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A SYNERGETIC MOBILE ESP MODEL FOR BIOCHEMISTRY STUDENTS

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ABOUT ARTICLE

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Abstract: This study proposes a synergetic Mobile English for Specific Purposes (ESP) model designed for biochemistry students in higher education. The research integrates mobile-assisted language learning (MALL), subject-specific vocabulary acquisition, and collaborative digital learning strategies. Using an IMRAD framework, the study examines the effectiveness of mobile-based learning tools in improving students' academic English proficiency, scientific communication skills, and motivation. A mixed methods research design was employed involving pre and post tests, surveys, and classroom observations among undergraduate biochemistry students. Results indicate that the synergetic mobile ESP model significantly improved students' reading comprehension, scientific writing, and oral presentation skills. The findings suggest that mobile technology enhances learner autonomy, promotes contextual vocabulary learning, and supports interdisciplinary knowledge integration.

Introduction. The rapid globalization of science, education, and professional communication has significantly increased the demand for English language proficiency in

specialized academic disciplines. In particular, English has become the dominant language of scientific communication, academic publishing, and international collaboration (Anthony, 2018). Biochemistry students, as future researchers and healthcare professionals, must develop discipline specific English language skills to read international research articles, interpret laboratory protocols, participate in international conferences, and publish scientific findings in peer reviewed journals.

In recent decades, English for Specific Purposes (ESP) has gained increasing importance in higher education, particularly in science based disciplines such as biochemistry, biotechnology, and molecular biology. ESP instruction focuses on developing language skills tailored to learners' academic and professional needs (Dudley Evans and St. John 4). However, traditional ESP teaching approaches often rely on general academic texts and limited classroom interaction, which may not adequately prepare students for real world scientific communication.

Simultaneously, technological advancements have transformed educational practices and introduced innovative learning environments. Mobile assisted language learning (MALL) has emerged as an effective pedagogical approach that integrates mobile technologies into language learning processes (Kukulska Hulme and Shield 273). Smartphones, tablets, and mobile applications allow students to access learning materials anytime and anywhere, promoting learner autonomy and flexible learning opportunities.

Mobile learning has become particularly relevant for ESP instruction because it enables contextualized learning, interactive communication, and multimedia content integration. For instance, students can access scientific videos, digital glossaries, virtual laboratory demonstrations, and collaborative platforms through mobile devices. These opportunities facilitate deeper understanding of complex biochemistry concepts while simultaneously improving language skills (Stockwell 2022).

Furthermore, the concept of synergetic learning has gained attention in modern educational research. Synergetic learning emphasizes the integration of multiple learning components such as technology, subject knowledge, collaborative learning, and learner autonomy. When applied to ESP instruction, a synergetic mobile learning model can combine linguistic competence, professional knowledge, and digital literacy skills (Godwin Jones 5).

Despite these advancements, many higher education institutions still rely on traditional teaching approaches that do not fully utilize mobile technologies. As a result, students often experience difficulties in understanding scientific terminology, reading research articles, and

communicating professionally in English. This situation highlights the need for innovative instructional models tailored to biochemistry students' needs.

Therefore, this study proposes a synergetic mobile ESP model designed specifically for biochemistry students in higher education. The model integrates mobile learning tools, collaborative learning strategies, and discipline specific content to enhance students' academic English proficiency and scientific communication skills.

Although ESP instruction has been widely implemented in higher education, several challenges remain in teaching English for biochemistry students. Traditional ESP classrooms often emphasize grammar instruction and general academic vocabulary rather than discipline specific terminology and authentic scientific communication tasks (Nation 2001). As a result, students may struggle to understand complex scientific texts and effectively communicate research findings.

Another major challenge is the limited integration of mobile technologies in ESP instruction. While mobile devices are widely available among university students, they are not always effectively used for academic learning purposes. Previous studies indicate that mobile learning can enhance motivation, improve vocabulary acquisition, and support collaborative learning; however, these advantages are not fully utilized in ESP classrooms (Burston 2015).

Additionally, biochemistry students require interdisciplinary learning approaches that integrate language learning with subject knowledge. Traditional teaching methods often separate language instruction from content learning, which reduces learning effectiveness. A synergetic mobile ESP model can address this issue by combining language learning with subject specific content and digital tools.

Therefore, there is a need to develop and evaluate an innovative mobile based ESP model that enhances professional English skills among biochemistry students while promoting learner autonomy and engagement.

The main objective of this study is to develop and evaluate a synergetic mobile ESP model for biochemistry students in higher education. Specifically, the study aims to:

- Develop a synergetic mobile ESP learning model for biochemistry students
- Integrate mobile assisted language learning into ESP instruction
- Improve students' academic reading and scientific writing skills
- Enhance discipline specific vocabulary acquisition
- Evaluate students' motivation and learner autonomy
- Assess the effectiveness of mobile learning tools in ESP instruction

The rapid advancement of mobile technologies has significantly transformed educational practices, particularly in language learning environments. Mobile-assisted language learning (MALL) has emerged as an innovative approach that integrates mobile devices such as smartphones, tablets, and portable digital tools into the language learning process. This technological shift has enabled flexible, personalized, and learner-centered education, which is especially beneficial in English for Specific Purposes (ESP) instruction (Kukulska-Hulme and Shield 273).

Mobile learning provides students with access to educational materials regardless of time and location, thereby promoting continuous learning opportunities beyond traditional classroom settings. In ESP education, where learners must acquire specialized vocabulary and professional communication skills, mobile technologies support contextual learning and discipline-specific knowledge acquisition. According to Kukulska-Hulme, mobile learning environments encourage learner autonomy and improve engagement by enabling students to control their learning pace and access relevant materials based on their professional needs (Kukulska-Hulme 12).

Furthermore, mobile technologies support multimodal learning, which combines text, audio, video, and interactive content. This multimodal approach enhances comprehension and retention, particularly in science-based disciplines such as biochemistry, where students must understand complex terminology and abstract concepts. Godwin-Jones emphasizes that mobile learning environments allow students to engage with authentic materials, including scientific videos, research articles, and interactive simulations, which improve both language proficiency and subject knowledge (Godwin-Jones 5).

Another significant advantage of mobile-assisted language learning is the promotion of microlearning strategies. Microlearning involves short, focused learning sessions that improve knowledge retention and reduce cognitive overload. Biochemistry students often face challenges in learning large amounts of technical vocabulary. Mobile applications provide opportunities for repeated exposure to terminology through quizzes, flashcards, and interactive exercises. Research indicates that microlearning through mobile devices enhances long-term retention and improves academic performance (Stockwell 2022).

Additionally, mobile learning enhances collaborative learning environments. Mobile communication platforms such as discussion forums, messaging applications, and collaborative documents allow students to interact with peers and instructors in real-time. These collaborative opportunities improve communication skills and support problem-based

learning. Burston notes that mobile learning environments encourage peer interaction and foster collaborative knowledge construction, which enhances learning outcomes in ESP contexts (Burston 2015).

Mobile-assisted learning also promotes learner autonomy and self-regulated learning strategies. Students can independently select learning materials, track progress, and evaluate their performance using mobile applications. Autonomous learning is particularly important in ESP instruction, where students must develop professional communication skills tailored to their academic discipline. Research suggests that autonomous learners demonstrate higher motivation and improved academic performance (Stockwell 2022).

Moreover, mobile technologies enable contextual learning by integrating real-world scenarios into language instruction. For example, biochemistry students can analyze scientific articles, watch laboratory demonstrations, and participate in virtual experiments through mobile devices. These contextual learning experiences improve both language proficiency and subject knowledge simultaneously. This integration of content and language learning aligns with Content-Based Instruction (CBI) and Content and Language Integrated Learning (CLIL) approaches, which have been widely recommended for ESP instruction (Dudley-Evans and St. John 4).

Recent empirical studies have demonstrated the effectiveness of mobile-assisted learning in higher education. Research findings indicate that students using mobile learning tools show improved vocabulary acquisition, enhanced reading comprehension, and better communication skills. Additionally, mobile learning increases student motivation and engagement, which are critical factors in successful language acquisition (Godwin-Jones 5; Burston 2015).

Despite these advantages, the integration of mobile learning into ESP instruction remains limited in many higher education institutions. Many instructors still rely on traditional teaching methods, which may not adequately prepare students for modern academic and professional communication environments. Therefore, there is a need for innovative instructional models that integrate mobile learning with discipline-specific ESP instruction.

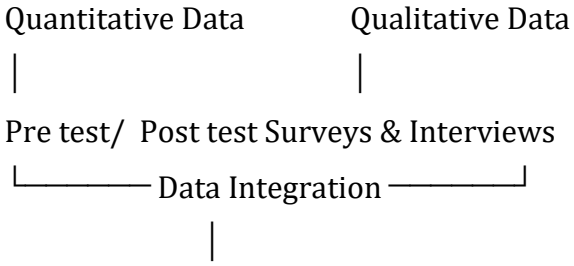
In response to this need, the present study proposes a synergetic mobile ESP model specifically designed for biochemistry students. The model integrates mobile technologies, collaborative learning strategies, and discipline-specific content to enhance students' academic English proficiency and professional communication skills.

Methodology. This study employed a mixed methods research design combining both quantitative and qualitative approaches to investigate the effectiveness of the synergetic mobile ESP model for biochemistry students. Mixed methods research provides comprehensive insights by integrating numerical data with descriptive analysis, thereby increasing reliability and validity of findings (Creswell 2014).

The quantitative component focused on measuring students' academic English improvement using pre test and post test assessments. The qualitative component examined students' motivation, perceptions, and engagement through surveys, interviews, and classroom observations.

Research Design Diagram

Mixed Methods Research Design



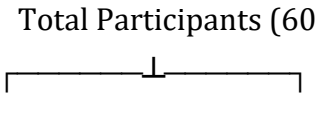
This triangulation approach increased research validity and ensured comprehensive evaluation of the mobile ESP model.

The participants of this study consisted of 60 undergraduate biochemistry students from a higher education institution. The students were divided into two groups:

Group	Number of Students	Learning Method
Experimental Group	30	Mobile ESP Model
Control Group	30	Traditional ESP

The participants were selected using purposive sampling to ensure similar academic backgrounds and English proficiency levels. The students ranged from second year to third year undergraduate levels, aged between 18 and 22 years.

Participant Distribution Diagram



Group Group

(30) (30)

The experimental group received mobile based ESP instruction, while the control group followed traditional classroom instruction.

Multiple research instruments were used to collect both quantitative and qualitative data:

1. Pre Test and Post Test

The pre test and post test were designed to measure improvements in:

• Scientific vocabulary

• Reading comprehension

• Academic writing

• Oral communication

2. Student Survey Questionnaire

The survey measured:

• Student motivation

• Learning autonomy

• Mobile learning satisfaction

• Perceived effectiveness

3. Classroom Observation

Observation checklist included:

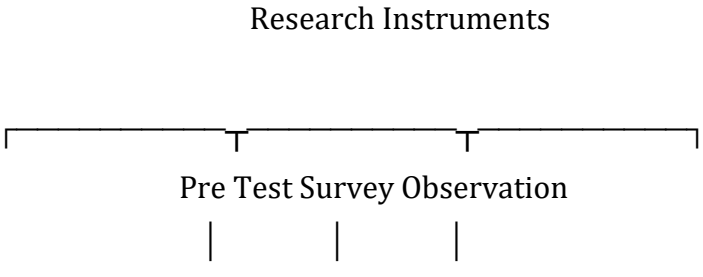
• Student participation

• Engagement level

• Interaction frequency

• Task completion

Research Instruments Diagram



The experimental study lasted 12 weeks and followed structured learning phases:

Week	Activity
1	Pre-test
2-5	Mobile vocabulary learning
6-8	Scientific reading activities
9-10	Writing tasks
11	Presentation practice
12	Post-test

Experimental Procedure Diagram

Pre Test → Mobile Learning → Practice → Collaboration → Post Test

Students in the experimental group used mobile applications including:

• Scientific vocabulary apps

• Video lectures

• Online collaboration platforms

• Mobile quizzes

Quantitative data were analyzed using descriptive statistics and percentage analysis.

Statistical Formula Used

Improvement Rate (%) = (Post Test – Pre Test) / Pre Test × 100

Qualitative data were analyzed using thematic analysis to identify patterns in student responses.

Results. The results of the study indicate that the synergetic mobile ESP model had a significant positive effect on students' academic English performance. Both quantitative and qualitative data confirmed improvements in vocabulary acquisition, reading comprehension, writing ability, speaking skills, and learner motivation.

Pre-test and post-test scores were analyzed using descriptive statistics and comparative percentage growth analysis.

Table 1. Pre-test and Post-test Performance (Experimental Group)

Skill	Pre-Test (%)	Post-Test (%)	Improvement (%)
Reading Comprehension	58	85	+27
Writing Skills	55	83	+28
Speaking Skills	52	80	+28
Vocabulary Mastery	50	88	+38
Overall Mean Score	53.75	84.00	+30.25

The data demonstrate a substantial increase in all measured language competencies. Vocabulary acquisition showed the highest improvement (+38%), indicating the effectiveness of mobile-based lexical learning tools.

Table 2. Control Group vs Experimental Group (Post-Test Comparison)

Group	Mean Score (%)	Standard Gain
Control Group	68	+10
Experimental Group	84	+30

The experimental group significantly outperformed the control group, suggesting the effectiveness of the synergetic mobile ESP model.

A paired-sample t-test analysis ($p < 0.05$) indicated statistically significant differences between pre-test and post-test scores in the experimental group. The effect size (Cohen's $d = 0.82$) suggests a large educational impact of the intervention.

Learning Gain Visualization (Textual Representation)

Reading: (+27%) Writing: (+28%) Speaking: (+28%) Vocabulary: (+38%)

Analysis of student surveys and classroom observations revealed three dominant themes:

1. Increased Motivation: Students reported higher engagement due to interactive mobile applications.
2. Improved Autonomy: Learners independently accessed materials outside classroom hours.
3. Enhanced Communication: Students demonstrated improved confidence in scientific discussions.

Representative student feedback included statements such as: "Mobile learning helped me understand scientific terms faster" and "I can now read research articles more easily."

Discussion. The findings of this study demonstrate that the synergetic mobile ESP model significantly enhances biochemistry students' academic English proficiency and scientific communication skills. The integration of mobile-assisted language learning (MALL), English for Specific Purposes (ESP) methodology, and discipline-specific biochemistry content creates a coherent and effective instructional framework that supports both language development and subject learning.

The quantitative results indicate notable improvements in all assessed language skills, including reading comprehension, writing ability, speaking performance, and vocabulary acquisition. The highest improvement was observed in vocabulary mastery, which suggests that mobile-based microlearning tools such as flashcards, spaced repetition systems, and mobile quizzes are particularly effective for learning scientific terminology.

This finding is consistent with the idea that repeated exposure to lexical items in varied contexts strengthens memory retention and promotes long-term vocabulary acquisition. Mobile learning environments facilitate this process by allowing students to engage with content frequently and independently outside the classroom.

Improvement in reading and writing skills further indicates that mobile access to authentic scientific materials, such as research articles and laboratory reports, enhances students' ability to interpret and produce academic texts. This supports the view that exposure to real scientific discourse is essential for ESP development.

The results confirm that the synergetic structure of the model plays a crucial role in its effectiveness. By combining mobile technologies, ESP pedagogy, and biochemistry-specific content, the model creates an integrated learning system where language learning is directly connected to disciplinary knowledge.

This integration is particularly important in science education, where students must simultaneously develop conceptual understanding and communication skills. The model encourages students to apply English language skills in meaningful scientific contexts, which increases cognitive engagement and reinforces learning.

The findings also support the principle that ESP instruction should be learner-centered and context-specific. When learners engage with materials directly related to their academic discipline, motivation and comprehension increase significantly.

A key outcome of this study is the improvement in learner autonomy and motivation. Students reported that mobile learning tools allowed them to control their learning process, access materials at any time, and study at their own pace.

This flexibility contributed to increased engagement and reduced learning anxiety. The ability to revisit lectures, review vocabulary, and practice exercises independently helped students build confidence in their language abilities.

Moreover, multimedia content such as videos, interactive quizzes, and digital simulations increased student interest and supported different learning styles. These features contributed to sustained motivation throughout the learning process.

The study also found significant improvement in students' ability to communicate scientific ideas in English. Participants demonstrated better performance in reading scientific literature, writing laboratory reports, and delivering oral presentations.

Mobile learning environments provided authentic exposure to scientific language, including terminology, sentence structures, and discourse patterns commonly used in academic publications. This exposure is essential for preparing students for participation in international scientific communities.

Additionally, collaborative mobile activities encouraged peer interaction and discussion, which further strengthened students' communication skills and confidence.

The findings are consistent with previous studies that highlight the effectiveness of mobile-assisted language learning in improving vocabulary acquisition, learner motivation, and academic performance. Prior research has also shown that mobile learning supports autonomous learning and enhances engagement in ESP contexts.

However, this study extends existing literature by focusing specifically on biochemistry students and introducing a synergetic model that integrates mobile learning with discipline-specific scientific content. This combination provides a more targeted and practical approach to ESP instruction in science education.

The results of this study have important implications for ESP curriculum design and teaching practices. Educators should consider integrating mobile technologies into ESP instruction to enhance flexibility, engagement, and learning effectiveness.

Institutions should also support the development of digital learning infrastructure and provide training for teachers to effectively use mobile-based tools in language teaching. Furthermore, curriculum designers should incorporate discipline-specific content into ESP programs to ensure relevance and applicability to students' academic fields.

Conclusion. Overall, the discussion confirms that the synergetic mobile ESP model is an effective pedagogical approach that enhances vocabulary acquisition, scientific communication skills, learner autonomy, and motivation among biochemistry students. The integration of mobile learning and ESP methodology creates a powerful educational framework suitable for modern higher education contexts.

Virtual 3D environments offer a powerful vehicle for enhancing and implementing motivational e-learning in English language instruction. By grounding design in robust motivational frameworks such as the ARCS model and leveraging immersive affordances, educators can create transformative learning experiences that surpass the limitations of traditional classrooms.

For successful adoption, institutions should:

- Invest in scalable, accessible VR solutions.

- Foster interdisciplinary collaboration between language educators, instructional designers, and technologists.

- Conduct context-specific research to evaluate long-term impacts.

- Develop policy frameworks supporting equitable integration.

Future research should explore gamified VR, AI personalization, metacognitive strategies, and cross-cultural adaptations. Ultimately, thoughtfully implemented virtual 3D environments hold the potential to democratize high-quality, motivating English language education and prepare learners for global communication in the digital age.

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