience evaluation, the score distributions for utility, novelty and relevance were analysed in the two institutions (Table 3). Overall, evaluations were high in both contexts, with all mean scores located towards the upper end of the scale. Utility and relevance showed the highest values in both universities, whilst novelty was also positively rated, although slightly lower. Monterrey tended to obtain somewhat higher scores than Cádiz in the three variables, but the overall pattern was highly similar across institutions, suggesting a favourable post-experience appraisal of the resource in both contexts.

Table 3. Descriptive statistics by variable and university.

Variable	University	Mean (M)	Median (Md)	Standard deviation (SD)	Minimum (Min)	Maximum (Max)
Utility	UCA	6.15	6.00	0.99	4.00	7.00
Utility	TEC	6.50	7.00	0.69	5.00	7.00
Novelty	UCA	6.05	6.00	1.15	3.00	7.00
Novelty	TEC	6.15	6.00	0.93	4.00	7.00
Relevance	UCA	6.10	6.00	0.91	4.00	7.00
Relevance	TEC	6.45	7.00	0.69	5.00	7.00

3.2 Phase 2. Normality of evaluation variables

To select the appropriate inferential procedure, normality was assessed separately for each variable and institution using the Shapiro-Wilk test (Table 4). In all cases, the normality assumption was not met ($p < .05$). Accordingly, the Mann-Whitney U test was used in the following phase.

Table 4. Normality of evaluation variables using Shapiro-Wilk.

Variable	University	Shapiro-Wilk (W)	p
Utility	UCA	0.791	<0.001
Utility	TEC	0.711	<0.001
Novelty	UCA	0.802	<0.001
Novelty	TEC	0.817	0.002
Relevance	UCA	0.836	0.003
Relevance	TEC	0.739	<0.001

3.3 Phase 3. Between-institution comparisons

To assess between-university differences in post-experience evaluation, comparisons between Cádiz and Monterrey were performed using the two-tailed Mann-Whitney U test (Table 5). Although Monterrey showed slightly higher scores in all three variables, none of the differences reached statistical significance. The two institutions therefore exhibited a comparable post-experience pattern of evaluation within this balanced exploratory sample.

Table 5. Between-university differences using Mann-Whitney U.

Variable	Mann-Whitney (U)	p
Utility	163.0	0.2757
Novelty	197.0	0.9424
Relevance	158.5	0.2282

3.4 Phase 4. Qualitative appraisal of the added value of the experience

To examine the added value attributed to the experience in relation to the usual course resources, the open-ended responses were analysed thematically. The responses converged on a clear and coherent pattern in both institutions. Three recurrent themes emerged. First, students emphasised the possibility of visualising the engine and its components more clearly, often describing the experience as a way of making the content less abstract. Second, many responses pointed to a better understanding of the system, its parts and their relations, suggesting that the resource supported comprehension rather than merely attracting attention. Third, the experience was frequently described as more dynamic, interactive or engaging than the usual course resources. A smaller but still recurrent set of responses also referred to a greater sense of realism and proximity to practice.

Taken together, the qualitative material supports the quantitative findings and reinforces the interpretation of the resource as more than a novel or technologically appealing addition. Rather, students tended to frame it as a pedagogically useful complement to lectures, notes and practical sessions, especially because it allowed them to see the engine more clearly, understand it better and engage with the content in a more direct way. In this sense, the results provide initial evidence that this line of work merits further study, particularly from the perspective of the pedagogical value that students attribute to the resource after use.

4 CONCLUSIONS

Engineering is grounded in continuous innovation and the quest for optimization. Consequently, engineering education must evolve alongside the new tools and methodologies arising from technological advancement. This research serves to broaden the resources available to instructors and students in their pursuit of excellence.

The screen-based 360°visualization experience of an engine received high ratings for utility and relevance, with slightly lower but still positive ratings for novelty. Participants described the resource as more dynamic, interactive and engaging than usual course materials. Their qualitative comments suggest that the visualization helped them see the engine more clearly, relate its components and engage with the content in a more direct way. These findings should be interpreted as evidence of perceived pedagogical value rather than as direct evidence of learning gains.

The comparison between the two institutions showed no statistically significant differences in students' ratings. This result suggests a comparable pattern of post-experience appraisal across the two implementations. Overall, the study provides preliminary evidence that screen-based 360° visualization can be a useful complement in engineering teaching, particularly for technical content that benefits from spatial and visual representation.

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REFERENCES

[1] A.P. da Cunha, "Emerging digital technologies in engineering education: pedagogical potential for active learning and competency development", Seven Editora, pp. 2567–2584, 2025. https://sevenpubl.com.br/editora/article/view/8821

[2] Y-P. Hsu, D.F. Chiang and I. Kehinde, "Transforming engineering education in the digital era: findings from a systematic review", Front. Educ., 10:1568917, 2025. https://doi.org/10.3389/feduc.2025.1568917.

[3] E.J. López, P.A.L. Leyva, A.A. López, F.J.O. Estrella, J.J.D. Vázquez, B.L. Velázquez and V.M.M Molina, "Mechanics 4.0 and Mechanical Engineering Education", Machines, 12: 320, 2024. https://doi.org/10.3390/machines12050320

[4] P. Nedungadi, M.G. Thushara, G. Veena, K.-Y. Tang and R. Raman, "Emerging technologies for STEM education: global evidence on learning, equity, and SDG4", Humanit Soc Sci Commun, vol. 13, Article 522, 2026. https://doi.org/10.1057/s41599-026-06565-w

[5] J. He, Dan Chia-Tien Lo, Y. Xie and J. Lartigue, "Integrating Internet of Things (IoT) into STEM undergraduate education: Case study of a modern technology infused courseware for embedded system course", 2016 IEEE Frontiers in Education Conference (FIE), pp. 1–9, 2016. https://doi.org/10.1109/FIE.2016.7757458

[6] M. Holly, J. Pirker, S. Resch, S. Brettschuh and C. Gütl, "Designing VR Experiences – Expectations for Teaching and Learning in VR", Educational Technology & Society, 24(2), pp. 107–119, 2021. https://www.jstor.org/stable/27004935

[7] R. Kaviyaraj and M. Uma, "Augmented Reality Application in Classroom: An Immersive Taxonomy", 2022 4th International Conference on Smart Systems and Inventive Technology (ICSSIT), pp. 1221-1226, 2022. https://doi.org/10.1109/ICSSIT53264.2022.9716325

[8] J. Acker, I. Rogers, D. Guerra-Zubiaga, M.H. Tanveer and A.A.A. Moghadam, “Low-Cost Digital Twin Approach and Tools to Support Industry and Academia: A Case Study Connecting High-Schools with High Degree Education”, Machines, 11(9): 860, 2023. https://doi.org/10.3390/machines11090860

[9] H. Rahman, S.A. Wahid, F. Ahmad and N. Ali, “Game-based learning in metaverse: Virtual chemistry classroom for chemical bonding for remote education”, Educ Inf Technol, 29, pp. 19595–19619, 2024. https://doi.org/10.1007/s10639-024-12575-5

[10] K.C. Huang, S.-W. Wu, X. Cui, H.-T. Lin and M. Bodin, “Enhancing Manufacturing Efficiency Through the Integration of Smart Manufacturing and Virtual Reality Technologies”, in Advances in Intelligent Data Analysis and Applications. ECC 2024, Smart Innovation, Systems and Technologies, vol. 444, pp. 365-376, Springer, Singapore, 2026. https://doi.org/10.1007/978-981-96-7273-8_31

[11] D. de Oliveira, “Assessing ChatGPT in digital education: A case study on student perception”, Digital Engineering, 7: 100067, 2025. https://doi.org/10.1016/j.dte.2025.100067

[12] M.E. Kunkel, A. Sauer, C. Isaacs, T.A.F. Ganga, L.H. Fazan, E. Keller-Rorato, “Teaching Bioinspired Design for Assistive Technologies Using Additive Manufacturing: A Collaborative Experience”, Biomimetics, 10(6): 391, 2025. https://doi.org/10.3390/biomimetics10060391