Mastering Professional English Communication: A Guide to Education 4.0 Tools and Techniques for ESL Teachers

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Abstract

In today's rapidly evolving globalised landscape, proficient English communication skills are essential for professionals across diverse industries. The emergence of Education 4.0, integrating advanced technologies and innovative teaching methods, presents unique prospects to enrich Professional English Communication (PEC). Using the TPACK framework within Education 4.0, this study seeks to enhance PEC skills. The research aims to examine how language educators utilize Education 4.0 tools, pedagogical methods, and content knowledge to optimize PEC skill acquisition. The research focuses on exploring the potential of Indian Higher Education language educators in leveraging Education 4.0 tools for teaching PEC. By analyzing current practices and exploring innovative approaches, this study aims to provide insights into the adaptation of teaching strategies to meet the evolving needs of learners. Employing a quasi-experimental design, 89 participants were purposively selected. Initial data collection involved a pre-test questionnaire, followed by intervention through Skill Share Sessions using Education 4.0. After four weeks, a post-test questionnaire was administered, with data analysed using paired sample t-tests in SPSS. Results indicate significant enhancements in students' PEC skills, crucial for the evolving workforce. Participants benefitted substantially from Education 4.0 tools and strategies, though limitations were noted, paving the way for future research directions.

Keywords: Content Knowledge, Education 4.0, Pedagogical Knowledge, Professional English Communication, Technological Knowledge

1. Introduction

In the ever-evolving landscape of education, the integration of technology has played a pivotal role in transforming traditional teaching and learning methodologies. Over the years, educators and researchers have embraced the potential of technology as a catalyst for change, leading to the emergence of what is now commonly referred to as Education 4.0. This new paradigm encompasses a holistic approach that leverages the power of digital tools and innovative strategies to enhance the educational experience for learners in the 21st century. Education 4.0 which is derived from Industry 4.0, represents a significant shift from the conventional classroom setup, where students were passive recipients of knowledge, towards a learner-centric environment that fosters creativity, critical thinking, collaboration, and problem-solving skills. It recognizes the need to prepare individuals for a rapidly changing world, characterized by technological advancements and increasing interconnectedness.

Education 4.0 promotes personalized learning paths and adaptive learning systems that cater to the individual needs, interests, and learning styles of students. It utilizes Artificial Intelligence (AI) and data analytics to provide tailored content, assessments, and feedback (Miranda et al., 2021). Education 4.0 integrates various technologies into the learning process. This includes the use of Virtual Reality (VR) and Augmented Reality (AR) for immersive learning experiences, AI-powered chatbots for personalized assistance, and Internet of Things (IoT) devices for connected learning environments. Education 4.0 recognizes the need for lifelong learning and continuous professional development in an ever-evolving world. It promotes self-directed learning, access to online resources, and opportunities for upskilling and reskilling. Education 4.0 approach actively promotes collaboration and meaningful connections among learners and educators from various cultural backgrounds, thereby fostering deep intercultural understanding and empathy. However, achieving this goal necessitates the utilization of a universal language. There are numerous mobile applications accessible to aid in the learning of English Communication. These applications leverage technology to provide interactive and personalized language learning experiences. Mobile applications such as Busuu, ELSA, Duolingo, Rosetta Stone, Hello Talk, Memrise, Babbel, and Idict support Education 4.0 paved the way for enhancing English Communication (Álvarez Valencia, 2016).

English has emerged as the global lingua franca, connecting people from diverse cultures and backgrounds across the world. In recent

years, the significance of English proficiency has extended beyond basic communication skills, particularly in professional contexts. As the global economy becomes increasingly interconnected and businesses expand their operations internationally, the ability to communicate effectively in professional English has become a vital asset for individuals in the modern generation. Proficiency in Professional English opens up a multitude of opportunities in various sectors, ranging from business and finance to technology, healthcare, and academia (Bhatia & Bremner, 2012). It not only enhances employability but also equips individuals with the tools to excel in a highly competitive global job market. The benefits of possessing proficient English skills lead to encompassing career progression, enhanced access to knowledge, networking prospects, cultural adaptability, and versatility (Dhivya, Hariharasudan, & Nawaz, 2023). Embracing Professional English widens the spectrum of opportunities available to individuals, empowering them to thrive in an ever more interconnected and fiercely competitive global job market.

This research paper seeks to investigate the potential of Education 4.0 in enhancing Professional English Communication (PEC). It aims to explore Technical, Content, and Pedagogical knowledge within the Education 4.0 framework that can be effectively utilized to facilitate the development of language skills specifically tailored to professional contexts. This study employs a quasi-experimental research design and employs a paired sample t-test as a statistical tool to analyze the results. Additionally, the research aims to validate its findings by involving Higher Education language educators from the southern region of Tamil Nadu, India.

2. Review of Literature

2.1 Education 4.0

The evolution of Education 4.0 represents a significant shift in the field of education, driven by technological advancements and changing educational paradigms. It builds upon the previous generations of education and embraces the opportunities presented by the fourth industrial revolution. As internet connectivity improved and digital resources became more accessible, online learning platforms emerged, offering flexible and personalized learning experiences in support of Education 4.0. This opened up opportunities for learners to access educational content anytime, anywhere, transcending geographical and temporal boundaries (Wallner & Wagner, 2016). Massive Open Online Courses (MOOCs) gained popularity, enabling individuals to acquire knowledge and skills from renowned institutions and experts worldwide (Mohamad Alakrash & Abdul Razak, 2020). Furthermore, the rise of mobile devices, such as smartphones and tablets, contributed to the ubiquity of technology in education. Mobile learning applications and educational games provide interactive and engaging experiences, catering to the diverse learning styles of students. AI and VR technologies also found their way into classrooms, immersing learners in virtual environments and creating unique opportunities for experiential learning (Haderer & Ciolacu, 2022). Education 4.0 encompasses more than just the integration of technology. It embraces a pedagogical shift that focuses on developing essential 21st-century skills, including digital literacy, information literacy, critical thinking, creativity, communication, and collaboration. Educators are encouraged to adopt learner-centred approaches, where students actively participate in the co-creation of knowledge and develop skills that are relevant to the demands of the digital age (Hariharasudan & Kot, 2018).

2.2 Professional English Communication (PEC)

PEC refers to the ability to effectively convey ideas, information, and opinions in the English language within a professional context (Bhatia & Bremner, 2012). It involves the use of appropriate vocabulary, grammar, tone, and style to communicate, confidently, and professionally with colleagues, clients, and stakeholders in various professional settings. Proficient PEC skills are essential in today's globalized and interconnected world (Gajek et al., 2022). They play a crucial role in career advancement, networking, collaboration, and building strong professional relationships. Enhancing productivity, teamwork, and fostering understanding among colleagues from diverse backgrounds through effective workplace communication is crucial hence it is essential for preparing students for their future employment by developing strong communication skills (Thavabalan et al., 2021). Proficient PEC enables individuals to convey their expertise, establish credibility, and achieve success in their professional endeavours (Anaelka, 2018). Technology-mediated approaches, such as mobile applications and online platforms, provide accessible resources for self-study and language practice (Carrió-Pastor & Skorczynska, 2015). Moreover, recognizing the evolving landscape of education, teachers need to equip themselves with new technology for teaching PEC. By integrating modern technological tools and platforms into their teaching practices, educators can enhance the effectiveness of their instruction and better prepare students for communication in professional settings aligning with the demands of contemporary workplaces. (Gavrilova & Kira Trostina, 2014). Hence the following hypothesis is derived

H1: Utilizing Education 4.0 results in improved proficiency in teaching PEC skills compared to the pre-implementation phase.

2.3 Content Knowledge

Listening skills are of paramount importance in PEC as they facilitate comprehension, understanding, and effective communication in diverse workplace settings. According to a previous study active listening is vital for building positive relationships, among co-workers (Symonenko, 2020). Effective listening allows professionals to grasp instructions, understand client needs, negotiate effectively, and respond appropriately, thereby contributing to successful communication and overall organizational success. Effective interpersonal communication is essential for building professional relationships. Research emphasizes the importance of active listening, empathy, and using appropriate language in establishing rapport and understanding the needs of colleagues, clients, and stakeholders (Torres & Zeidler, 2002).

Effective PEC relies heavily on speaking skills, which are of utmost importance (Al-Eiadeh et al., 2016). These skills empower

individuals to articulately convey ideas, deliver impactful presentations, actively participate in meetings, negotiate with confidence, and foster robust professional relationships. Presentations and public speaking are integral parts of Professional Communication. Research highlights the significance of organization, clarity, and delivery techniques in effective presentations (Muttaqin & Chuang, 2022). Developing skills such as structuring content, using visual aids, maintaining eye contact, and engaging the audience can enhance PEC in public speaking contexts.

Reading skills are essential for effective PEC as they enable individuals to access and comprehend written information, stay informed about industry trends, conduct research, and enhance their knowledge in specific domains (Krepel et al., 2021). In professional environments, individuals frequently come across technical or specialized texts pertinent to their expertise. Proficiency in reading is paramount for professionals to grasp and manoeuvre through these specialized materials, which encompass technical manuals, industry reports, academic journals, and research papers. A firm grasp of technical terminology, specialized vocabulary, and industry-specific concepts is imperative for accurately interpreting and effectively applying the information contained within these texts. Such skills are indispensable in today's professional landscape. (Bojovic, 2010).

Effective professional writing requires clarity and coherence. Clarity involves expressing ideas concisely and understandably, avoiding ambiguity and confusion. Coherence entails organizing thoughts logically and maintaining a cohesive flow of information throughout the writing (Tangpermpoon, 2008). Developing these skills enables professionals to convey their messages accurately and engage readers effectively. Proficiency in grammar, vocabulary, and sentence structure is crucial for professional writing. Proper grammar usage ensures clear communication and helps convey ideas accurately (Demydovych & Holik, 2020). A strong vocabulary allows professionals to use precise and appropriate language, while varied sentence structures add depth and sophistication to their writing. Continuous learning and practice in these areas enhance professionals' writing skills (Sajid & Siddiqui, 2015). Adopting an appropriate tone and style is essential in professional writing. Professionals need to consider their audience, purpose, and context when determining the tone and style of their writing. The tone should be professional, respectful, and consistent with the intended message. Writing style should align with the expectations and conventions of the specific professional field or industry (Mayer, 2014). Developing the ability to adjust tone and style using professional content enhances the effectiveness of professional writing. To effectively teach PEC using Education 4.0, teachers must prioritize building a solid foundation of content knowledge. This entails not only mastering the intricacies of the English language but also understanding the specific communication skills required in professional contexts. Therefore, the subsequent hypothesis is formulated.

H2: The utilization of Education 4.0 leads to an enhanced proficiency in Content Knowledge for teaching PEC skills compared to the proficiency levels before its implementation.

2.4 Pedagogical Knowledge

Pedagogical knowledge is essential for teaching PEC using Education 4.0, as it helps educators and learners adopt effective instructional strategies, facilitate engaged learning experiences, and support students' language development. Pedagogical knowledge begins with understanding learners' needs, goals, and proficiency levels (Moreno & Vermeulen, 2015). Educators and learners must assess learning language abilities of their own, identify their specific PEC goals, and consider their learning styles (Srivani & Hariharasudan, 2023). This knowledge enables them to tailor instruction and learning materials to meet the diverse needs of learners (Demydovych & Holik, 2020). Pedagogical knowledge plays a crucial role in designing a curriculum that aligns with PEC goals. Educators should consider incorporating real-world tasks, industry-specific contexts, and authentic materials into the curriculum (Hariharasudan et al., 2021). They must identify language skills and sub-skills relevant to professional communication, create meaningful learning objectives, and design appropriate assessment methods (Walsh & Rúsquez, 2020).

Education 4.0 emphasizes the integration of technology into teaching and learning processes (Gajek et al., 2022). Pedagogical knowledge enables learners to leverage digital tools, online resources, and learning management systems to enhance PEC instruction. Blended learning approaches, combining face-to-face and online components, facilitate self-paced learning, collaborative activities, and personalized feedback (Torres & Zeidler, 2002). Task-based and project-based learning approaches provide students with opportunities to practice PEC in authentic contexts (Thavabalan et al., 2021). Pedagogical knowledge guides educators in designing tasks and projects that simulate real-world professional situations, allowing students to develop language skills while addressing practical challenges. Such approaches foster critical thinking, collaboration, and problem-solving skills (Saha, 2023). PEC often involves interactions with individuals from diverse cultural backgrounds. Pedagogical knowledge supports the development of intercultural competence, helping students understand cultural differences, adapt their communication styles, and demonstrate respect and sensitivity in professional contexts. Hence teachers need to adopt new teaching and communicative strategies utilizing Education 4.0, such as active listening, negotiation, and persuasive techniques, to enhance students' ability to navigate cross-cultural communication challenges (Allam, 2016). Therefore, the following hypothesis is formulated.

H3: The utilization of Education 4.0 leads to an enhanced proficiency in Pedagogical Knowledge for teaching PEC skills compared to the proficiency levels before its implementation.

2.5 Technological Knowledge

Technological knowledge is crucial for studying PEC using Education 4.0, as it involves leveraging digital tools, online platforms, and technological resources to enhance language learning and communication (Dhivya, Hariharasudan, Ragmoun, et al., 2023). Digital

literacy is fundamental for students to navigate and utilize digital tools effectively. It encompasses the ability to use technology for communication, information retrieval, collaboration, and content creation. Students need to be proficient in operating computers, accessing online resources, and using productivity tools such as word processors, presentation software, and communication platforms (Farias-Gaytan et al., 2022). With the digital age, reading has expanded to online platforms, e-books, and digital articles. Professionals must develop digital reading skills to effectively navigate and extract information from online sources (Srivani, Hariharasudan, & Pandeeswari, 2022). Digital reading skills include the ability to skim and scan web content, evaluate online sources for reliability, and adapt reading strategies to accommodate digital texts (Eshet-Alkalai, 2004).

Proficient use of online communication tools is essential for PEC. Students need to be familiar with email etiquette, online discussion forums, video conferencing platforms, and messaging applications (Thavabalan et al., 2020). Technological knowledge of these tools allows students to engage in effective communication, collaborate with peers, and interact with instructors in a virtual learning environment (Tinmaz et al., 2022). Education 4.0 encourages students to create digital content as part of their learning process (Srivani, Hariharasudan, Nawaz, et al., 2022). Technological knowledge in content creation tools such as multimedia presentation software, video editing applications, and graphic design platforms enables students to develop professional-looking presentations, videos, infographics, and other digital artefacts. It enhances their ability to communicate ideas effectively using multimedia elements (Kaeophanuek et al., 2018).

In the Education 4.0 era, mobile applications such as Busuu and ELSA have become increasingly popular for learning English communication. These apps provide users with the convenience of learning at their own pace and on their schedule (Oliveira & Saraiva, 2023). Furthermore, they often incorporate gamification and interactive features to make learning more engaging and enjoyable (Li & Yu, 2022). The Busuu app is a language learning platform that offers courses in various languages, including English (Winans, 2020). It provides interactive lessons, vocabulary exercises, grammar practice, and speaking opportunities to help users improve their language skills. Additionally, Busuu incorporates social features that allow users to connect with native speakers and receive feedback on their language proficiency. The ELSA (English Language Speech Assistant) app focuses specifically on improving English pronunciation and speaking skills (Dhivya, Hariharasudan, Ragmoun, et al., 2023). It utilizes speech recognition technology and artificial intelligence to provide users with personalized feedback on their pronunciation (Kholis, 2021). ELSA offers a range of exercises and practice activities to help users enhance their spoken English, with a particular emphasis on inducing accents and improving fluency. Numerous Education 4.0 applications, such as Duolingo, Rosetta Stone, Babbel, Memrise, Busuu, HelloTalk, Tandem, Lingodeer, FluentU, and Pimsleur, are designed to facilitate universal access and are readily available. Their efficacy hinges upon their ability to align closely with the specific requirements of individual learners. Consequently, language educators must possess a thorough understanding of these applications. Their proficiency in this regard is instrumental in guiding learners towards selecting and utilizing the most appropriate application to optimize their learning experience. Therefore, the following hypothesis is derived.

H4: The utilization of Education 4.0 leads to an enhanced proficiency in Technical Knowledge for teaching PEC skills compared to the proficiency levels before its implementation.

The following concept map (Figure 1) is a visual tool used to represent the relationships between different concepts. It is typically created to illustrate the connections and hierarchy among various ideas using the Technological Pedagogical Content Knowledge (TPACK) framework within Education 4.0 for teaching PEC.

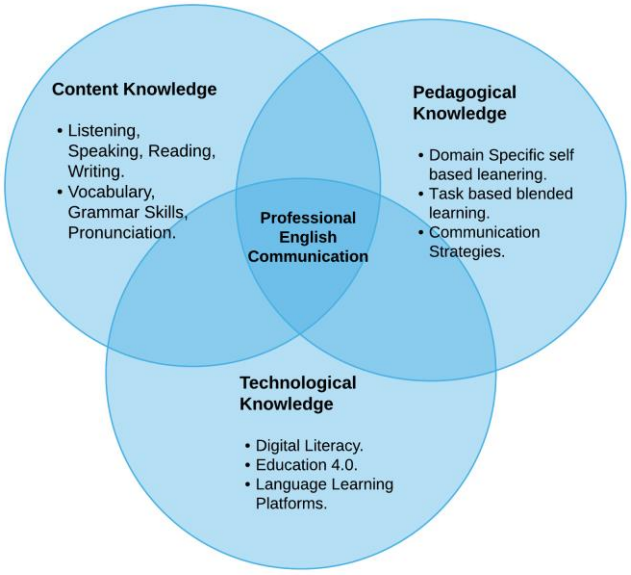

Figure 1. Concept map using Education 4.0 framework

2.6 Statement of the Problem

In today's globalized world, the importance of PEC skills is widely recognized. However, many learners continue to encounter challenges in acquiring and developing these essential skills. One significant obstacle is the struggle faced by educators in effectively incorporating PEC into their curricula using traditional educational approaches. Despite the potential of Education 4.0, characterized by technology integration and learner-centred methods, its specific application to enhance PEC remains largely unexplored.

The existing gap in understanding the challenges and opportunities associated with using Education 4.0 for teaching PEC necessitates focused research. Therefore, this study aims to address this gap by utilizing the Technological Pedagogical Content Knowledge (TPACK) framework. This research delves into the integration of Education 4.0 to enhance teaching strategies employed by language educators, specifically focusing on the effective learning of PEC skills by students. By examining how educators utilize Education 4.0 tools, pedagogical methods, and content knowledge, the study aims to identify innovative approaches to optimize PEC skill development in higher education. Through this investigation, the research seeks to provide insights into how educators can harness the potential of Education 4.0 to create dynamic and engaging learning environments conducive to the effective acquisition of PEC skills among students.

2.7 Objectives of the Study

- To investigate the Content Knowledge for teaching PEC using Education 4.0
- To identify the Pedagogical Knowledge for teaching PEC using Education 4.0
- To explore the Technological Knowledge for teaching PEC using Education 4.0

3. Methodology

The research employed a quantitative approach, utilizing a quasi-experimental research design. Sampling techniques were implemented to select participants from the pool of Higher Education language educators through purposive sampling techniques. A visual representation of the research plan can be seen in Figure 2, The current study focuses specifically on Higher Education language educators. Initially, a pre-test was administered to gauge the participants' prior knowledge of content, pedagogy, and technical aspects of teaching PEC skills. A questionnaire utilizing a 5-point Likert scale was utilized for this purpose. Following that, in the intervention period, Skill Share Sessions were conducted among teachers to enhance teaching PEC skills by integrating Education 4.0 using the TPACK framework. The duration of the intervention was extended over four weeks. After the intervention, a post-test was administered using a separate questionnaire that utilized a 5-point Likert scale, aiming to evaluate any enhancements or progress made. Pre-test and post-test assessments will gauge the effectiveness of teachers' instructional strategies, ensuring alignment with learning objectives and fostering a culture of continuous improvement. The collected data from both questionnaires were analyzed using IBM SPSS statistical tool version 21.

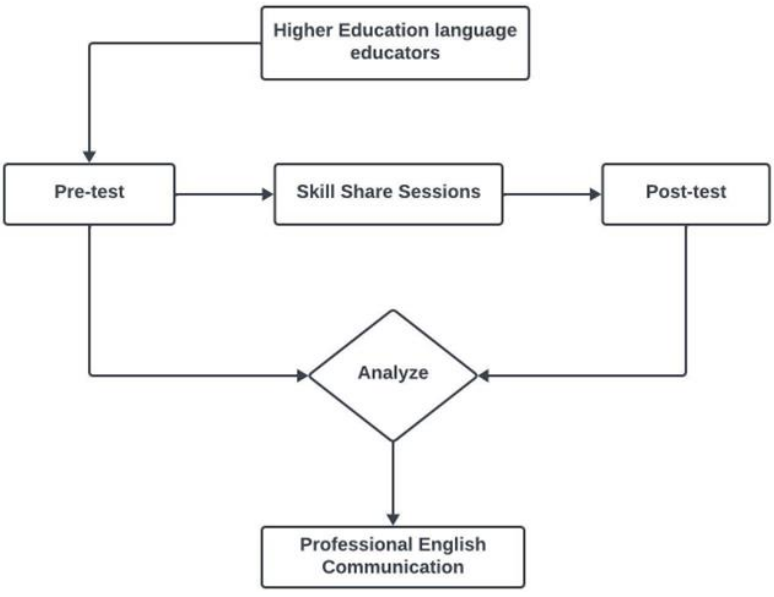

Figure 2. Visual representation of the research plan

3.1 Participants

Before conducting the survey, explicit consent was obtained from participants to carry out the research. Subsequently, invitations were extended to potential participants, highlighting the importance of their involvement and emphasizing the principles of voluntary participation, confidentiality, and anonymity. It was assured that the collected data would only be presented in summarized form. The study employed a quasi-experimental design specifically targeting teaching PEC skills using Education 4.0. Therefore, Higher Education

language educators in the southern region of Tamil Nadu were purposefully selected as participants. A total of 89 Higher Education language educators participated in the study. All participants were requested to complete a pre-test questionnaire, which included demographic information.

3.2 Instruments

The pre-test involved the distribution of a questionnaire via Google Forms, utilizing a 5-point Likert scale 1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree to collect participants' opinions solely on their skills. All questionnaire questions were made mandatory to ensure participants' full completion before submitting the forms and also included a section to gather participants' demographic information. A total of 20 questions were included in the questionnaire, evenly distributed across various variables such as Content Knowledge, Pedagogical Knowledge, Technological Knowledge and PEC. To ensure the questionnaire's validity, field experts reviewed and validated it. The questionnaire's reliability was assessed using the IBM SPSS tool. Table 1 depicts the case summary of participation and Table 2 resulting in a Cronbach's Alpha value of 0.824, indicating a good level of internal consistency.

Table 1. Case Summary Processing

		N	%
Cases	Valid	89	100.0
	Excluded[a]	0	.0
	Total	89	100.0

Source: Values are given based on the collected data

Table 2. Reliability

Cronbach's Alpha	N of Items
.824	20

Source: Values are given based on the collected data

For the post-test, a similar Likert scale-based questionnaire was created, mirroring the structure of the pre-test questionnaire. The post-test questionnaire also consisted of 20 questions, equally distributed among the variables. Demographic details of the participants can be found in Table 3.

Table 3. Demographic details

S.no	**Demographic details**	**Range**
1	Gender	Male = 40; Female = 49
2	Age	Aged < 20 = 45; Age > 20 = 44
3	Region	Urban = 45; Rural = 44
4	Education	Post Graduate = 44 ; Doctorate = 45

Source: Values are given based on the collected data

3.3 Procedure

Detailed instructions regarding the study were provided to the participants, along with the establishment of a dedicated WhatsApp group to address any inquiries or concerns they might have had. Using Google Forms, a pre-test was administered to 89 Higher Education language educators, ensuring that all fields in the questionnaire were mandatory to guarantee complete form submissions. The questionnaire, which aimed to evaluate participants' existing knowledge was distributed via the WhatsApp group. The data collected from the pre-test questionnaire were securely stored for further analysis.

The intervention plan, Skill Share Session is crafted as a three-day workshop to assess and enhance teachers' teaching skills in PEC using Education 4.0. Through comprehensive training sessions, hands-on workshops, collaborative lesson planning, and ongoing support, educators will develop proficiency in integrating Education 4.0 within the TPACK framework specifically tailored for teaching PEC. Figure 3 shows the detailed plan of the training sessions following the TPACK framework for teaching PEC skills

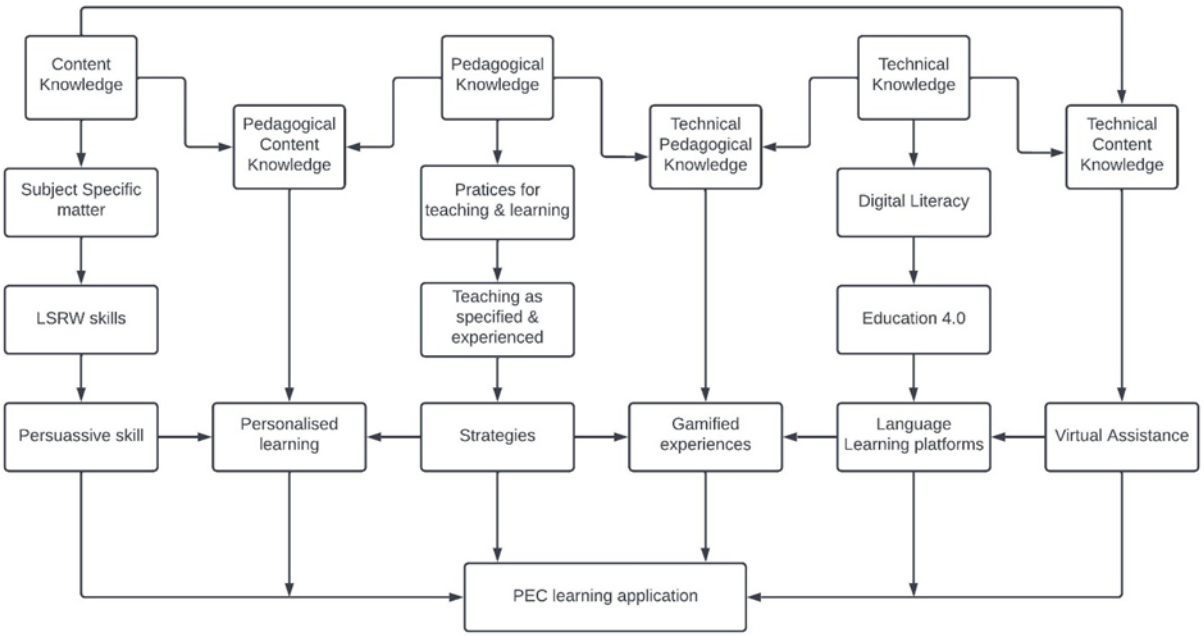

Figure 3. Detailed intervention of the study

On the first day of the workshop, participants were introduced to the core concepts of TPACK with a specific focus on enhancing PEC skills. Through interactive sessions, participants gained insights into how technology, teaching methods, and subject matter knowledge intersect to create effective learning experiences. They explored strategies for integrating digital tools and resources into their English language instruction, understanding how these tools can support diverse learning styles, enhance digital literacy skills and engage students in meaningful communication activities.

The second day of the workshop provided training to the participants with hands-on experience in managing Education 4.0 platforms such as ELSA, Busuu, Duolingo, Chatbots, Hello Talk, Duolingo, Memrise, Rosetta stone for teaching PEC. Through practical workshops and demonstrations, participants learned how to navigate various digital learning platforms, create interactive learning materials, and facilitate online communication and collaboration among students. They gained confidence in using technology to deliver dynamic and engaging Professional English language lessons, incorporating multimedia resources, interactive exercises, and real-world simulations to enhance students' language proficiency such as LSRW skills.

On the third day, the focus shifted to the importance of collaborative lesson planning and ongoing support for students in the context of technology-enhanced teaching. Participants explored collaborative planning strategies, such as co-designing lessons, sharing resources, and providing peer feedback, to optimize the use of technology in Professional English language instruction. Additionally, they discussed ways to offer personalized support and guidance to students as they navigate digital learning environments, ensuring that all learners have equitable access to resources and opportunities for success in developing their English communication skills.

The workshop spans three days through offline mode, each consisting of six hours of training per day. The first three hours are dedicated to theory sessions, where participants learn the concepts and principles of the TPACK framework along with strategies for integrating technology into their teaching practices. The subsequent three hours are reserved for discussion sessions, allowing participants to engage in collaborative activities using Education 4.0, share ideas, and address any questions or concerns they may have. Following the completion of the three-day workshop, participants are tasked with implementing the TPACK framework in their classrooms over four weeks, during regular class hours. After the implementation period, a post-test is administered to the participants using a questionnaire to assess the effectiveness of the intervention. The data collected from the post-test was stored and both the pre- and post-test data were analyzed using the Paired Sample t-test in SPSS version 21 to evaluate any significant changes in participants' teaching practices and students' learning outcomes.

4. Results

The research findings, obtained through the utilization of SPSS and the implementation of a paired sample t-test, have been documented in the tables presented below. The paired sample t-test was employed to determine the extent of improvement observed during the intervention period. The paired sample t-test is a statistical method that allows for the comparison of means between two groups, enabling the evaluation of assumptions made about the population as part of hypothesis testing, through which the impact of the intervention on the population could be assessed. The average means of the pre-test data for all variables were computed using SPSS and are presented in Table 4. The pre-test average mean values were as follows: Professional English Communication (PEC) - 4.0719, Content Knowledge (CK) - 4.1438,

Pedagogical Knowledge (PK) - 4.2337, and Technological Knowledge (TK) - 4.2337. Similarly, the average mean values of the post-test data were also computed using SPSS. The post-test average mean values were as follows: Professional English Communication (APEC) - 4.6112, Content Knowledge (ACK) - 4.5326, Pedagogical Knowledge (APK) - 4.6697, and Technological Knowledge (ATK) - 4.7101. Additionally, Table 4 provides the standard deviation (SD) values for all variables, which were calculated based on a sample size of 89 participants.

Table 4. Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PEC	4.0719	89	.36587	.03878
	APEC	4.6112	89	.39122	.04147
Pair 2	CK	4.1438	89	.31187	.03306
	ACK	4.5326	89	.35025	.03713
Pair 3	PK	4.2337	89	.26669	.02827
	APK	4.6697	89	.27486	.02913
Pair 4	TK_	4.2337	89	.29269	.03103
	ATK	4.7101	89	.33305	.03530

Source: Values are given based on the collected data

Table 5 presents the paired sample correlation, employing Pearson's correlation coefficient to assess the magnitude and direction of linear associations between variable pairs. In establishing meaningful associations between variables, correlation values play a crucial role. The range of Pearson's correlation coefficient, denoted as "r," extends from -1 to 1, indicating perfect positive correlations. The determination of the significance of a correlation is based on the analysis of the p-value. A p-value lower than 0.05 indicates a statistically significant correlation, whereas a p-value greater than 0.05 suggests a lack of statistical significance. It is important to consider both the Pearson coefficient and the p-value together. Table 5 presents the correlation values and corresponding p-values for each variable, pairing the pre-test and post-test data for the respective variables, employing a paired sample t-test and showing the positive correlations and statistically significant values for all the variables.

Table 5. Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PEC & APEC	89	.880	.000
Pair 2	CK & ACK	89	.760	.000
Pair 3	PK & APK	89	.805	.000
Pair 4	TK & ATK	89	.712	.000

Source: Values are given based on the collected data

Table 6 displays the outcomes of the paired sample test, presenting the mean difference and standard deviation (SD) scores for all variables. In this analysis, the average means of the variables obtained from both the test data are compared. To assess the observed improvement during the intervention period, a paired sample t-test was performed. The differences between the average means of the pre-test data and the post-test data were determined by comparing them for the following variable pairs: PEC - APEC, CK - ACK, PK - APK, and TK - ATK. To evaluate the statistical significance of the findings, a two-tailed significance test was performed with a 95% confidence interval, resulting in p-values of 0.000, indicating significance.

Table 6. Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair1	PEC - APE	-.53933	.18685	.01981	-.57869	-.49997	-27.230	88	.000
Pair2	CK - ACK	-.38876	.23230	.02462	-.43770	-.33983	-15.788	88	.000
Pair3	PK - APK	-.43596	.16939	.01796	-.47164	-.40027	-24.280	88	.000
Pair4	TK - ATK	-.47640	.24028	.02547	-.52702	-.42579	-18.705	88	.000

Source: Values are given based on the collected data

Figure 4 illustrates the progress achieved during the intervention period, specifically focusing on the improvement among all the variables. The bar diagram demonstrates enhancement compared to the pre and post-test.

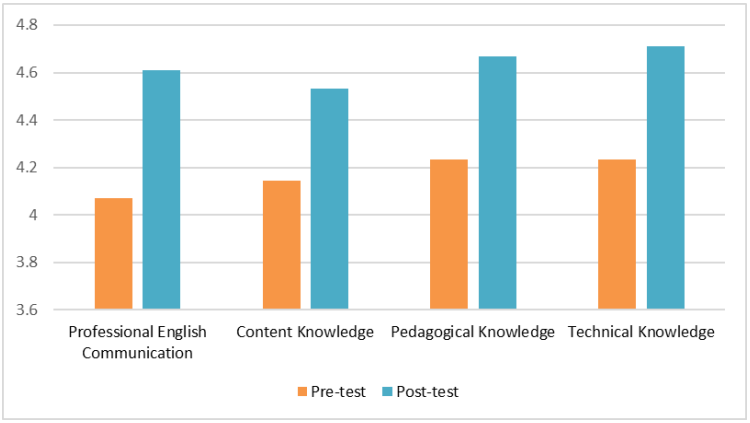

Figure 4. Mean difference

Source: Illustrated by the researchers

4.1 Hypothesis Testing

The tabulations presented in Tables 4-6 were employed to conduct hypothesis testing and corroborate the research findings. The analysis employed the paired sample t-test, a statistical technique that allowed for the comparison of means across groups. The aim was to investigate a hypothesis and determine whether a specific process significantly affects the participants.

H1: Utilizing Education 4.0 results in improved proficiency in teaching PEC skills compared to the pre-implementation phase.

Upon reviewing the statistics presented in Table 4, it was noted that the average means of the pre-test values for PEC (mean = 4.0719, Standard Deviation = 0.36587) were comparatively lower than the average means of the post-test values (mean = 4.6112, Standard Deviation = 0.39122). The significance value is supported by the correlation coefficient values for PEC (r = 0.880), as shown in Table 5, which is slightly below 0.9 and depicts a positive correlation. Table 6 shows that the paired difference between the test values produced an extremely significant result, with a p-value of 0.00, indicating mean differences between pre and post-test values. Furthermore, Figure 4 provides evidence of utilizing Education 4.0 results in an improved proficiency in teaching PEC skills compared to the pre-implementation phase. Hence, the research hypothesis H1 was confirmed.

H2: The utilization of Education 4.0 leads to an enhanced proficiency in Content Knowledge for teaching PEC skills compared to the proficiency levels before its implementation.

After analyzing the statistics in Table 4, it was noted that the average means of the pre-test values for Content Knowledge (mean = 4.1438, Standard Deviation = 0.31187) were comparatively lower than the average means of the post-test values (mean = 4.5326, Standard Deviation = 0.35025). The significance value is further supported by the correlation coefficient values for Content Knowledge (r = 0.760) presented in Table 5, which is slightly below 0.9 and depicts a positive correlation. Table 6 shows that paired differences between the test values resulted in a highly significant outcome with a p-value of 0.00, indicating mean differences between pre and post-test values. Additionally, Figure 4 shows that the utilization of Education 4.0 leads to an enhanced proficiency in Content Knowledge for teaching PEC skills compared to the proficiency levels before its implementation. Therefore, the research hypothesis H2 was affirmed.

H3: The utilization of Education 4.0 leads to an enhanced proficiency in Pedagogical Knowledge for teaching PEC skills compared to the proficiency levels before its implementation.

Upon examining the statistics in Table 4, it can be observed that the average means of the pre-test values for Pedagogical Knowledge (mean = 4.2337, Standard Deviation = 0.26669) were comparatively lower than the average means of the post-test values (mean = 4.6697, Standard Deviation = 0.27486). The significance value is supported by the correlation coefficient values for Pedagogical Knowledge (r = 0.805) as presented in Table 5, which is slightly below 0.9 and depicts a positive correlation. Table 6 shows that the paired difference between the test values yielded a highly significant result with a p-value of 0.00, indicating mean differences between pre and post-test values. Furthermore, Figure 4 shows the utilization of Education 4.0 leads to an enhanced proficiency in Pedagogical Knowledge for teaching PEC skills compared to the proficiency levels before its implementation. Therefore, the research hypothesis H3 was accepted.

H4: The utilization of Education 4.0 leads to an enhanced proficiency in Technical Knowledge for teaching PEC skills compared to the proficiency levels before its implementation.

After analyzing the statistics in Table 4, it was observed that the average means of the pre-test values for Technological Knowledge (mean = 4.2337, Standard Deviation = 0.29269) were lower than the average means of the post-test values (mean = 4.7101, Standard Deviation = 0.33305). The significance value is further supported by the correlation coefficient values for Technological Knowledge (r = 0.712) presented in Table 5, which is slightly below 0.9 and depicts a positive correlation. Table 6 shows that paired differences between both test values resulted in a highly significant outcome with a p-value of 0.00, indicating mean differences between pre and post-test values. Additionally, Figure 4 shows that the utilization of Education 4.0 leads to an enhanced proficiency in Technical Knowledge for teaching

PEC skills compared to the proficiency levels before its implementation. Therefore, the research hypothesis H4 was confirmed.

5. Discussion

Education 4.0 plays a significant role in the enhancement of communication skills, with the integration of effective learning methods and teaching techniques leading to improved abilities among students and the creation of sustainable learning environments. The present research examines the impact of Education 4.0 on teaching PEC Skills. Table 7 shows the study's findings aim to address the hypothesis by providing real-time performance-based evidence.

Table 7. Comparative analysis of existing research with the outcome of the study

S.no	Research Question	Existing Research		The outcome of the present study
		Findings	References	
H1	Utilizing Education 4.0 results in improved proficiency in teaching PEC skills compared to the pre-implementation phase.	Traditional teaching methods were used to enhance communication skills.	(Eady, Michelle J. and Lockyer, 2013; Matsumoto-Royo & Ram ŕez-Montoya, 2021; Pastore et al., 2019; Richards, 2013)	Education 4.0 supports personalized learning which induces motivation and enhances the communication skills among the learners while fostering a sustainable environment.
H2	The utilization of Education 4.0 leads to an enhanced proficiency in Content Knowledge for teaching PEC skills compared to the proficiency levels before its implementation.	Language textbooks and their instructional methods were used for broadening the content knowledge.	(Gavrilova & Kira Trostina, 2014; Symonenko, 2020; Torres & Zeidler, 2002)	Education 4.0 enables immersive learning experiences, independently explores language content resources, and actively participates in authentic contexts.
H3	The utilization of Education 4.0 leads to an enhanced proficiency in Pedagogical Knowledge for teaching PEC skills compared to the proficiency levels before its implementation.	Engaging students in authentic and contextualized pedagogical activities such as collaborative learning.	(Dhivya, Hariharasudan, Ragmoun, et al., 2023; Kholis, 2021; Saha, 2023; Villalobos-Z úñiga & Cherubini, 2020)	Integration of AI gives access to a wide range of resources and materials and supports knowledge retention, contributing to the observed improvement in Pedagogical Knowledge.
H4	The utilization of Education 4.0 leads to an enhanced proficiency in Technical Knowledge for teaching PEC skills compared to the proficiency levels before its implementation.	Emphasis on formal education, lectures, textbooks and hands-on training were used to enhance the language skills.	(Eady, Michelle J. and Lockyer, 2013; Pastore et al., 2019; Saidani Neffati et al., 2021)	Meets the diverse needs and learning styles of students and induces problem-solving abilities, and digital literacy. Adaptability and creativity were instilled.

The findings emphasize the critical role of teaching through Education 4.0 in fostering PEC. Education 4.0, characterized by the integration of digital technologies such as AI, VR, and interactive platforms, not only enhances engagement and motivation among learners but also facilitates personalized learning pathways tailored specifically for developing PEC skills (Eady, Michelle J. and Lockyer, 2013), (Demydovych & Holik, 2020; Godfroid et al., 2013). Traditional teaching methods cannot often address the nuanced language needs required for effective professional communication, resulting in less impactful learning experiences (Molina-azorin et al., 2021). However, the current study underscores how educators can harness the power of Education 4.0 to provide immersive, self-directed learning opportunities that cater to the specific demands of PEC, thus significantly enhancing learning outcomes among students.

Education 4.0, which encompasses the integration of digital technologies into the learning environment, offers a wide range of resources and tools that can enhance content knowledge acquisition among teachers as well as students (Gavrilova & Kira Trostina, 2014) and the current study aligns with it by enhancing the teaching strategies among the language educators for teaching PEC. These technologies include multimedia content, interactive platforms, mobile applications and online resources that provide teachers with access to a wealth of information (Torres & Zeidler, 2002). In contrast, traditional instructional methods often rely on language textbooks as the primary source of knowledge. The results of the present study are in line with previous research that supports the effectiveness of Education 4.0 in promoting content knowledge acquisition among language educators (Sophonhiranrak, 2021). The interactive nature of Education 4.0 allows learners to engage with multimedia content, simulations, and virtual environments, providing them with immersive learning experiences. These interactive elements can enhance comprehension, retention, and application of content knowledge for learning PEC among students (Matsumoto-Royo & Ram ŕez-Montoya, 2021).

The findings of the currentstudy align with previous research that supports the effectiveness of Education 4.0 in enhancing pedagogical knowledge for teaching PEC (Troussas et al., 2020). Education 4.0, which integrates digital technologies into the learning environment, offers various opportunities for teaching the English language in authentic and contextualized pedagogical activities (Dhivya, Hariharasudan, Ragmoun, et al., 2023). Collaborative teaching, especially when utilizing AI, encourages active engagement among educators worldwide, highlighting the importance of fostering critical thinking and problem-solving skills among students. (Winans, 2020). By working together in groups, educators can engage in discussions, share ideas, and provide feedback to one another, fostering a deeper

understanding of pedagogical concepts using technology (Symonenko, 2020) and the current study supports this by connecting people through the Education 4.0 applications for teaching PEC. Furthermore, Education 4.0 provides access to a wide range of resources and materials that support pedagogical knowledge development for teaching PEC. Online repositories, interactive modules, and multimedia content offer educators diverse and engaging learning materials for language teaching (Goldin et al., 2022). These resources can expose students to various pedagogical approaches, teaching strategies, and effective communication techniques.

The findings of present study align with previous research that supports the effectiveness of Education 4.0 in promoting technological knowledge acquisition for teaching PEC (Fleaca & Stanciu, 2019; Allam, 2016). In line with the previous finding the current study shows that the integration of digital technologies in Education 4.0 opens up new avenues for personalized teaching and learning experiences. By leveraging tools such as VR simulations, AR applications, and adaptive learning platforms, educators can tailor their teaching methods to meet the diverse needs and learning styles of students. The previous study shows that teachers who have access to multimedia content, simulations, virtual laboratories, and interactive exercises can provide them with a deeper understanding of technical concepts (Eshet-Alkalai, 2004). Moreover, the current study aligns with it by pointing out, that Education 4.0 offers flexibility and accessibility in accessing technological knowledge resources. Teachers can access a wide range of online materials, videos, and tutorials at their convenience, enabling them to review and reinforce their understanding of technical concepts (Farias-Gaytan et al., 2022).

Hence, the current study demonstrates that integrating Education 4.0 for teaching PEC entails the interconnection of Content Knowledge, Pedagogical Knowledge, and Technological Knowledge, yielding positive outcomes for both educators and students. The novelty of the study lies in its unique approach to addressing teaching strategies among language educators using the TPACK framework for developing PEC skills using Education 4.0. By utilizing Education 4.0 principles and incorporating technology-based tools and applications, the study offers a contemporary and innovative method for teaching PEC and enhancing language proficiency among students. Additionally, the study explores the impact of digital literacy among language educators, collaboration with native speakers, and the integration of various language skills on overall language development. These aspects contribute to the novelty and originality of the research, providing valuable insights into effective teaching strategies for improving PEC among students in today's digital age. Furthermore, the study revealed that participants could experience distractions while using the Internet due to the overwhelming abundance of available information.

6. Conclusion

In conclusion, the study conducted to enhance teaching PEC skills using Education 4.0 through the TPACK framework yielded significant findings. The integration of Education 4.0 tools and resources within the TPACK framework showcased its effectiveness in improving language proficiency, fostering learner confidence, promoting collaboration, providing access to authentic resources, enabling flexibility, and developing technological competence. The results highlighted that the TPACK framework played a crucial role in ensuring the effective integration of technology into language instruction. It provided educators with a systematic approach to combining their pedagogical knowledge, content knowledge, and technological knowledge, resulting in a well-balanced and seamless integration of Education 4.0 tools. This integration facilitated not only personalized and self-paced learning experiences for learners but also for educators to explore language resources independently and develop their teaching strategies for PEC skills at their own pace.

In conclusion, the findings of this study provide substantial evidence that Education 4.0, implemented through the TPACK framework, holds great potential for enhancing PEC skills. The insights gained from this research contribute to the ongoing exploration of innovative approaches to language instruction and highlight the transformative impact of technology on language learning outcomes. Educators and stakeholders can utilize these findings to design effective language programs that leverage Education 4.0 tools, promote active engagement, and empower learners to succeed in professional communication contexts.

The study limitations should be considered. Firstly, the relatively small sample size may restrict the generalizability of the findings to a broader population and the study is limited only to Higher Education language educators. Additionally, the four-week duration of the study may not allow for a thorough examination of the long-term effects of the intervention. Furthermore, the study's focus on specific language learning such as PEC may overlook other potential factors that could influence the outcomes. To address these limitations, future research should involve larger and more diverse samples, longer intervention periods, and a broader range of variables to gain a more comprehensive understanding of the topic.

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Authors contributions

D. Sri Dhivya: Conceptualization, Methodology, Writing-Original draft, performed the statistical analysis and interpreted the findings.

K. Gurusamy: Supervision, Writing-reviewing & editing.

E. Balamurali: Visualization, Investigation.

A. Pradheepa: Coordinated data collection and analysis.

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No additional data are available.

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