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Integrating TPACK for Soft Skills and Communication in Engineering Education: Definition, Concept, Strategies, Challenges, and Opportunities

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ABSTRACT

Soft skills and communication are essential for engineering students but are often overlooked in technical education because of the heavy focus on subject knowledge. This review explored how the Technological Pedagogical Content Knowledge (TPACK) framework can enhance the teaching of communication and soft skills in engineering education. Using a systematic review approach, this study analyzed concepts and definitions, according to relevant research. We also incorporated insights from a Lecture Series conducted for first-year engineering students. The review found that TPACK effectively integrated communication content, pedagogy, and technology to create interactive and engaging learning environments. However, challenges such as limited technological readiness among teachers, low student motivation, and insufficient institutional support hindered its implementation. Because engineering graduates require both technical and communication competencies, integrating TPACK offers a practical solution to bridge this gap. This review provided strategies and recommendations to help educators and institutions strengthen soft skills instruction in engineering programs to meet future workforce demands.

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1. INTRODUCTION

In recent years, there has been growing awareness of the need to integrate soft skills and communication skills into engineering education, as these competencies are essential for professional success (Rosina *et al*., 2021). However, engineering education in many contexts remains heavily focused on technical knowledge, often neglecting communication and interpersonal skills, which are critical for effective teamwork, leadership, and client interactions in professional engineering environments. Some of the methods are using technology to improve this matter (Barak, 2007; Valanides & Angeli, 2008).

Despite various attempts to address this gap, communication skills training often lacks structured pedagogical and technological integration, making it less effective and disconnected from students' technical learning (Purwianingsih *et al*., 2023; Shulman, 1986). This creates a significant challenge in producing graduates who are technically proficient yet unable to communicate and collaborate effectively in multidisciplinary teams.

The Technological Pedagogical Content Knowledge (TPACK) framework offers a comprehensive model to address these challenges by guiding educators in integrating technology with pedagogy and content to enhance teaching and learning experiences. While TPACK has been applied in various fields of education, its use in teaching soft skills and communication to engineering students remains underexplored. The combination of communication content knowledge, appropriate pedagogical methods, and relevant technological tools is essential to create interactive and engaging learning environments. However, many communication teachers in technical education struggle with aligning technology and pedagogy, often due to limited exposure to innovative teaching strategies and digital tools that can make communication instruction more relevant to engineering students' needs (Jibril *et al*., 2024; Ibarrientos, 2024; Mishra & Koehler, 2006). Although several studies have examined the use of TPACK in technical education, much of this research focuses on core engineering subjects rather than communication and soft skills. This leaves a gap in understanding how TPACK can specifically enhance the teaching of communication in engineering, particularly in contexts where students may undervalue soft skills compared to technical knowledge. Moreover, teachers' lack of technological readiness and insufficient pedagogical strategies for teaching communication in technical classrooms remain unresolved issues. While some research highlights the importance of integrating technology into communication teaching, it often fails to provide practical strategies that combine content, pedagogy, and technology in a way that is meaningful and sustainable.

There are many review papers regarding the teaching and learning process (see **Table 1**). However, to date, there is limited review-based research that systematically explores how TPACK can be applied to improve communication and soft skills instruction for engineering students, especially considering the pedagogical, technological, and institutional challenges faced in real educational contexts. Although some frameworks and models have been proposed for general TPACK integration, they rarely address the unique needs of soft skills teaching in engineering. Therefore, this paper focuses on reviewing the integration of TPACK for teaching communication and soft skills in engineering education, while identifying practical strategies, existing gaps, and potential solutions.

Based on a systematic review of existing literature and supported by an illustrative case of a Lecture Series implemented for first-year engineering students, this paper analyzes how TPACK can be employed to develop communication skills effectively. The case study demonstrates the real application of TPACK and highlights practical challenges, such as teacher preparedness, student engagement, and technological limitations, thereby enriching

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the review with contextual insights. The increasing importance of soft skills in engineering education, along with the need for effective teaching frameworks, underlines the relevance of this study.

The purpose of this review is to analyze how TPACK can be used to enhance the teaching of communication and soft skills in engineering, by identifying effective strategies and tools while recognizing the limitations and challenges of current practices. The novelty of this paper lies in connecting TPACK explicitly with soft skills and communication instruction in engineering education, an area that has not been systematically reviewed despite its practical importance. Furthermore, by including reflections from a real classroom implementation, this study adds depth and practical value to the existing body of knowledge. The impact of this review is to provide practical insights and recommendations for educators, policymakers, and institutions on how to improve communication skills teaching in engineering through TPACK, contributing to the broader goal of producing well-rounded engineering graduates equipped with both technical and interpersonal competencies.

2. METHODS

This study adopted a systematic review approach to analyze the integration of the TPACK framework in teaching soft skills and communication in engineering education. The purpose of this review was to identify key strategies, theoretical foundations, and challenges in applying TPACK to develop communication competencies among engineering students. The review also explored how TPACK components (content, pedagogy, and technology) were combined to enhance the teaching and learning of communication skills in technical education contexts.

The literature reviewed in this study was gathered from reputable academic databases (Google Scholar) focusing on publications from 2013 to 2024. The search included keywords such as "TPACK and communication skills," "TPACK in engineering education," and "teaching soft skills with technology." The selected studies were limited to those that directly discussed the use of TPACK for communication or professional skills, particularly in engineering and technical education, while studies focusing solely on TPACK for technical subjects without soft skills were excluded.

The analysis focused on how TPACK components were integrated to teach communication and soft skills, highlighting the strategies and technologies used, pedagogical approaches, and challenges encountered by educators. In addition to reviewing existing literature, this study used a Lecture Series conducted for first-year engineering students as an illustrative case to support the analysis. The Lecture Series provided practical insights into how TPACK was applied in real classroom settings to teach communication effectively.

Through this method, the study provided a comprehensive understanding of current trends and gaps in TPACK-based soft skills education and offered recommendations for future research, teaching practices, and teacher development.

3. RESULTS AND DISCUSSION

3.1. Searching Documents

Table 1 presents an overview of previous review studies on the teaching and learning process, particularly in higher education. These studies provide a broad understanding of how various instructional methods, learning models, and pedagogical innovations have been analyzed to improve educational outcomes. The reviews examine topics such as active

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learning, technology integration, collaborative learning, and the development of essential skills, offering valuable insights into the evolution of teaching and learning practices. However, although these reviews contribute significantly to the field of education, many focus on general teaching strategies and do not specifically address how soft skills and communication are taught, particularly in technical fields like engineering. These data were then used to create the concept and explanations in the next sections.

Table 1. Previous review studies on the teaching and learning process (2023-2025).

No	Title	References
1	The compleat lextutor application tool for academic and technological lexical learning: Review and bibliometric approach	(Abduh *et al*., 2023)
2	Bibliometric analysis using vosviewer with publish or perish of computational thinking and mathematical thinking in elementary school	(Abidin *et al*., 2025)
3	Bibliometric computational mapping analysis of publications on mechanical engineering education using vosviewer	(Al Husaeni & Nandiyanto, 2022)
4	How technology can change educational research? Definition, factors for improving quality of education and computational bibliometric analysis	(Al Husaeni *et al*., 2024a)
5	Digital transformation in special needs education: Computational bibliometrics	(Al Husaeni & Wahyudin, 2023)
6	Chatbot artificial intelligence as educational tools in science and engineering education: A literature review and bibliometric mapping analysis with its advantages and disadvantages	(Al Husaeni *et al*., 2024b)
7	Bibliometric analysis of educational research in 2017 to 2021 using VOSviewer: Google scholar indexed research	(Al Husaeni *et al*., 2023a)
8	A bibliometric analysis of vocational school keywords using VOSviewer	(Al Husaeni & Nandiyanto, 2023a)
9	Bibliometric analysis of high school keyword using VOSviewer indexed by Google Scholar	(Al Husaeni & Nandiyanto, 2023b)
10	How to create augmented reality (AR) applications using unity and vuforia engine to teach basic algorithm concepts: Step-by-step procedure and bibliometric analysis	(Al Husaeni *et al*., 2024c)
11	Bibliometric analysis of special needs education keyword using VOSviewer indexed by google scholar	(Al Husaeni *et al*., 2023b)
12	Phylogenetic analysis of Bengkulu citrus based on DNA sequencing enhanced chemistry students' system thinking skills: Literature review with bibliometrics and experiments	(Amida *et al*., 2024)
13	Augmented reality for cultivating computational thinking skills in mathematics completed with literature review, bibliometrics, and experiments for students	(Angraini *et al*., 2024)
14	Problem based learning (PBL) learning model for increasing learning motivation in chemistry subject: Literature review with bibliometric analysis	(Arifiani *et al*., 2025)
15	Bibliometric analysis using VOSViewer with Publish or Perish of metacognition in teaching english writing to high school learners	(Damkam & Chano, 2024)
16	Global research trends of mathematics literacy in elementary school: A bibliometric analysis	(Farokhah *et al*., 2024)
17	How to teach fraction for empowering student mathematics literacy: Definition, bibliometric, and application using digital module	(Farokhah *et al*., 2025)
18	Empowering language models through advanced prompt engineering: A comprehensive bibliometric review	(Fatawi *et al*., 2024)
19	Water hyacinth and education research trends from the scopus database: A bibliometric literature review	(Hofifah & Nandiyanto, 2024)

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Table 1 (continue). Previous review studies on the teaching and learning process (2023-2025).

No	Title	References
20	Examining climate change issues for improving cross-generation awareness in 21st century agenda: A bibliometric approach	(Ibrahim *et al*., 2024)
21	How eyes and brain see color: Definition of color, literature review with bibliometric analysis, and inquiry learning strategy for teaching color changes to student with mild intelligence barriers	(Juhanaini *et al*., 2023)
22	Bibliometric analysis using VOSviewer with Publish or Perish of role-play in the teaching and learning	(Kongsaenkham & Chano, 2024)
23	Development of intelligent tutoring system model in the learning system of the Indonesian national armed forces completed with bibliometric analysis	(Kurniawan *et al*., 2024)
24	Bibliometric analysis using VOSviewer with Publish or Perish of identifying local legends through project-based learning for critical thinking skills in English	(Lestari, 2024)
25	A computational bibliometric analysis of science education research using VOSviewer	(Maryanti *et al*., 2023)
26	Sustainable development goals (SDGs) in science education: Definition, literature review, and bibliometric analysis	(Maryanti *et al*., 2022)
27	Bibliometric analysis of the integration of digital tools in marine conservation education	(Muktiarni & Widiaty, 2023)
28	Bibliometric analysis using VOSviewer with Publish or Perish of CEFR-based comparison of English language teaching models for communication	(Nadtayay & Wongsaphan, 2025)
29	Bibliometric analysis using VOSviewer with Publish or Perish of pre-service English teachers research	(Nithideechaiwarachok & Chano, 2025)
30	Bibliometric analysis for understanding “science education” for “student with special needs” using VOSviewer	(Nursaniah & Nandiyanto, 2023)
31	Evaluation of assessment projects in English language education: A bibliometric review	(Oya, 2024)
32	Bibliometric analysis using VOSviewers with Publish or Perish of “academic reading”	(Pujiastuti, 2024)
33	Implementation of independent curriculum differentiation learning in physics learning in high school completed with literature review and bibliometric analysis	(Putra *et al*., 2024)
34	Bibliometric analysis in chemistry education: Exploring system thinking skill in water treatment	(Ragadhita *et al*., 2023)
35	Trends and developments in research on adsorption in education: Bibliometric analysis	(Ragadhita *et al*., 2024)
36	Bibliometric analysis on artificial intelligence research in Indonesia vocational education	(Rahmiyanti, 2024)
37	Bibliometric analysis using Vosviewer with Publish or Perish of mathematical proficiency	(Rohimah, 2025)
38	Empowering engineering female students to improve retention and progression: A program evaluation study completed with bibliometric analysis	(Shafiq *et al*., 2024)
39	Prototype of greenhouse effect for improving problem-solving skills in science, technology, engineering, and mathematics (STEM)-education for sustainable development (ESD): Literature review, bibliometric, and experiment	(Solihah *et al*., 2024)
40	Artificial intelligence (AI)-based learning media: Definition, bibliometric, classification, and issues for enhancing creative thinking in education	(Solihat *et al*., 2024)

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Table 1 (continue). Previous review studies on the teaching and learning process (2023-2025).

No	Title	References
41	Computing bibliometric analysis with mapping visualization using vosviewer on "pharmacy" and "special needs" research data in 2017-2021	(Sudarjat, 2023)
42	How to do research methodology: From literature review, bibliometric, step-by-step research stages, to practical examples in science and engineering education	(Susilawati *et al*., 2025)
43	Android application for smart diagnosis of children with disabilities and its correlation to neuroscience: Definition, literature review with bibliometric analysis, and experiments	(Wagino *et al*., 2024)
44	Spatial visualization ability assessment for analyzing differences and exploring influencing factors: Literature review with bibliometrics and experiment	(Yang *et al*., 2024)
45	The use of mobile learning in schools as a learning media: Bibliometric analysis	(Zafrullah & Ramadhani, 2024)

3.2. Theoretical Foundations: TPACK for Soft Skills and Communication in Engineering Education

The TPACK framework is a comprehensive model that guides educators in integrating technology effectively with pedagogy and content (**Figure 1**). Many reports regarding TPACK are available (Jibril & Adedokun-Shittu, 2024; Ibarrientos, 2024; Mishra & Koehler, 2006). Initially designed to support subject-specific teaching, TPACK has been widely adopted to address broader educational needs, including soft skills and communication, areas often overlooked in engineering education. By combining content, pedagogy, and technology, TPACK helps create engaging and effective learning experiences that foster essential communication competencies among engineering students.

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The TPACK framework consists of three core knowledge areas, each essential for teaching communication and soft skills:

(i) Content Knowledge (CK): Understanding key communication concepts, such as verbal and non-verbal communication, active listening, empathy, interpersonal interaction, and professional writing.

(ii) Pedagogical Knowledge (PK): Knowing how to teach these communication concepts effectively using methods such as collaborative learning, group discussions, debates, role-playing, and reflective practice.

(iii) Technological Knowledge (TK): Using digital tools to enhance learning, including platforms for interaction (e.g., Padlet, Zoom), AI-based writing assistants, online simulations, and gamified assessments (e.g., Quizizz).

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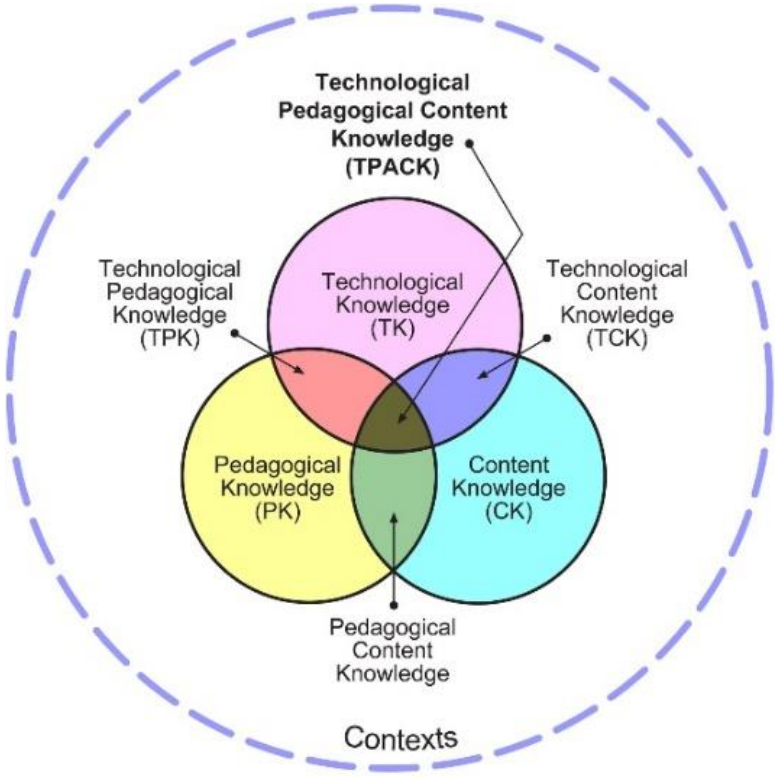

Figure 1. Concept of TPACK (adopted from: https://educationaltechnology.net/).

Beyond these individual domains, TPACK emphasizes the intersections of knowledge that are critical for teaching communication skills in engineering:

(i) Pedagogical Content Knowledge (PCK): Designing activities that align communication skills with appropriate teaching strategies (e.g., using case studies to practice negotiation and persuasion).
(ii) Technological Content Knowledge (TCK): Selecting technology that effectively conveys communication content (e.g., using videos for demonstrating non-verbal cues).
(iii) Technological Pedagogical Knowledge (TPK): Applying technology to support communication pedagogy (e.g., using online forums for peer feedback and interaction).
(iv) TPACK (the integrated model): Blending content, pedagogy, and technology to create comprehensive, interactive communication learning experiences tailored to engineering contexts.

In the context of engineering education, integrating TPACK is crucial because:

(i) Engineering students often focus heavily on technical skills and lack exposure to structured communication training.
(ii) Effective communication is essential for professional engineering roles, including teamwork, project presentations, client communication, and cross-disciplinary collaboration.
(iii) Soft skills like collaboration, empathy, and leadership are often required in real-world engineering projects but are difficult to teach without interactive, practical approaches.

Using TPACK, educators can:

(i) Design interactive and technology-enhanced learning environments that simulate real communication situations.
(ii) Engage students actively in learning through practical tasks like role-plays, simulations, and technology-supported group work.

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(iii) Provide personalized feedback using AI and digital platforms to improve student communication performance.
(iv) Align communication teaching with engineering-specific professional contexts, making learning relevant and applicable.

Features of TPACK are in the following:

(i) TPACK serves as a conceptual framework that elucidates the types of knowledge essential for teachers to effectively practice pedagogy in a technology-enhanced learning environment.
(ii) It aids in identifying the diverse forms of knowledge required by teachers to integrate technology into their teaching, addressing the intricate and context-specific nature of teacher expertise.
(iii) The framework delineates the interdependencies and complexities among Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK) necessary for technology-integrated teaching.
(iv) It explores the intricate relationships among content, pedagogy, and technology knowledge areas, guiding teachers in understanding the organizational prerequisites for utilizing technology effectively in teaching and learning.
(v) TPACK emphasizes more than simply adding ICT to traditional methods, emphasizing instead a deep understanding of how ICT (Technological Content Knowledge - TCK) can be used to access and process subject matter, enhance learning (Technological Pedagogical Knowledge - TPK), and integrate with Pedagogical Content Knowledge (PCK).
(vi) It provides a framework for designing teacher education programs that address challenges stemming from an overemphasis on theoretical technological knowledge compared to practical knowledge in lesson design using technology.
(vii) TPACK guides the effective use of technology to teach specific content or subjects by navigating the interactions among Technology, Pedagogy, and Content.
(viii) It distinguishes TPACK capabilities from subject knowledge, technological proficiency, and pedagogical knowledge, focusing on teachers' skills in integrating pedagogy and appropriate technology use for the subjects they teach.
(ix) TPACK supports optimal utilization of technology across various disciplines taught in educational settings.

It serves as an organizational framework for developing educational technology in professional development programs tailored for teacher educators, pre-service, and in-service teachers.

TPACK serves as a flexible and structured framework for addressing the gap between theoretical knowledge of communication and its practical application in engineering education. By combining appropriate content, pedagogy, and technology, TPACK enables the development of effective and engaging soft skills learning that prepares engineering students for real-world communication demands.

3.3. Strategies for Implementing TPACK in Soft Skills Education

Implementing the TPACK framework to teach soft skills and communication in engineering education requires a deliberate integration of content, pedagogy, and technology. The Lecture Series described in the attached file illustrates practical ways TPACK can be applied to support soft skills learning in real classroom settings. These strategies ensure that students engage actively with communication tasks while leveraging appropriate technological tools to enhance learning.

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Several key strategies for implementing TPACK in communication and soft skills instruction include:

(i) Aligning content with real-life communication needs: Teaching materials should focus on practical communication skills relevant to engineering contexts, such as interpersonal communication, presentation skills, teamwork, and negotiation. Content should be tailored to professional scenarios that engineering students will likely encounter.

(ii) Using interactive pedagogical approaches: Pedagogical strategies that encourage active participation and collaboration are essential. These include:
- Group discussions to foster critical thinking and teamwork.
- Role-playing and simulations to practice real-world communication scenarios (e.g., mock interviews, client presentations).
- Collaborative projects that require students to communicate, negotiate, and solve problems together.

(iii) Integrating technology to enhance engagement and feedback: Technology should not only deliver content but also support interactive and reflective learning. Effective tools include:
- Quizizz for gamified formative assessments that make learning engaging and reinforce key concepts.
- Padlet as an interactive platform for brainstorming, sharing ideas, and collaborative writing.
- Video-based tools and simulations to demonstrate and practice non-verbal communication and presentation skills.
- AI-based feedback tools for writing and speaking tasks, providing personalized and immediate feedback to students.

(iv) Scaffolding learning with step-by-step tasks: Communication skills should be built progressively, starting with basic theoretical understanding, moving to guided practice, and culminating in autonomous performance. For instance, students may begin with analyzing good communication models before attempting their role-plays.

(v) Connecting technology with pedagogy and content: Technology use should be meaningfully aligned with pedagogical goals and communication content, rather than being used as an add-on. For example:
- Using discussion boards and online forums to promote written communication and peer interaction.
- Implementing interactive quizzes to assess understanding of communication principles in real time.
- Applying virtual presentations to simulate workplace communication situations.

(vi) Encouraging reflective practice and feedback: Reflection activities, supported by technology, help students critically evaluate their communication performance. This includes:
- Recording and reviewing their presentations.
- Peer feedback using digital tools (e.g., Padlet for anonymous feedback on presentations).
- Teacher-led debrief sessions using real examples from student work to highlight best practices and areas for improvement.

These strategies show that effective TPACK implementation for soft skills instruction requires intentional alignment of content, pedagogy, and technology to create interactive, engaging, and professionally relevant learning experiences. By using these integrated

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strategies, educators can help engineering students develop the communication skills needed for future workplace success.

3.4. Illustrative Case: Application of TPACK in a Lecture Series for Engineering Students

Table 2 illustrates a sample lesson plan that demonstrates how the TPACK framework can be applied to teaching essential soft skills for engineering students. The plan integrates Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK) to create a comprehensive learning experience. Each week focuses on a specific soft skill, including communication, teamwork, leadership, problem-solving, adaptability, and professionalism, aligning with the core competencies required in the engineering profession.

Table 2. Sample TPACK-based lesson plan for teaching essential soft skills in engineering education.

Contents	Content Knowledge (CK)	Pedagogical Knowledge (PK)	Technological Knowledge (TK)	Activities/ Assignments
Introduction to Soft Skills Understanding soft skills and their importance Key soft skills: communication, teamwork, problem-solving, leadership, adaptability	Interactive lecture Group discussion on the importance of soft skills	Presentation software (e.g., PowerPoint, Prezi) Online survey tools (e.g., Google Forms)	Presentation software (e.g., PowerPoint, Prezi) Online survey tools (e.g., Mentimeter, Padlet, Google Forms)	Pre-assessment with Quizziz survey Interactive lecture with examples and case studies Group discussion and sharing personal experiences
Communication Skills Verbal and non-verbal communication effective listening and feedback Email and report writing	Role-playing exercises Peer review activities	Communication platforms (e.g., Zoom, MS Teams Writing tools (e.g., Grammarly)	Communication platforms (e.g., Zoom, MS Teams) Writing tools (e.g., Grammarly)	Role-playing different communication scenarios Peer review of written communication (emails, reports)
Teamwork and Collaboration Dynamics of working in teams Conflict resolution and negotiation Building trust and rapport	Group projects Team-building activities	Collaboration tools (e.g., Google Docs, Trello) Virtual team-building games	Collaboration tools (e.g., Google Docs, Trello) Virtual team-building games	Group project planning using Trello Virtual escape room for team-building
Problem-Solving and Critical Thinking Steps in problem-solving Critical thinking techniques Decision-making processes	Case study analysis Brainstorming sessions	Mind mapping tools (e.g., Mind Meister) Decision-making software (e.g., SWOT analysis tools)	Mind mapping tools (e.g., Mind Meister) Decision-making software (e.g., SWOT analysis tools)	Analyse case studies using mind mapping tools Conduct a SWOT analysis on a given problem
Leadership and Initiative Leadership styles and qualities Taking initiative and being proactive Motivating and inspiring others	Leadership simulations Reflective journaling	Simulation software (e.g., leadership games) Digital journals or blogs	Simulation software (e.g., leadership games) Digital journals or blogs	Leadership simulation game Reflective journal entries on leadership experiences

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Table 2 (continue). Sample TPACK-based lesson plan for teaching essential soft skills in engineering education.

Contents	Content Knowledge (CK)	Pedagogical Knowledge (PK)	Technological Knowledge (TK)	Activities/ Assignments
Professionalism and Work Ethic Professional behaviour and ethics Time management and punctuality Accountability and responsibility	Ethical dilemma discussions Time management workshops	Time management apps (e.g., To do list) Online ethics courses	Time management apps (e.g., To do list) Online ethics courses	Discuss ethical dilemmas in engineering Create and manage a personal timetable using a time management app
Review and Assessment Recap of all soft skills covered Importance of continuous improvement	Self-assessment and reflection Group presentations	Online assessment tools (e.g., Kahoot) Presentation software	Online assessment tools (e.g., Kahoot) Presentation software	Self-assessment quizzes on Kahoot Group presentations on a selected soft skill and its application in engineering

Content Knowledge is represented through clearly defined topics, such as verbal and non-verbal communication, leadership styles, and problem-solving strategies. These contents ensure that students gain a solid understanding of essential soft skills relevant to professional engineering contexts. Pedagogical Knowledge is addressed through interactive and student-centered methods, including role-playing, case studies, simulations, peer reviews, and group discussions. These approaches promote active learning and help students practice communication and interpersonal skills in collaborative environments.

Technological Knowledge is embedded through various digital tools that support and enhance learning activities. For instance, interactive platforms like Quizizz, Padlet, and Kahoot are used for assessments and discussions, while collaboration tools like Google Docs and Trello facilitate teamwork and project management. Communication platforms such as Zoom and writing tools like Grammarly are utilized for practicing written and verbal communication. Tools like Headspace for stress management and simulation games for leadership are incorporated to address adaptability and leadership topics.

By integrating TPACK elements, the lesson plan ensures that soft skills education is engaging, relevant, and practical, enabling engineering students to connect these skills with real-life professional situations. It also emphasizes technology-enhanced active learning, which supports reflective practice and continuous improvement in soft skills development.

The implementation of TPACK in teaching soft skills and communication can be illustrated through a Lecture Series conducted for first-year engineering students. This series aimed to develop essential communication competencies using a combination of content knowledge (communication principles), pedagogical strategies (active learning), and technological tools to support learning. Although this review focuses broadly on TPACK in soft skills education, this case offers a practical example of how TPACK can be applied in engineering classrooms.

The Lecture Series demonstrated the integration of TPACK components in the following ways:

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(i) Content Knowledge (CK): The series focused on teaching professional communication skills, including:
- Verbal and non-verbal communication.
- Presentation skills.
- Group discussions and teamwork communication.
- Listening and interpersonal skills.
- Etiquette in professional and academic settings.

(ii) Pedagogical Knowledge (PK): A variety of interactive and student-centered learning activities were used to teach these communication skills, such as:
- Role-playing to simulate real-life communication scenarios, including interviews and presentations.
- Group projects and peer interactions to foster collaboration and teamwork.
- Presentations and speaking tasks to encourage practice and confidence-building.
- Teacher modeling and demonstrations of effective communication strategies.

(iii) Technological Knowledge (TK): Several digital tools and platforms were integrated to support communication practice, including:
- Quizizz for gamified assessments of communication concepts, making learning engaging and interactive.
- Padlet for collaborative brainstorming and discussion, allowing students to share ideas and feedback anonymously and comfortably.
- Online simulations and video-based tasks to practice and analyze non-verbal communication, body language, and presentation skills.
- Audio and video recordings of student presentations, enabling reflection and self-evaluation.

The combination of these elements created a dynamic learning environment where students actively engaged in communication tasks supported by technology and guided by structured pedagogy. The technology was not simply an add-on but was integrated intentionally to enhance pedagogy and content delivery. For example, Padlet was used to facilitate post-presentation peer feedback, and Quizizz provided an immediate formative assessment of communication principles, making the learning process more interactive and responsive.

The Lecture Series also highlighted some important reflections and outcomes relevant to TPACK-based soft skills instruction:

(i) Students responded positively to interactive activities and real-life simulations, which helped reduce anxiety and increase participation.

(ii) The use of technology, such as Padlet and Quizizz, motivated students to engage more actively than in traditional classroom discussions.

(iii) Recording and reviewing presentations allowed students to reflect on their performance and identify areas for improvement, supporting deeper learning.

(iv) However, some students faced challenges adapting to digital tools, especially those with limited prior experience in using educational technology, highlighting the need for gradual scaffolding.

Overall, this Lecture Series illustrates how TPACK can be effectively applied to communication and soft skills instruction in engineering education. It shows that by combining relevant content, interactive pedagogy, and supportive technology, educators can create meaningful learning experiences that develop essential communication competencies for engineering students.

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3.5. Challenges in Applying TPACK for Soft Skills in Engineering Education

While the TPACK framework offers a comprehensive approach to integrating technology, pedagogy, and content for soft skills education, its practical application in engineering education is not without challenges. Teaching communication and soft skills to engineering students requires thoughtful alignment of these three domains, yet educators often face several barriers when attempting to implement TPACK effectively.

One of the most prominent challenges is the limited technological readiness of teachers. Although many educators recognize the value of integrating digital tools, not all teachers are proficient in using educational technology to support communication instruction. Some lack confidence in applying platforms like Quizizz, Padlet, or AI-based tools, which makes it difficult to design interactive and technology-enhanced learning activities for soft skills development.

Another significant challenge is students' varying engagement and adaptability to technology-based learning. Not all engineering students are equally comfortable with online platforms and digital communication tools, especially when asked to perform tasks such as virtual presentations, role-plays, or collaborative discussions in unfamiliar formats. This variation affects the consistency of learning outcomes, as some students may struggle to participate fully in tech-integrated activities.

Additionally, institutional and infrastructural constraints limit the broader adoption of TPACK-based instruction. In many engineering institutions, technological resources are either insufficient or unevenly distributed, with limited access to advanced platforms or reliable internet connections. These constraints hinder the ability to conduct technology-mediated learning activities effectively, especially for communication tasks that require real-time interaction and feedback.

Another issue is the lack of professional development opportunities for teachers to learn how to integrate TPACK into communication and soft skills education. While many faculty development programs focus on technical or subject-based pedagogy, few address the unique demands of teaching communication skills to engineering students using TPACK. Without proper training, educators may default to traditional methods and avoid integrating technology meaningfully.

Furthermore, students' perception of soft skills as secondary to technical knowledge poses an attitudinal challenge. Engineering students often prioritize technical courses and may underestimate the importance of communication skills, reducing their motivation to engage in communication tasks, even when designed using interactive and innovative methods.

Cultural factors also influence the success of TPACK-based communication instruction. In some contexts, students may feel uncomfortable participating in activities such as role-plays or discussions due to cultural norms that discourage open expression or critique, limiting the effectiveness of pedagogical strategies aimed at enhancing communication.

Overall, these challenges highlight the need for targeted interventions at both institutional and instructional levels to support the effective use of TPACK in soft skills education. Addressing these barriers requires teacher training, infrastructure development, pedagogical innovation, and cultural adaptation to ensure that communication skills instruction becomes an integral and effective part of engineering education.

3.6. Future Directions and Recommendations

Addressing the challenges of integrating TPACK for soft skills and communication in engineering education requires strategic actions from educators, institutions, and policymakers. Future efforts should focus on strengthening the capacity of teachers, improving technological infrastructure, and developing pedagogical models that align with

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the specific needs of engineering students. Several key directions and recommendations emerge from this review:

(i) Enhancing teacher training and professional development: There is a critical need for specialized training programs that prepare educators to integrate TPACK into soft skills instruction. Such programs should focus on practical strategies for combining communication content, pedagogy, and technology. Teachers should be trained not only in using digital tools but also in designing interactive and technology-supported communication tasks that engage engineering students.

(ii) Providing institutional and technological support: Educational institutions must invest in reliable technological infrastructure to facilitate TPACK-based learning environments. This includes ensuring access to interactive learning platforms, AI-based tools, and stable internet connections, especially for activities that require real-time communication practice. Institutions should also support the development of resource repositories with ready-to-use communication modules that align with TPACK principles.

(iii) Developing context-specific and culturally relevant TPACK models: Since communication styles and teaching contexts vary, future work should focus on creating TPACK frameworks tailored to engineering students' professional communication needs. These models should consider local cultural norms, industry expectations, and students' professional environments, ensuring that soft skills education is meaningful and applicable.

(iv) Strengthening interdisciplinary collaboration: Communication and engineering educators should work together to co-develop integrated learning experiences. Collaborative teaching models that combine technical content with communication tasks can create more authentic and relevant learning environments, helping students see the value of soft skills in their professional future.

(v) Fostering student engagement and motivation: Since engineering students may undervalue soft skills, educators need to implement strategies that emphasize the relevance of communication in real engineering contexts. Embedding communication activities within technical courses and using project-based learning that requires collaboration and presentation can increase student motivation.

(vi) Encouraging reflective and experiential learning: Students should be encouraged to reflect on their communication experiences through activities such as video analysis of presentations, peer feedback, and self-assessment exercises. Incorporating reflection into the learning process helps students internalize communication skills and understand their practical importance.

(vii) Conducting ongoing research and evaluation: Continuous research is needed to evaluate the effectiveness of TPACK-based communication teaching methods in engineering education. Studies should explore student outcomes, teacher experiences, and technological innovations to refine and improve teaching practices.

Future directions should aim at building comprehensive support systems for educators and students, ensuring that soft skills and communication training become an integral part of engineering education through thoughtful TPACK integration. These efforts are essential to prepare engineering graduates who are not only technically proficient but also effective communicators, ready to meet the demands of the modern workplace.

4. CONCLUSION

This review has highlighted the critical role of the TPACK framework in supporting the teaching of soft skills and communication in engineering education. As engineering students

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often prioritize technical knowledge, the integration of communication and soft skills training is essential to prepare them for the collaborative and interdisciplinary demands of modern engineering workplaces. By combining content knowledge of communication, effective pedagogy, and appropriate technological tools, TPACK offers a structured yet flexible approach for educators to design meaningful learning experiences that go beyond traditional methods.

Through the analysis of existing practices and the illustration provided by the Lecture Series case, this paper has shown that interactive, technology-enhanced pedagogies can significantly improve student engagement and help develop essential communication competencies. Tools such as Quizizz, Padlet, and online simulations, when aligned with sound pedagogical strategies, provide students with opportunities to practice and reflect on their communication skills in authentic and engaging ways.

However, several challenges remain in applying TPACK to soft skills instruction in engineering, including teachers' limited technological proficiency, uneven access to resources, and students' low motivation toward communication tasks. Addressing these issues requires targeted teacher training, institutional investment in infrastructure, and the development of context-specific TPACK models that consider the professional realities of engineering fields.

TPACK represents a valuable framework for transforming soft skills education in engineering, ensuring that communication training is both effective and relevant to students' future careers. By adopting TPACK, educators can create integrated learning environments that support not only technical excellence but also the communication and interpersonal skills necessary for engineering graduates to succeed in complex professional settings. Moving forward, collaborative efforts among educators, institutions, and policymakers are needed to fully realize the potential of TPACK in shaping well-rounded, industry-ready engineers.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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