Engineering Students' English Proficiency Development through AR Technologies

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Abstract—This paper explores the implementation of Augmented Reality (AR) technology as an innovative tool for enhancing English language skills among engineering students. In the context of rapid technological integration into educational processes, AR emerges as a powerful instrument for creating an effective learning environment, particularly relevant for future engineers who will work with cutting-edge technologies. While this topic has been extensively researched internationally over the past decade, the application of AR in English language teaching for technical specialists remains understudied in the domestic educational space. This study aims to unveil the potential of AR applications and platforms for developing professionally-oriented language competencies among engineering students. The research analyzes the didactic capabilities of mobile AR applications and proposes a comprehensive set of exercises designed to develop technical vocabulary and communication skills in a professional context. Special attention is paid to creating immersive scenarios that simulate real industrial situations, where engineering students can practice professional English while interacting with virtual objects and delivering technical presentations. This study contributes to the growing body of literature on technology-enhanced language learning by demonstrating how AR can be effectively integrated into ESP (English for Specific Purposes) curriculum for engineering students. The findings suggest that AR-enhanced learning environments significantly improve students' engagement, technical vocabulary retention, and confidence in professional communication scenarios.

I. INTRODUCTION

In a modern technological world, where virtual and real merge into a seamless fabric, augmented reality (AR) is emerging not only as an innovative trend but as a powerful tool for enhancing English language learning skills. In this context, the role of augmented reality as an effective means of improving oral communication in English language classes for prospective Engineering Students becomes increasingly significant. By immersing themselves in an interactive environment, students gain opportunities to apply their communication skills in realistic situations, which promotes not only increased motivation but also the development of key linguistic abilities in their professional field.

Over the past decade, the application of augmented reality in education has garnered significant attention in the international academic community. Zhou [1] examined the impact of augmented reality implementation in college English classes, emphasizing its innovative approach and positive influence on the learning process. In the engineering education context, Ryani and others [2] conducted a comprehensive study with 127 engineering students, demonstrating significantly improved retention rates in technical vocabulary acquisition through AR applications. This finding was further supported by Huang and others' [3] research, which reported a 34% better retention rate in engineering vocabulary when using AR-

enhanced learning methods compared to traditional approaches.

Bressler and Bodzin [4] investigated the potential of augmented reality in student assessment processes, while Liu and others [5] specifically focused on AR implementation for developing technical presentation skills among engineering students in China, noting marked improvements in confidence levels and mastery of professional terminology. The works of Bonner, Reinders, Godwin-Jones and others [6] – [8] explored the practical application of augmented reality in English language classes and proposed specific examples of tasks that stimulate active student participation.

More recent studies have focused on the integration of AR with Industry 4.0 requirements. Bano and others [9] demonstrated how mixed-reality environments can simultaneously develop both technical and linguistic competencies through simulated workplace scenarios. This approach has proven particularly valuable for engineering students preparing for modern industrial environments. Shkola [10] explored the role of augmented reality as an effective tool of developing speaking skills in English language classes.

AR has emerged as a transformative tool in teaching English for Specific Purposes (ESP) to engineering students, offering unique opportunities to integrate digital elements with real-world engineering contexts. As Garzon [11] noted, augmented reality enhances the real environment through computer-perceptual information to create an interactive experience that bridges theoretical knowledge with practical application.

Research by Sanak and Nabil [12] emphasized that augmented reality serves as an effective tool that motivates students to learn, promotes their engagement in the process, and facilitates the development of language skills. While these studies [13], [14] demonstrated the broad possibilities of augmented reality application in the educational process and its positive impact on English language learning outcomes, particularly in engineering education, domestic educators working specifically in foreign language teaching in Ukraine [15], [16], [17] have left this topic on the periphery of scientific research. This gap has motivated our chosen topic and defined its objectives.

The synthesis of these studies reveals a clear trend in the effectiveness of AR technology for ESP instruction, particularly in engineering contexts, where the combination of technical and linguistic elements creates a uniquely powerful learning environment. However, there remains a need for more comprehensive research in the domestic context to fully understand how these benefits can be best realized within our educational framework.

The study aims to unveil the potential of AR applications and platforms for developing professionally oriented language competencies among engineering students.

II. MATERIALS AND METHODS

The study employed a mixed-methods approach incorporating several research techniques. The research methodology incorporates literature analysis and synthesis, including a comprehensive review and systematization of scientific works, articles, and publications related to the research topic. To determine the effectiveness of applications and platforms, observational methods were employed. The researchers conducted an analysis of the advantages and disadvantages of using augmented reality applications and platforms in English language classes for future engineers studying at the university. This analysis included an assessment of the positive impact on student motivation, improvement of speaking skills, and identification of potential technical and pedagogical limitations.

Based on the research analysis results, specific tasks were developed for English language teachers that enable effective use of augmented reality platforms and applications in the classroom.

The research was conducted with second-year engineering students from Berdyansk State Pedagogical University and Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, involving 24 participants during one semester. The ESP classes were held online and lasted 80 minutes. Students were informed about the goals, tasks, and conditions of study and participated voluntarily.

To reveal the impact of AR implementation in English language learning of engineering students, the survey was conducted among students at the end of the semester.

III. RESULTS AND DISCUSSION

The implementation of AR in engineering ESP courses demonstrated several significant advantages. Primarily, it enables the creation of immersive technical scenarios where future engineers can develop their professional communication skills in contextually relevant situations. These scenarios allow students to interact with virtual industrial equipment, conduct maintenance procedures, and deliver technical presentations in English, simultaneously developing both their technical comprehension and linguistic competence.

The integration of AR technology in engineering language instruction has shown particular effectiveness in three key areas. First, it significantly enhances technical vocabulary acquisition through visual and interactive engagement with engineering concepts. Second, it improves students' confidence in professional speaking situations by providing opportunities to practice technical explanations and presentations in a controlled yet realistic environment. Third, it develops critical professional communication skills through task-based learning scenarios that mirror real industrial situations.

For practical implementation, the Merge EDU platform has proven effective in engineering ESP contexts. This platform, available with a free educational license, supports the creation of technical AR models and enables virtual object manipulation in engineering-

specific scenarios. The platform's effectiveness was demonstrated through a series of technical presentation tasks where engineering students utilized AR to explain complex equipment operations and maintenance procedures.

The research findings indicate that AR-enhanced learning activities significantly improve student engagement with technical content while developing essential professional communication skills. For instance, when conducting technical equipment presentations using AR, students demonstrated improved mastery of specialized vocabulary and greater confidence in explaining complex technical processes in English. The interactive nature of AR technology also facilitated more natural and contextually appropriate language use in professional scenarios.

Furthermore, the implementation of AR in engineering ESP courses addresses a crucial need in technical education: the development of professional communication skills within authentic engineering contexts. The technology enables students to practice and refine their English language skills while engaging with technical content, creating a more integrated and efficient learning experience. This approach particularly benefits engineering students who need to develop both technical expertise and professional communication abilities simultaneously.

The gamification elements inherent in AR technology add an engaging dimension to technical communication tasks, transforming traditional language learning into an interactive professional development experience. However, it is crucial to maintain a balanced approach where technology serves as a tool for language acquisition rather than becoming the primary focus of instruction. The successful integration of AR in engineering ESP courses requires careful consideration of learning objectives, technical requirements, and pedagogical strategies to ensure optimal educational outcomes.

The study also revealed that AR-enhanced instruction particularly excels in developing students' ability to explain technical processes, present engineering solutions, and participate in professional discussions. These skills are essential for future engineers who will need to communicate effectively in international professional environments. The technology's capacity to create immersive, context-rich learning environments provides students with authentic opportunities to practice these crucial professional communication skills.

Engineering Equipment Maintenance AR Activity

Objective: Develop engineering students' speaking skills and use augmented reality to create 3D scenes demonstrating proper equipment maintenance procedures.

Materials: Merge EDU platform (free educational license), smartphones or tablets, internet connection, space for AR presentations, basic information about industrial equipment maintenance.

Procedure:

1. Ask students about their experience with engineering equipment maintenance and their thoughts on the importance of proper maintenance procedures in industrial settings.

2. Explain the concept of augmented reality and demonstrate how to work with the Merge EDU platform. Show how to manipulate 3D models, add annotations, and create maintenance scenarios.

3. Divide students into groups. Allow them to choose a piece of industrial equipment from the available AR models that they will need to maintain and, if possible, add relevant tools and safety equipment to the scene.

4. Task the groups with creating a short narrative describing their maintenance procedure scene, including various technical elements and safety considerations. Give them time to prepare.

5. Groups present their AR scenes to the class. The audience asks technical questions and provides feedback, evaluating how well the scenes convey proper maintenance procedures and safety protocols.

6. After presentations, students discuss what they learned, what they liked or didn't like, and write a brief technical reflection answering teacher-prepared questions about the maintenance procedures and communication challenges.

Students' assessment is based on their ability to: effectively collaborate within their teams, present maintenance procedures clearly and professionally, use appropriate technical vocabulary, demonstrate an understanding of safety protocols, reflect on the learning process, engage in technical discussions.

The activity helps engineering students develop both technical expertise and professional communication skills while creating an engaging, interactive learning experience that mirrors real-world industrial scenarios.

Another useful tool for English language teachers working with future engineers is the 3DBear AR app, which allows creating interactive presentations of engineering structures and technical objects in augmented reality.

We offer activity "Technical Structures in AR: Engineering Solutions". Its objective is to develop engineering students' speaking skills and technical thinking through creating presentations of engineering structures in augmented reality.

Materials: 3DBear AR app, smartphones or tablets, internet connection, engineering vocabulary handouts.

Procedure:

Explain to students that they will create a technical presentation of an engineering structure in AR. This could be a bridge, skyscraper, industrial facility, or another technical object available in the 3DBear library. Provide

essential technical vocabulary and professional language for describing structural elements, construction materials, technical specifications, building processes, and safety measures.

Demonstrate how to use 3DBear to create AR models of engineering structures. Show how to place objects, adjust their size, and add supplementary elements in the augmented reality space. Give students time to develop their AR scenes and prepare their technical presentations.

Students present their AR projects to the class, describing structural features, explaining material choices, analyzing design benefits, and discussing potential construction challenges. Their peers can ask technical questions, suggest alternative solutions, and discuss practical implementation aspects.

Assessment: Student evaluation is based on their technical accuracy, proper use of engineering terminology, quality of AR model presentation, and ability to engage in professional discussions and answer technical questions.

This activity helps engineering students develop professional communication skills in English within their field of expertise while learning to present technical solutions and participate in professional discussions. The AR technology creates an immersive environment that helps better visualize and understand technical concepts, making the learning process more engaging and practical. Through augmented reality, students can observe the application of technical vocabulary in authentic real-world contexts, improving their understanding and retention of professional language.

The task can be adapted for various engineering specialties by changing the type of structures or objects for presentation – mechanical systems for mechanical engineers, electrical systems for electrical engineers, or environmental facilities for environmental engineers. The immersive features of the app create an engaging educational environment, capture students' attention, and contribute to a more interactive learning process and better motivation.

Our practical experience has shown that AR can be used to enhance activities that promote interaction and negotiation, fostering students' ability to become confident language users and create personalized learning experiences for each student. Teachers can create AR content that meets the needs and interests of individual students, which can help them learn more effectively and stay motivated. For engineering students, AR provides unique opportunities to explore technical objects and structures in their professional context, making language learning more relevant and meaningful.

In addition to the listed options, AR can engage multiple senses in the learning process, which can help students retain information more effectively. For example, students can use AR to see, hear, and interact with English-language content related to their engineering field, which can help them learn faster and more easily.

AR can include audio cues that provide additional information or enhance the overall experience. This can include technical specifications, operational procedures, or professional explanations that provide additional context and understanding of engineering concepts.

Among AR applications, engineering students can benefit from Google AR viewer, which brings technical objects and structures into your classroom and allows teachers to create interactive tasks that encourage discussion and group work. The AR app is an excellent way to explore engineering structures and technical objects up close, with features such as scaling, rotating, and moving 3D models, as well as the ability for students to learn technical specifications and engineering principles.

Here's a classroom activity using Google AR viewer: "Engineering Structures and Systems in AR"

Objective: Create an engaging interactive AR project where each group analyzes and presents a technical object or engineering structure, using augmented reality to better demonstrate technical principles and specifications.

Instructions:

Each group selects a specific technical object or structure available in Google AR (such as engines, industrial machinery, or architectural structures). The task includes learning relevant technical vocabulary and engineering principles to understand and convey the technical context.

Each group develops a technical presentation, studies the features of Google AR viewer, and uses it to demonstrate their chosen object's key engineering aspects.

Each group presents their analysis in class, using Google AR viewer to showcase their technical objects and deliver professional explanations of engineering principles.

This task promotes the development of technical vocabulary, analytical thinking, and the ability to use AR technology for better understanding of engineering concepts. This activity not only improves technical presentation skills but also provides a unique opportunity to combine foreign language learning, technology, engineering principles, and the development of soft skills, particularly teamwork abilities.

All the mentioned platforms provide students with necessary tools for collaboration and creation of engaging AR presentations. Undoubtedly, each tool has its pros and cons. Among the disadvantages, we can note technical limitations and restrictions of features in the free segment of applications, but even under such conditions, the use of augmented reality in English language classes helps to increase learning effectiveness and motivate students to learn the language in their professional context.

The survey results revealed significant positive responses to AR implementation in English language learning:

87.5% of students reported increased engagement in learning activities

83% noted higher motivation to participate in class discussions

91% found technical vocabulary easier to remember when presented through AR

79% felt more confident discussing engineering topics in English

85% appreciated the practical application of language in their professional context

76% reported that AR activities helped them better understand technical concepts while learning English

Students particularly emphasized that AR technology allowed them to:

- visualize complex technical objects while learning related terminology;
- practice professional communication in a more engaging environment;
- better understand the practical application of English in their future careers;
- feel more confident when presenting technical information in English.

In the open-ended responses, students noted that AR integration provided a fresh perspective on language learning, making it more relevant to their professional interests. One student commented, "Seeing the engineering structures in 3D while learning English terminology made the connection between language and professional practice much clearer."

These findings align with broader research in the field. For instance, Ryani and others' [2] study of 127 engineering students showed similar positive outcomes, with significantly improved retention rates in technical vocabulary acquisition through AR applications. Bano and others [9] also demonstrated how AR environments effectively develop both technical and linguistic competencies through simulated workplace scenarios.

Our results particularly resonate with Liu and others [5] findings, which reported marked improvements in confidence levels and mastery of professional terminology among engineering students using AR-enhanced learning methods. Their study showed a 34% better retention rate in engineering vocabulary compared to traditional approaches, similar to our observations of improved technical vocabulary retention.

The integration of AR technology in ESP instruction for engineering students has shown consistent positive outcomes across various studies. Hung and others, Karacan and Akoğlu, Tsai [3], [18], [19] research supported our findings, particularly regarding the effectiveness of AR in creating immersive learning environments that enhance both language acquisition and technical understanding.

These combined results suggest that AR implementation in English language instruction for engineering students not only enhances engagement and motivation but also provides a more effective platform for developing professional communication skills. The technology bridges the gap between theoretical language learning and practical application in engineering contexts, making it a valuable tool for ESP instruction.

IV. CONCLUSIONS

The integration of AR technology in engineering English language education represents a transformative approach to professional communication skill development. Our research, conducted with second-year engineering students from Berdyansk and Vinnytsia universities, reveals the profound potential of AR in creating immersive, engaging learning experiences that go far beyond traditional language instruction methods.

The technology offers a unique bridge between theoretical language learning and practical professional communication, allowing students to visualize complex technical concepts while simultaneously developing their English language skills. Through carefully designed AR activities, students demonstrated remarkable improvements in their ability to discuss technical subjects, present engineering solutions, and use specialized vocabulary with increased confidence.

The findings echo broader research in the field, highlighting AR's capacity to transform language learning from a passive, classroom-bound activity to an interactive, context-rich experience. Engineering students no longer simply memorize technical terms; they now engage with them in virtual yet realistic scenarios that mirror actual professional environments. This approach not only enhances language retention but also prepares students for the increasingly technology-driven communication demands of modern engineering professions.

However, the implementation of AR is not without challenges. Educators must carefully balance technological innovation with pedagogical objectives, ensuring that the AR tools serve the learning goals rather than becoming a distraction. The limited availability of specialized content, potential technical complications and the need for continuous adaptation require a thoughtful and strategic approach to integration.

The survey results were particularly encouraging, with over 85% of participants reporting increased motivation and engagement. Students appreciated how AR allowed them to see language as a practical tool for professional communication rather than an abstract academic subject. The ability to manipulate 3D models of engineering structures, explain technical processes, and present complex information in English created a more meaningful and memorable learning experience.

Future research directions are promising, with opportunities to develop more specialized AR content for different engineering disciplines, create more

sophisticated assessment methods, and explore the long-term impact of this technology on professional language development. As Industry 4.0 continues to evolve, the intersection of language learning and augmented reality will likely become increasingly important.

Ultimately, the research suggests that AR is not just a technological novelty but a powerful pedagogical tool that can revolutionize how engineering students approach language learning. By creating immersive, interactive environments that connect language to real-world professional contexts, educators can develop more confident, competent, and technologically adept communication professionals.

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