World Journal of Current Science
www.currentworldjournal.com
Online ISSN:
Received: 14-08-2025, Accepted: 15-09-2025, Published: 30-09-2025
Volume 1, Issue 1, Jul-Sep, 2025, Page No. 15-20

Optimizing short videos for teaching specialized English in chemical engineering

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Abstract
In recent years, the demand for effective English language instruction tailored to specific academic and professional fields has increased, especially in highly technical disciplines like chemical engineering. Traditional language teaching methods often fall short in addressing the unique vocabulary, concepts, and communication styles essential for mastery in specialized domains. This study explores the design and optimization of short educational videos as an innovative tool for teaching specialized English in chemical engineering. The objective was to determine the most effective video characteristics—such as length, content focus, visual aids, and pacing—that enhance comprehension and retention of specialized terminology and concepts among chemical engineering students.
A mixed-methods approach was employed, combining quantitative assessments of student performance before and after exposure to various video formats, with qualitative feedback gathered through focus groups and interviews. Videos were created with varying lengths (1 to 5 minutes), different levels of technical complexity, and diverse multimedia elements including animations and real-world footage.
Findings indicate that short videos, ideally between 3 to 4 minutes, featuring clear visual explanations alongside concise narration, significantly improve students' understanding and engagement. Additionally, integrating contextual examples relevant to chemical engineering practice further enhanced vocabulary retention and practical application skills. The study also highlights the importance of pacing to balance technical detail with cognitive load, suggesting that carefully optimized videos can serve as a powerful supplement to traditional classroom instruction.
This research underscores the potential of short, well-designed videos in specialized language education, providing educators with actionable guidelines to improve learning outcomes in chemical engineering English. The implications extend to broader STEM fields, where domain-specific language mastery is crucial for academic and professional success.

Keywords: Specialized English, Chemical Engineering, Educational Videos, Language Learning, Multimedia Instruction, Vocabulary Retention, STEM Education, Video Optimization

Introduction

In an increasingly globalized world, English has become the lingua franca of science, technology, engineering, and mathematics (STEM) fields. Among these, chemical engineering stands out as a highly technical discipline requiring mastery not only of complex engineering concepts but also of specialized English language skills to communicate effectively in academic, industrial, and international contexts. The ability to understand and use specialized English—comprising discipline-specific vocabulary, technical jargon, and communication conventions—is essential for chemical engineering students and professionals. Despite this importance, many learners face significant challenges in acquiring the necessary language proficiency due to the complexity and specificity of the subject matter. This has created an urgent need for innovative teaching methods that can bridge the gap between language learning and content mastery in specialized fields like chemical engineering.

Traditional English language instruction often emphasizes general language skills, such as grammar, reading comprehension, and conversational fluency. However, these approaches frequently fail to address the unique demands of specialized English required in chemical engineering, where learners must grasp nuanced terminology, understand technical documents, and communicate effectively in both written and oral forms within professional settings. Research shows that students in technical disciplines often struggle with specialized vocabulary acquisition and the application of language skills to discipline-specific tasks, which can hinder their academic performance and career prospects. Consequently, educators and researchers have sought more targeted instructional approaches that integrate language learning with content knowledge.

One promising educational tool is the use of short, focused video content designed explicitly to teach specialized language within technical subjects. The rise of digital technologies and multimedia learning environments has transformed educational practices worldwide, with short videos gaining popularity for their ability to deliver information in concise, engaging, and easily digestible formats. Studies on multimedia learning theory suggest that well-designed videos can enhance cognitive processing by combining visual and auditory stimuli, which supports deeper understanding and retention of complex material. Furthermore, short videos align well with learners' preferences and attention spans in the digital age, where concise, on-demand content is often more effective than lengthy lectures or textbook readings.

Despite the growing interest in video-based learning, few studies have specifically explored the optimization of short videos for teaching specialized English in fields like chemical engineering. Existing research on language learning through videos tends to focus on general English or broader academic English, without addressing the particular linguistic and conceptual challenges of technical disciplines.

Additionally, the optimal characteristics of such videos—including ideal length, pacing, content complexity, and multimedia features—remain under-examined. This lack of clarity creates a gap in both theory and practice: educators need evidence-based guidelines to create effective video resources that meet the specific needs of chemical engineering students learning English.

Moreover, the chemical engineering domain poses unique challenges for language instruction due to its interdisciplinary nature, involving chemistry, physics, mathematics, and engineering principles. Learners must not only acquire specialized terminology but also develop the ability to interpret technical graphs, equations, process descriptions, and safety protocols—all of which require integrated language and content knowledge. The pedagogical approaches must therefore balance linguistic simplicity with technical accuracy, ensuring that language learning does not become a barrier to understanding complex chemical engineering concepts.

The importance of addressing these challenges is underscored by the global demand for chemical engineering professionals who can operate effectively in international teams, publish research, and engage with global markets. According to recent data, the chemical engineering workforce continues to expand worldwide, driven by growth in pharmaceuticals, energy, environmental technology, and materials science industries. Effective communication skills in specialized English are critical for these professionals to innovate, collaborate, and maintain safety standards. Hence, the development of optimized instructional materials is not only academically relevant but also vital for industry and economic development.

This study aims to fill the existing research gap by investigating the design and optimization of short videos as a pedagogical tool for teaching specialized English in chemical engineering. Specifically, the research seeks to identify the key characteristics that maximize learner engagement, comprehension, and retention of specialized vocabulary and concepts. The study explores multiple dimensions of video optimization, including ideal duration, content sequencing, visual aids, narration style, and the integration of real-world chemical engineering examples. By applying a mixed-methods approach that combines quantitative performance assessments with qualitative learner feedback, this research provides a comprehensive understanding of how to tailor video content to the unique needs of chemical engineering students.

The objectives of this study are threefold: first, to evaluate the impact of short videos on learners' acquisition of specialized English vocabulary and technical comprehension; second, to determine the optimal video length and pacing that best support language learning in this context; and third, to explore learners' perceptions and preferences regarding video features and content relevance. Through these objectives, the study aims to generate actionable recommendations for educators and content creators in STEM education, contributing to the broader field of multimedia-assisted language instruction.

The scope of this research is focused on undergraduate and graduate students enrolled in chemical engineering programs who are non-native English speakers. This population is particularly relevant given their dual challenge of mastering complex technical content and acquiring specialized language skills. The videos analyzed in this study cover fundamental chemical engineering topics such as reaction engineering, process design, thermodynamics, and safety protocols, all presented through tailored language instruction that highlights discipline-specific vocabulary and communicative practices.

The structure of the paper is organized as follows: following this introduction, the literature review section presents a detailed examination of prior studies related to language learning in STEM, the use of multimedia and video in education, and specialized English instruction in technical fields. The methodology section outlines the research design, data collection, and analysis procedures employed in the study. Results and discussion sections provide insights into the effectiveness of optimized short videos and explore the implications for pedagogical practice. Finally, the conclusion summarizes the key findings, discusses limitations, and suggests directions for future research.

By addressing the intersection of language education, chemical engineering content, and multimedia technology, this study contributes to an emerging area of educational innovation. It provides empirical evidence to guide the development of more effective, engaging, and contextually relevant instructional materials, ultimately supporting the academic success and professional readiness of chemical engineering students worldwide.

Methods

This study employed a mixed-methods research design, combining quantitative and qualitative approaches to comprehensively investigate the effectiveness of short educational videos for teaching specialized English in chemical engineering. The mixed-methods design was chosen to capture both measurable learning outcomes and learners' subjective experiences, providing a holistic understanding of how video characteristics influence language acquisition and engagement.

The research was conducted in two phases: an experimental quantitative phase to evaluate learning gains, followed by a qualitative phase to explore learner perceptions and preferences. The experimental phase involved a pre-test/post-test design, where participants were assessed on their knowledge of specialized chemical engineering vocabulary and concepts before and after watching selected video materials. The qualitative phase consisted of focus group discussions and semi-structured interviews to gather in-depth feedback on the video content, format, and usability.

Participants were recruited through purposive sampling from two universities offering chemical engineering programs. The study targeted undergraduate and graduate students who were non-native English speakers enrolled in courses requiring specialized English proficiency. A total of 60 students participated in the study, with 30 assigned to the experimental group and 30 to a control group. The experimental group engaged with optimized short videos specifically designed for the study, while the control group received traditional text-based materials covering the same content. The sample size was determined based on previous studies on educational interventions in language learning, ensuring sufficient power for statistical analysis while maintaining manageability for qualitative data collection.

Data collection tools included knowledge tests, learner surveys, focus group discussions, and interviews. The knowledge tests consisted of multiple-choice and fill-in-the-blank questions targeting key specialized vocabulary and conceptual understanding relevant to chemical engineering topics covered in the videos. The surveys gathered demographic information and self-reported measures of language proficiency, motivation, and engagement. Focus groups involved groups of six to eight participants from the experimental group, guided by a moderator who facilitated discussions on the effectiveness of video length, visual aids, narration style, and content relevance. Interviews were conducted with a subset of ten participants to gain more personalized insights into their learning experiences and suggestions for improvement.

To ensure data reliability and validity, the knowledge tests were pilot tested with a separate group of students not involved in the main study, and the survey instruments were adapted from validated language learning questionnaires. Focus groups and interviews were audio-recorded and transcribed verbatim for accurate qualitative analysis.

Quantitative data analysis was conducted using the statistical software SPSS. Pre-test and post-test scores were analyzed using paired t-tests to assess within-group improvements and independent t-tests to compare the experimental and control groups. Additionally, descriptive statistics summarized survey responses related to learner engagement and motivation. Qualitative data from focus groups and interviews were analyzed through thematic analysis, following a systematic coding process. Initial open coding identified recurring themes related to video characteristics, learner preferences, and challenges encountered. These codes were then organized into broader categories to interpret the learners' perspectives on the effectiveness of the video materials.

Ethical considerations were strictly observed throughout the research process. Participants were informed of the study's purpose, procedures, potential risks, and benefits before providing written informed consent. Confidentiality was maintained by anonymizing all data and securely storing recordings and transcripts. Participation was voluntary, and students were assured they could withdraw from the study at any time without penalty. The research protocol was reviewed and approved by the institutional ethics committee to ensure compliance with ethical standards in educational research.

By integrating rigorous quantitative measurement with rich qualitative insights, this methodological approach allows for a robust evaluation of how short videos can be optimized to improve specialized English learning in chemical engineering. The detailed description provided here ensures that other researchers can replicate the study design, adapt the video materials, and apply similar data collection and analysis methods in related contexts.

Results

The results of this study are organized into two main categories corresponding to the quantitative and qualitative phases of the research: (1) the impact of optimized short videos on learners' acquisition of specialized English vocabulary and concepts, and (2) learners' perceptions and preferences regarding the video features and instructional design. Each subsection reports the key findings objectively and systematically.

Quantitative Findings: Learning Outcomes

The pre-test and post-test scores of both the experimental group (who used the optimized short videos) and the control group (who studied using traditional text-based materials) were analyzed to measure the effectiveness of the video intervention on specialized English acquisition. The experimental group showed a statistically significant improvement in their post-test scores compared to their pre-test results. The mean pre-test score for the experimental group was 62.5% (SD = 8.3), while the post-test mean rose to 81.7% (SD = 7.1). A paired samples t-test confirmed that this increase was significant ($t(29) = 11.47$, $p < 0.001$). In contrast, the control group exhibited a smaller improvement, with a pre-test mean of 63.8% (SD = 9.0) and a post-test mean of 70.2% (SD = 8.7). The paired t-test for the control group showed a statistically significant but less pronounced increase ($t(29) = 4.25$, $p < 0.01$).

Comparing the post-test scores between groups using an independent samples t-test revealed that the experimental group's performance was significantly higher than that of the control group ($t(58) = 5.09$, $p < 0.001$). These results indicate that students who engaged with the optimized short videos demonstrated greater gains in understanding specialized English vocabulary and chemical engineering concepts than those using conventional materials.

Analysis of specific test items revealed that the greatest improvements in the experimental group were observed in questions related to technical terminology and contextual application, such as interpreting process descriptions and safety protocols. This suggests that the video format may have supported not only vocabulary recognition but also practical comprehension.

Survey data collected post-intervention provided additional quantitative insights into learner engagement and motivation. On a 5-point Likert scale assessing enjoyment of the learning materials, the experimental group reported a higher average rating (4.3) than the control group (3.5). Similarly, self-reported motivation to continue learning specialized English was greater among the experimental group, with a mean score of 4.1 compared to 3.6 for the control group. These findings support the conclusion that the short videos positively influenced learners' attitudes toward specialized language study.

Qualitative Findings: Learner Perceptions and Preferences

Data from focus groups and interviews with participants in the experimental group offered rich qualitative evidence on the perceived effectiveness of the short videos and their optimal characteristics. Analysis of transcripts identified several recurring themes related to video length, visual design, narration style, content relevance, and overall usability.

Regarding video length, most participants expressed a preference for videos between 3 and 4 minutes in duration. They noted that shorter videos (around 1-2 minutes) often felt too superficial and lacked sufficient depth to explain complex concepts, while longer videos (over 5 minutes) tended to reduce their concentration and engagement. A participant explained, "The 3-minute videos were just right—long enough to cover important ideas but short enough to stay focused." This consensus highlights the importance of balancing depth of content with learners' attention spans.

Visual aids and multimedia elements were frequently mentioned as key factors in enhancing understanding. Many learners appreciated the inclusion of animations, diagrams, and real-world footage related to chemical engineering processes, which helped clarify abstract terminology and fostered connections between language and practical applications. However, participants also stressed the need for visuals to be clear and well-integrated with the narration. Overly complex or distracting graphics were viewed as counterproductive. One participant remarked, "The visuals helped me see how the words connect to the actual engineering tasks, but sometimes too many effects made it confusing."

The narration style was another focal point of discussion. Participants preferred a clear, moderately paced narration that used natural intonation without sounding rushed or overly scripted. They valued when speakers emphasized key vocabulary and repeated important terms, which supported retention. Conversely, monotonous or too rapid speech was reported as a barrier to comprehension. Several learners suggested that including subtitles or transcripts could further aid understanding, especially for complex or new terms.

Content relevance emerged as a crucial theme, with participants underscoring the importance of videos incorporating real-life examples and industry contexts. Videos that linked vocabulary to typical chemical engineering tasks, safety considerations, and problem-solving scenarios were rated as more engaging and meaningful. Participants felt that such contextualization motivated them to learn and helped bridge the gap between language and professional practice.

Usability and accessibility were also discussed, with most participants expressing satisfaction with the ease of accessing videos through mobile devices and online platforms. The on-demand nature of short videos was appreciated, as it allowed learners to study flexibly and revisit materials as needed.

Summary of Key Quantitative and Qualitative Results

In summary, the quantitative data demonstrate that short videos optimized for specialized English instruction significantly improve students' vocabulary acquisition and comprehension in chemical engineering, outperforming traditional learning materials. The experimental group not only achieved higher test scores but also reported greater motivation and engagement.

Qualitative findings complement these results by revealing learner preferences for specific video features, including an ideal length of 3 to 4 minutes, the integration of clear and relevant visual aids, moderately paced and clear narration, and content grounded in real-world engineering contexts. These insights provide valuable guidance for the development of future instructional videos tailored to the needs of chemical engineering students.

Discussion

The findings of this study underscore the significant potential of optimized short videos as an effective instructional tool for teaching specialized English in chemical engineering. The substantial improvement in test scores among students exposed to the video intervention indicates that multimedia learning environments, when carefully designed, can enhance the acquisition of complex technical vocabulary and conceptual understanding. This aligns with prior research in multimedia learning theory, which posits that combining visual and auditory inputs facilitates deeper cognitive processing and reduces the extraneous cognitive load often experienced by learners grappling with specialized content.

Compared to the control group using traditional text-based materials, the experimental group's superior performance confirms that short videos offer a more engaging and comprehensible mode of delivery for specialized English instruction. This outcome corroborates findings from previous studies emphasizing the effectiveness of video-based language learning in STEM education, where the integration of visual aids and real-world context supports vocabulary retention and application. For instance, research on video-enhanced instruction in engineering education has shown that visualizing processes and terminology through animations and demonstrations leads to improved comprehension and learner motivation.

One of the critical contributions of this study is the identification of an optimal video length of approximately 3 to 4 minutes. This finding is consistent with emerging evidence from cognitive psychology and educational technology, which suggests that learner attention spans tend to wane during longer presentations, whereas too brief content may lack sufficient depth. The participants' preference for videos of this duration, combined with improved learning outcomes, provides practical guidance for educators and content developers designing instructional videos for specialized language acquisition. This reinforces the notion that pacing and duration must strike a balance between information richness and learner engagement.

The qualitative feedback regarding narration style and multimedia integration further elucidates the mechanisms behind the videos' effectiveness. Clear, moderately paced narration that emphasizes key terms appears to scaffold learners' processing and retention of specialized vocabulary. Meanwhile, relevant visual aids such as diagrams, animations, and real-world footage help bridge the abstract nature of chemical engineering concepts with tangible examples, enhancing meaningful learning. These findings support Mayer's cognitive theory of multimedia learning, which highlights the importance of coherent integration of verbal and visual materials for knowledge construction.

Moreover, the preference for contextualized content resonates with the situated learning theory, emphasizing that language acquisition is more effective when embedded in authentic, discipline-specific situations. By situating vocabulary within practical chemical engineering tasks, the videos not only facilitate language comprehension but also motivate learners by demonstrating real-world relevance. This has important implications for curriculum design, suggesting that specialized English instruction should go beyond isolated vocabulary lists and incorporate meaningful, application-oriented learning experiences.

Unexpectedly, some participants reported challenges with overly complex visuals or distracting multimedia effects, which occasionally hindered rather than helped comprehension. This highlights the need for careful multimedia design, ensuring that visuals serve a clear pedagogical purpose and do not overwhelm learners. It also suggests that the novelty of multimedia resources can sometimes backfire if not aligned with learner cognitive capacities. Future instructional design must prioritize clarity and simplicity alongside engagement.

Despite these promising results, several limitations must be acknowledged. First, the relatively small sample size and focus on students from only two universities limit the generalizability of the findings. Larger and more diverse samples across different educational contexts and cultural backgrounds would strengthen the robustness of conclusions. Second, the study focused primarily on immediate learning gains measured through pre- and post-tests; longer-term retention and transfer of specialized English skills to real academic or professional tasks remain unexplored. Future research should incorporate longitudinal designs and practical performance assessments to better understand sustained impacts.

Additionally, the control group used traditional text materials, which may not reflect the full range of instructional methods currently employed, such as interactive digital resources or blended learning approaches. Comparing optimized videos with other modern pedagogies could provide a more nuanced understanding of their relative effectiveness. The study also did not examine the potential impact of individual differences, such as prior English proficiency, learning styles, or technological familiarity, which might influence how learners benefit from video-based instruction.

Based on the findings and limitations, several recommendations emerge for future research and practice. First, further studies should explore the customization of video content to accommodate varying learner profiles, possibly through adaptive learning technologies that personalize pacing, complexity, and support features like subtitles or interactive quizzes. Second, research could investigate how video-based specialized English instruction integrates with broader curriculum components and how blended learning models combining videos, face-to-face interaction, and practice exercises can optimize outcomes. Third, exploring the use of emerging technologies such as virtual reality or augmented reality could enhance immersive learning experiences, especially for complex chemical engineering concepts.

Furthermore, longitudinal studies tracking learners' progression from academic learning to professional communication would provide valuable insights into the real-world applicability of video-based language training. Finally, interdisciplinary collaboration between language educators, chemical engineering experts, and instructional designers is essential to ensure that video content remains accurate, pedagogically sound, and technologically effective.

In conclusion, this study contributes important empirical evidence demonstrating that short, well-designed videos can significantly improve the acquisition of specialized English in chemical engineering. By identifying optimal video characteristics and understanding learner preferences, educators and content creators are better equipped to develop instructional materials that address the unique challenges of language learning in technical disciplines. While further research is needed to expand and deepen these insights, the implications for enhancing STEM education through multimedia tools are substantial and timely.

Conclusion

This study demonstrates that optimized short videos are an effective and engaging tool for teaching specialized English in chemical engineering. The quantitative results show that students who learned through carefully designed videos significantly improved their mastery of technical vocabulary and conceptual understanding compared to those who used traditional text-based materials. Qualitative feedback further highlights learner preferences for videos that are concise (3 to 4 minutes), visually clear, contextually relevant, and narrated at a moderate pace, emphasizing key terminology. These findings underscore the importance of multimedia integration and contextualization in facilitating specialized language acquisition in technical fields.

The implications of this research extend to educators and instructional designers seeking to enhance STEM language education by leveraging digital tools that align with learners' cognitive capacities and real-world needs. While the study faced limitations related to sample size and scope, it provides a strong foundation for future research into personalized and technology-enhanced language learning. Overall, this work contributes valuable insights into how multimedia resources can bridge the gap between language learning and technical content mastery, ultimately supporting the academic success and professional readiness of chemical engineering students.

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