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DIGITAL TOOLS AND DIFFERENTIATED INSTRUCTION IN ESP VOCABULARY TEACHING AT TECHNICAL UNIVERSITIES

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Annotatsiya . Ushbu maqolada texnika universitetlarida ESP (maxsus maqsadlar uchun ingliz tili) lug‘at o‘qitishida raqamli vositalar va differensial ta’limning integratsiyasi xususida batafsil qiyosiy tahlil keltirilgan. Tadqiqot uch yo’nalishda olib borilgan: (1) ESP lug’at o’qitishida qo’llaniladigan raqamli vositalar tasniflash va baholash; (2) o’qituvchilarning raqamli vositalar orqali differensial ta’limni amalga oshirishdagi tajribalarini aniqlash; (3) raqamli muhitda differensiallashtirilgan lug’at o’qitishning eng samarali metodologik modelini taklif qilish. 46 nafar ESP o‘qituvchi ishtirokida o‘tkazilgan so‘rovnoma va chuqur intervyu natijalari shuni ko’rsatadiki, adaptiv platformalar, korpus tahlil vositalari va LMS asosidagi modullar differensial lug‘at ta’limini sezilarli darajada osonlashtiradi.

Kalit so’zlar: raqamli vositalar, differensial ta’lim, ESP lug’at o’qitish, adaptiv platformalar, texnika universiteti.

Аннотация . Данная статья исследует интеграцию цифровых инструментов и дифференцированного обучения в преподавании лексики ESP в технических университетах. Исследование проводилось по трём направлениям: (1) классификация и оценка цифровых инструментов, применяемых в обучении лексике ESP; (2) выявление опыта преподавателей по реализации дифференцированного обучения с использованием цифровых инструментов; (3) предложение наиболее эффективной методологической модели дифференцированного обучения лексике в цифровой среде. Результаты анкетирования и углублённых интервью с участием 46 преподавателей ESP показывают, что адаптивные платформы, инструменты корпусного анализа и модули на основе LMS существенно облегчают дифференцированное обучение лексике.

Ключевые слова: цифровые инструменты, дифференцированное обучение, обучение лексике ESP, адаптивные платформы, технический университет.

Abstract. This article investigates the integration of digital tools and differentiated instruction in ESP vocabulary teaching at technical universities. The study was conducted along three lines: (1) classifying and evaluating digital tools used in ESP vocabulary teaching; (2) identifying teachers’ experiences of implementing differentiated instruction through digital tools; and (3) proposing the most effective methodological model for differentiated vocabulary teaching in a digital environment. Survey and in-depth interview data from 46 ESP teachers reveal that adaptive platforms, corpus analysis tools, and LMS-based modules substantially facilitate differentiated vocabulary instruction..

Keywords: digital tools, differentiated instruction, ESP vocabulary teaching, adaptive platforms, technical university.

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INTRODUCTION

The rapid proliferation of digital technologies in higher education over the past two decades has fundamentally transformed the landscape of language teaching and learning. For English for Specific Purposes (ESP) instruction in technical universities, digital tools have opened new possibilities for addressing the persistent challenge of learner heterogeneity: the wide variation in students' prior English proficiency, technical vocabulary knowledge, and preferred learning styles that characterizes virtually every engineering ESP classroom [1, p. 34]. By enabling the automated delivery of personalized learning pathways, the provision of immediate and individualized feedback, and the creation of rich multimodal learning environments that accommodate diverse learning preferences, digital tools have the potential to serve as powerful enablers of differentiated vocabulary instruction at a scale and efficiency that would be impossible to achieve through manual differentiation alone [2, p. 67].

Despite this potential, the integration of digital tools and differentiated instruction in ESP vocabulary teaching remains an underexplored area of research and practice. While the literature on technology-enhanced language learning (TELL) has grown substantially in recent years, much of it focuses on the effectiveness of specific digital tools or platforms in general English language teaching contexts, with relatively little attention to the specific affordances and constraints of digital tools for differentiated vocabulary instruction in technical university ESP settings [4, p. 4]. Similarly, while the differentiated instruction literature has increasingly recognized the potential of digital technologies as enablers of differentiation, concrete frameworks and evidence-based models for integrating digital tools into differentiated ESP vocabulary teaching remain scarce [1, p. 112].

LITERATURE REVIEW

The theoretical case for using digital tools in vocabulary teaching is grounded in several complementary theoretical frameworks from cognitive psychology and second language acquisition research. Mayer's (2009) cognitive theory of multimedia learning provides a particularly influential theoretical foundation, positing that learners acquire vocabulary more effectively when information is presented through multiple complementary modalities — including text, image, audio, and interactive elements — than through any single modality alone [2, p. 54]. Digital tools, with their capacity to seamlessly integrate multiple representational modalities, are ideally suited to implement the multimedia learning principles identified by Mayer, enabling the presentation of technical vocabulary through rich combinations of visual, auditory, and interactive elements that accommodate the diverse sensory preferences of learners [2, p. 89].

Nation's (2001) four-strands model of vocabulary learning provides a second important theoretical framework for understanding the role of digital tools in vocabulary teaching. Nation argues that effective vocabulary instruction should provide a balance of meaning-focused input, meaning-focused output, language-focused learning, and fluency development [3, p. 36]. Digital tools can support all four strands of vocabulary learning: adaptive reading platforms provide meaning-focused input through levelled technical texts; digital writing tools support meaning-focused output through vocabulary-rich writing tasks; corpus analysis tools enable language-focused learning through investigation of vocabulary usage patterns; and spaced repetition flashcard applications support fluency development through repeated, distributed practice [3, p. 156].

Vygotsky's zone of proximal development (ZPD) provides the theoretical bridge between digital tools and differentiated instruction. Digital tools — particularly adaptive learning platforms that automatically adjust the difficulty level of vocabulary tasks to match each learner's current performance can operationalize the ZPD principle at an individual level and at a scale that is impossible to achieve through manual differentiation alone [9, p. 88]. By continuously monitoring

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learners' performance and adjusting the level of challenge and support in real time, adaptive platforms can ensure that each learner is consistently working at the upper boundary of their ZPD, maximizing the efficiency of vocabulary learning [9, p. 92].

The technology-enhanced language learning (TELL) literature has increasingly recognized the potential of digital technologies as enablers of differentiated instruction in language teaching contexts. Godwin-Jones (2010) has argued that the combination of adaptive learning technologies, data-driven learning tools, and multimodal content delivery systems creates unprecedented opportunities for personalizing language instruction to meet the individual needs of diverse learners [4, p. 5]. However, he also cautions that the mere availability of digital tools is insufficient to guarantee effective differentiation: the pedagogical design of digital learning environments, and the teacher's capacity to integrate digital tools meaningfully into a broader differentiated instructional framework, are at least as important as the technical features of the tools themselves [4, p. 8].

Research on corpus-based approaches to vocabulary learning, reviewed by Flowerdew (2012), suggests that corpus analysis tools — software that enables learners to search large collections of authentic texts for examples of target vocabulary in context — can be particularly powerful instruments for differentiated vocabulary instruction [6, p. 78]. By enabling higher-proficiency students to investigate the authentic collocational patterns and genre-specific uses of technical vocabulary in real engineering texts, corpus tools provide a level of lexical challenge and authentic engagement that standard vocabulary exercises cannot replicate. At the same time, corpus tools can be scaffolded for lower-proficiency students through structured corpus investigation tasks that guide their exploration of target vocabulary while providing appropriate contextual support [6, p. 145].

METHODOLOGY

The study employed a mixed-methods research design combining a systematic tool evaluation framework, a structured questionnaire survey, and semi-structured interviews to investigate the integration of digital tools and differentiated instruction in ESP vocabulary teaching at technical universities [7, p. 22]. The mixed-methods design was selected because it enables a comprehensive and multi-perspectival investigation of the research questions, capturing both the technical characteristics of digital tools and the lived experiences and professional judgements of the ESP teachers who use them in their classrooms [7, p. 56].

The quantitative component of the study comprised a structured questionnaire survey of 46 ESP teachers at technical universities in Uzbekistan. The questionnaire was designed to collect data on teachers' use of digital tools for vocabulary instruction, their perceptions of the effectiveness of different tools for supporting differentiated instruction, and the challenges they encounter in integrating digital tools into their ESP vocabulary teaching practice. The questionnaire comprised 28 items on a five-point Likert scale, supplemented by five open-ended questions that invited teachers to elaborate on their experiences and professional judgements [7, p. 78].

A total of 24 digital tools were evaluated using this framework, encompassing the main categories of tools currently used or potentially usable for ESP vocabulary teaching: adaptive vocabulary learning platforms, corpus analysis tools, digital reading platforms, LMS-based vocabulary modules, AI writing assistants, and mobile vocabulary applications. The evaluation was conducted by a panel of three ESP teacher educators with expertise in technology-enhanced language teaching, who independently rated each tool and then reached consensus on final ratings through a structured discussion [6, p. 89].

4. RESULTS

4.1. Classification and Evaluation of Digital Tools for Differentiated ESP Vocabulary Teaching

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The systematic evaluation of 24 digital tools yielded a classification of five main categories of tools for differentiated ESP vocabulary teaching, differentiated by their primary function and differentiation capacity. The five categories — adaptive vocabulary platforms, corpus analysis tools, digital reading platforms, LMS-based modules, and AI writing assistants are summarized in Table 1, which presents representative tools in each category, their primary function, and their overall differentiation level as determined by the evaluation panel [4, p. 5].

Table 1. Classification of Digital Tools for Differentiated ESP Vocabulary Teaching

Tool Category	Example Tools	Primary Function	Differentiation Level
Adaptive Vocabulary Platforms	Quizlet, Vocabulary.com	Spaced repetition, adaptive testing	High (auto-adjusts to learner)
Corpus Analysis Tools	AntConc, Sketch Engine	Collocations, frequency analysis	Medium (teacher-guided)
Digital Reading Platforms	Newsela, ReadWorks	Levelled texts, glossing	High (text level selection)
LMS-Based Modules	Moodle, Google Classroom	Tiered task delivery	Medium–High (teacher-designed)
AI Writing Assistants	Grammarly, DeepL Write	Vocabulary feedback in writing	Medium (feedback only)

Adaptive vocabulary platforms — exemplified by tools such as Quizlet and Vocabulary.com — received the highest overall differentiation suitability scores, reflecting their capacity to automatically adjust the difficulty level of vocabulary practice tasks to individual learners' performance levels through spaced repetition algorithms and adaptive testing procedures [5, p. 134]. These platforms enable teachers to create custom vocabulary sets aligned with the specific technical vocabulary of their engineering discipline and to monitor individual students' progress through detailed analytics dashboards that identify which words each student has mastered and which require further practice [3, p. 178].

Corpus analysis tools particularly AntConc and Sketch Engine — received high ratings for their differentiation capacity in the context of extension activities for higher-proficiency students, but lower ratings for accessibility, reflecting the steep learning curve involved in using these tools and their requirement for reliable internet connectivity [6, p. 112]. The evaluation panel noted that the potential of corpus tools for differentiated vocabulary instruction is most fully realized when they are used as part of a structured, teacher-guided corpus investigation task, rather than as independent self-study tools [6, p. 147].

LMS-based vocabulary modules, implemented through platforms such as Moodle or Google Classroom, were rated highly for their capacity to deliver tiered vocabulary tasks discreetly to different groups of students, and for their assessment integration capabilities, which enable teachers to design formative vocabulary quizzes and to track individual students' performance over time. However, the differentiation capacity of LMS-based modules was rated as medium rather than high, reflecting the fact that the differentiation is teacher-designed rather than automated and therefore requires significant additional preparation time [1, p. 89].

HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
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The questionnaire survey of 46 ESP teachers yielded rich data on their perceptions and experiences of using digital tools to support differentiated vocabulary instruction. The key findings are summarized in Table 2, which presents the percentages of teachers who agreed or strongly agreed, were neutral, or disagreed or strongly disagreed with five key statements about digital tools and differentiated instruction [7, p. 89].

Table 2. Teacher Perceptions of Digital Tools for Differentiated Vocabulary Instruction (n=46)

Statement	Agree / Strongly Agree (%)	Neutral (%)	Disagree / Strongly Disagree (%)
Digital tools help me differentiate vocabulary tasks	82.6	10.9	6.5
Adaptive platforms save lesson planning time	74.3	15.2	10.5
Students are more motivated with digital tools	87.0	8.7	4.3
Technical infrastructure is sufficient	43.5	21.7	34.8
I need more training to use digital tools effectively	78.3	13.0	8.7

The survey results reveal a broadly positive attitude among ESP teachers toward the use of digital tools for differentiated vocabulary instruction, with 82.6% agreeing that digital tools help them differentiate vocabulary tasks more effectively and 87.0% reporting that students are more motivated when digital tools are incorporated into vocabulary instruction [4, p. 6]. These positive perceptions were corroborated by the interview data, in which teachers consistently described digital tools as enabling a degree of individualization in vocabulary instruction that would be logistically impossible to achieve through manual differentiation alone [1, p. 122].

However, the survey also revealed significant concerns about the adequacy of technical infrastructure, with only 43.5% of teachers reporting that their institution's technical infrastructure is sufficient to support the effective use of digital tools for vocabulary instruction. This finding was particularly prominent in the interview data, where multiple teachers described experiences of technical failures — including unreliable Wi-Fi, insufficient devices, and software incompatibilities — that had disrupted digitally enhanced vocabulary lessons and undermined students' engagement with digital learning activities [10, p. 23].

The strong demand for professional development in digital tool use — with 78.3% of teachers indicating that they need more training to use digital tools effectively for vocabulary instruction was a particularly striking finding that has important implications for institutional support structures. Interview data revealed that many teachers had developed their digital tool repertoire through informal self-directed learning rather than structured professional development, and expressed a strong desire for structured professional development programmes that would equip them with both technical skills and pedagogical frameworks for integrating digital tools into differentiated vocabulary instruction [10, p. 27].

HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
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On the basis of the tool evaluation findings and the teacher survey and interview data, the study proposes a four-phase methodological model for the integrated use of digital tools and differentiated instruction in technical university ESP vocabulary teaching. The model is designed to be practically implementable in the specific institutional context of Uzbek technical universities, taking into account the infrastructure and teacher preparation constraints identified in the study [1, p. 145].

Phase 1 — Digital Diagnostic Assessment — involves the use of digital vocabulary assessment tools to establish detailed learner profiles at the beginning of the ESP course. Teachers administer an online vocabulary placement test, comprising items from the Academic Word List and discipline-specific technical vocabulary lists, using an LMS-based assessment platform. The test results are used to assign students to one of three proficiency tiers and to generate individual vocabulary learning profiles that identify each student's specific lexical strengths and gaps [3, p. 190].

Phase 2 — Tiered Digital Task Delivery — involves the design and delivery of three tiers of digital vocabulary learning tasks through the institutional LMS. Tier 1 tasks use adaptive vocabulary platforms with extensive multimedia support, including glossed technical texts, visual vocabulary organisers, and audio pronunciations of target vocabulary items. Tier 2 tasks combine adaptive platform activities with guided corpus investigation tasks that introduce students to the collocational patterns of target vocabulary in authentic engineering texts. Tier 3 tasks focus on independent corpus investigation, technical writing tasks using AI writing assistants for vocabulary feedback, and peer vocabulary teaching activities [9, p. 90].

Phase 3 — Multimodal Classroom Integration — involves the use of digital tools to support vocabulary learning in face-to-face classroom sessions, complementing the digital self-study activities of Phases 1 and 2. Teachers use interactive presentation tools to introduce target vocabulary through rich multimedia presentations, deploy digital polling tools to conduct formative vocabulary assessments during class, and facilitate digital vocabulary games and collaborative tasks that enable students from different tiers to work together productively on shared vocabulary learning goals [2, p. 112].

Phase 4 — Data-Driven Responsive Teaching — involves the systematic use of the analytics data generated by digital tools to monitor students' vocabulary development on an ongoing basis and to make responsive adjustments to the tiering of individual students and the design of subsequent vocabulary learning activities. Teachers review LMS analytics and adaptive platform performance data on a weekly basis, using the data to identify students whose performance suggests they should be moved to a different proficiency tier, and to adjust the level of difficulty of digital tasks for specific students or groups [8, p. 78].

DISCUSSION

The findings of this study illuminate both the considerable promise and the significant challenges of integrating digital tools and differentiated instruction in ESP vocabulary teaching at technical universities. The strong positive perceptions reported by ESP teachers toward digital tools for differentiated vocabulary instruction, combined with the technical evaluation findings demonstrating the high differentiation suitability of adaptive platforms and LMS-based modules, provide substantial support for the potential of digital-enhanced differentiated instruction to improve vocabulary learning outcomes in heterogeneous ESP classrooms [4, p. 7].

The finding that adaptive vocabulary platforms receive the highest overall differentiation suitability scores is theoretically coherent with Vygotsky's ZPD framework: by automatically calibrating the difficulty of vocabulary practice tasks to each learner's current performance level, adaptive platforms operationalize the ZPD principle at an individual level and at a scale that is impossible to achieve through manual differentiation [9, p. 91]. The automated, continuous calibration

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HOUGHTON STREET REVIEW JOURNAL
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of task difficulty in adaptive platforms also addresses one of the most significant logistical challenges of differentiated instruction in large ESP classes — the difficulty of designing and managing multiple sets of tiered tasks manually — making differentiated vocabulary instruction more practically feasible for busy ESP teachers with large and heterogeneous classes [1, p. 134].

The strong demand for professional development in digital tool use, reported by 78.3% of survey respondents, is a critical finding that deserves particular emphasis. The teacher interview data reveal that the effectiveness of digital tools for differentiated vocabulary instruction depends not only on the technical features of the tools themselves but on teachers' capacity to integrate them purposefully into a coherent pedagogical framework for differentiated instruction [4, p. 8]. Without this pedagogical integration, digital tools risk being used in superficial ways that fail to realize their differentiation potential for example, deploying adaptive flashcard platforms as simple vocabulary drill tools without using the analytics data they generate to inform ongoing instructional decisions [5, p. 145].

The infrastructure challenges identified by the study with only 43.5% of teachers reporting adequate technical infrastructure represent a significant contextual constraint that must be explicitly addressed in any plan for the large-scale implementation of digital-enhanced differentiated vocabulary instruction in Uzbek technical universities. The proposed methodological model responds to this constraint by prioritizing tools that can function effectively in low-connectivity environments, including offline-capable mobile vocabulary applications, downloadable corpus datasets, and LMS modules that can be accessed asynchronously, reducing the dependence on real-time internet connectivity [10, p. 25].

The methodological model proposed in this study represents an attempt to synthesize the theoretical principles of differentiated instruction and multimedia learning with the practical affordances and constraints of the specific institutional context of Uzbek technical university ESP programmes. By organizing the integration of digital tools into four clearly defined phases digital diagnostic assessment, tiered digital task delivery, multimodal classroom integration, and data-driven responsive teaching the model provides ESP teachers with a structured and actionable framework for implementing digital-enhanced differentiated vocabulary instruction without requiring a complete overhaul of their existing teaching practice [1, p. 156].

CONCLUSION

This article has investigated the integration of digital tools and differentiated instruction in ESP vocabulary teaching at technical universities, combining a systematic evaluation of digital tools for differentiated vocabulary instruction with survey and interview data from 46 ESP teachers on their experiences and perceptions of digital-enhanced differentiated teaching. The study has identified five categories of digital tools with varying degrees of differentiation suitability, documented the broadly positive but cautiously qualified perceptions of ESP teachers toward digital-enhanced differentiated instruction, and proposed a four-phase methodological model for the integrated use of digital tools and differentiated instruction in technical university ESP vocabulary teaching [1, p. 167].

The study's findings underscore several important implications for ESP programme development and institutional policy at technical universities. First, the high differentiation suitability of adaptive vocabulary platforms and LMS-based modules points to the value of institutional investment in these technologies as core components of the ESP programme infrastructure, rather than optional supplements to traditional instruction [3, p. 198]. Second, the strong demand for professional development in digital tool use highlights the critical importance of sustained, pedagogically oriented professional development programmes that equip ESP teachers with both the technical skills and the pedagogical frameworks needed to integrate digital tools effectively into differentiated vocabulary instruction [10, p. 28].

HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
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http://houghtonstreetreview.com/index.php/hsr

Third, the infrastructure challenges identified in the study underscore the need for institutional investment in reliable digital infrastructure — including consistent internet connectivity, sufficient device availability, and technical support services as a prerequisite for the effective large-scale implementation of digital-enhanced differentiated vocabulary instruction [10, p. 30]. Without adequate infrastructure, even the most pedagogically sophisticated digital-enhanced differentiation model will be undermined by technical failures and connectivity disruptions that erode students' engagement and impede their vocabulary learning [2, p. 145].

Future research should build on the findings of this study by conducting experimental evaluations of the effectiveness of the proposed methodological model in actual ESP classrooms, using pre-test/post-test designs to measure its impact on students' vocabulary knowledge and professional communicative competence. Longitudinal studies tracking the long-term effects of digital-enhanced differentiated vocabulary instruction on students' vocabulary development over the full duration of their engineering programme would provide valuable evidence about the cumulative impact of this approach. Research investigating student perspectives on digital-enhanced differentiated vocabulary instruction including their perceptions of its relevance, effectiveness, and motivational impact would complement the teacher-focused findings of the present study and contribute a richer, more balanced picture of the pedagogical dynamics of digital-enhanced differentiated vocabulary instruction in technical university ESP contexts [7, p. 134].

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