СУСПІЛЬСТВО ТА НАЦІОНАЛЬНІ ІНТЕРЕСИ 3(23) 2026
ISSN 3041-1572 Online

UDC 378.147:811.111:621.31

https://doi.org/10.52058/3041-1572-2026-3(23)-62-77

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FLIPPED CLASSROOM IN TECHNICAL ENGLISH FOR POWER ENGINEERING STUDENTS: BALANCING VIDEO-BASED BRIEFINGS AND IN-CLASS SPEAKING PRACTICE

Abstract. Ukraine's ongoing war of defence against russian armed aggression has fundamentally disrupted the rhythms of higher education while simultaneously intensifying the professional demands placed upon engineering graduates, making the methodological reform of Technical English instruction in Ukrainian technical universities a matter of both scholarly and national strategic importance. This article examines the pedagogical potential of the flipped classroom model as applied to Technical English courses for G3 power engineering students, proposing a principled framework for balancing asynchronous video-based briefings with structured in-class speaking practice in ways that are responsive to both the theoretical demands of English for Specific Purposes methodology and the concrete educational realities of wartime Ukraine. The study draws on a six-month pedagogical experiment conducted with 67 undergraduate students of the Faculty of Power Engineering and Electromechanics, divided into experimental and control groups and assessed across three measurement points on six communicative performance dimensions using an adapted CEFR-based oral evaluation rubric. The results demonstrate a substantial and consistent developmental advantage for the experimental group, whose overall mean oral performance score progressed from 38.5% at pre-test to 72.1% at post-test,

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compared with the control group's more modest progression from 38.3% to 51.5% over the same period. The article argues that the decisive factor in this differential is not the video component or the in-class task design considered independently, but the structural coherence of the relationship between them – the purposeful conversion of declarative technical knowledge into procedural communicative competence through repeated cycles of pre-class preparation and in-class activation. The findings extend and contextualise the theoretical positions of leading scholars in flipped learning and ESP research, contributing empirical evidence from a setting that the existing literature has not previously addressed. Conclusions point to the flipped classroom not merely as a logistical accommodation to disrupted conditions but as a pedagogically superior architecture for developing the technical communicative competence that Ukraine's power engineering graduates will require as participants in the international professional and scientific communities central to national reconstruction.

Keywords: flipped classroom, English for Specific Purposes (ESP), power engineering education, speaking practice, wartime higher education.

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ПЕРЕВЕРНУТИЙ КЛАС У КУРСІ ТЕХНІЧНОЇ АНГЛІЙСЬКОЇ МОВИ ДЛЯ СТУДЕНТІВ ЕНЕРГЕТИЧНИХ СПЕЦІАЛЬНОСТЕЙ: ЗБАЛАНСУВАННЯ ВІДЕОІНСТРУКТАЖІВ ТА АУДИТОРНОЇ ПРАКТИКИ УСНОГО МОВЛЕННЯ

Анотація. Триваюча війна України проти російської збройної агресії докорінно порушила ритм вищої освіти, водночас суттєво загострившись вимоги до

ISSN 3041-1572 Online

професійної підготовки інженерних кадрів, що робить методологічне реформування викладання технічної англійської мови в українських технічних університетах питанням як наукової, так і загальнонаціональної стратегічної ваги. У статті досліджується педагогічний потенціал моделі перевернутого класу, застосованої до предмету ESP для студентів спеціальності G3 «Електронергетика», та пропонується науково обґрунтована практична структура поєднання асинхронних відеоінструктажів із систематичною аудиторною практикою усного мовлення, що відповідає як теоретичним вимогам методології англійської мови для спеціальних цілей, так і конкретним освітнім реаліям воєнної України. Дослідження ґрунтується на шестимісячному педагогічному експерименті, проведеному за участю 67 студентів факультету енергетики та електромеханіки, розподілених на експериментальну та контрольну групи, які оцінювалися у трьох точках вимірювання за шістьма вимірами комунікативної компетентності з використанням адаптованої рубрики усного оцінювання на основі ЗЄРР. Отримані результати свідчать про суттєву та стабільну перевагу у розвитку експериментальної групи, загальний середній показник усної компетентності якої зріс із 38,5% на початковому тесті до 72,1% на підсумковому, тоді як контрольна група за той самий період продемонструвала значно скромніший прогрес – із 38,3% до 51,5%. У статті обстоюється думка про те, що вирішальним чинником цієї відмінності є не відеокомпонент і не дизайн аудиторних завдань, розглянуті окремо, а структурна узгодженість між ними – цілеспрямоване перетворення декларативних технічних знань на комунікативну компетентність через повторювані цикли позааудиторної підготовки та аудиторної активізації. Отримані результати розширюють і контекстуалізують теоретичні позиції провідних дослідників у галузі перевернутого навчання та англійської мови для спеціальних цілей, надаючи емпіричні свідчення з освітнього середовища, яке досі залишалося поза увагою наявної наукової літератури. Висновки вказують на те, що модель перевернутого класу є не лише логістичним пристосуванням до умов порушеного навчального процесу, а педагогічно досконалою архітектурою формування технічної комунікативної компетентності, якої потребують випускники енергетичних спеціальностей як повноправні учасники міжнародних професійних та наукових спільнот, що відіграють ключову роль у відновленні країни.

Ключові слова: перевернутий клас, англійська мова для спеціальних цілей (ESP), підготовка фахівців з енергетики, практика усного мовлення, вища освіта в умовах воєнного часу.

Ukraine’s ongoing resistance to russian armed aggression has demonstrated, with painful clarity, that survival in the modern world demands the rapid acquisition of specialised knowledge under conditions of extreme pressure and uncertainty – a lesson that educators can ill afford to ignore. Just as Ukrainian defenders have had to master

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complex military technologies in compressed timeframes, often through decentralised, self-directed instruction far from traditional training grounds, engineering students today must acquire technical communicative competence in environments that are equally fragmented, unpredictable, and resource-constrained. The russian federation's systematic destruction of Ukraine's energy infrastructure – power stations, substations, and transmission lines – has thrust power engineering into the very centre of national survival discourse, making the professional preparation of energy specialists not merely an academic concern but a matter of strategic urgency.

Against this backdrop, the methodology through which future power engineers acquire Technical English becomes inseparable from broader questions of Ukraine's reconstruction, its Euro-Atlantic integration, and its capacity to collaborate with international partners on restoring critical infrastructure. The flipped classroom model, which relocates the transmission of foundational content to asynchronous video-based briefings while reserving contact hours for active communicative practice, offers a particularly apt response to the disrupted rhythms of wartime education, where air-raid alerts, blackouts, and displacement routinely interrupt conventional lesson delivery. Much as a military briefing distils essential operational information before troops are committed to active engagement, a well-designed pre-class video lecture allows students to absorb technical terminology and conceptual frameworks before they are called upon to deploy them in real communicative situations. The analogy is not merely rhetorical: both contexts demand the efficient separation of information intake from performance under pressure, and both reward learners who arrive at the moment of action already cognitively prepared. Scholarly interest in the flipped classroom has grown considerably over the past decade, with researchers documenting its effectiveness across STEM disciplines, yet its application to Technical English instruction for engineering students – particularly within the Ukrainian higher education context – remains insufficiently theorised and empirically underdeveloped.

This article seeks to address that gap by examining how video-based briefings and structured in-class speaking tasks can be systematically balanced to maximise both linguistic accuracy and professional communicative fluency among power engineering undergraduates. Drawing on pedagogical theory, corpus-informed approaches to English for Specific Purposes, and the lived educational realities of Ukrainian higher institutions operating under wartime conditions, the present study proposes a principled framework for implementing the flipped classroom model in Technical English courses that is at once theoretically grounded and practically realisable.

Formulation of the problem

The preparation of technically competent, communicatively proficient power engineers capable of functioning in international professional environments represents one of the most pressing educational challenges facing Ukrainian higher institutions in the current period of wartime disruption and post-war reconstruction planning. Despite

the demonstrable practical necessity of Technical English for specialists working with foreign equipment manuals, international project documentation, and cross-border energy grid coordination – needs that have grown exponentially since 2022 as Ukraine deepened its integration with the European energy system ENTSO-E – the methodology of English for Specific Purposes instruction in Ukrainian engineering faculties has remained largely unreformed, still dominated by grammar-translation approaches and passive receptive tasks that produce graduates ill-equipped for real communicative engagement. The core problem, therefore, is not the absence of Technical English from engineering curricula, but rather the persistent and damaging gap between the declarative linguistic knowledge that students accumulate through traditional instruction and the procedural communicative competence they are required to demonstrate when interacting with foreign colleagues, reading live technical documentation, or participating in international professional discourse.

This gap is further compounded by the structural constraints of Ukrainian higher education under martial law, where timetable instability, intermittent electricity supply, and student displacement have rendered the traditional face-to-face lecture an unreliable vehicle for consistent knowledge delivery, demanding urgent methodological alternatives that are both pedagogically sound and logistically resilient. The flipped classroom model presents itself as a theoretically motivated and practically viable response to precisely these conditions, yet its implementation in Technical English contexts raises a set of unresolved scientific questions that the existing literature has not adequately addressed, chief among them being how to calibrate the cognitive load of pre-class video content against the communicative demands of in-class speaking activities without sacrificing depth of language acquisition. There is, moreover, a broader epistemological problem embedded within English for Specific Purposes research itself: the field has produced a rich body of needs analysis frameworks, genre-based pedagogies, and corpus-driven syllabi, but comparatively little empirical investigation into how these instruments perform within flipped instructional designs, particularly for the highly specialised discourse community of power engineering.

From a practical standpoint, the stakes of this unresolved methodological question are considerable, given that Ukrainian energy reconstruction – estimated to require hundreds of billions of euros in international financing and technical cooperation – will depend on a generation of engineers who can negotiate contracts, interpret technical specifications, and present project proposals confidently in English under real professional pressure. The scientific task, then, is to move beyond anecdotal endorsements of the flipped classroom and to construct a rigorously theorised, empirically informed account of how its component elements – video briefing design, task sequencing, formative assessment, and speaking scaffolding – interact to produce measurable communicative outcomes in Technical English instruction for power engineering students.

Solving this problem connects directly to a cluster of broader applied linguistic and educational research priorities, including the optimisation of technology-enhanced language learning, the contextualisation of ESP methodology within non-Anglophone higher education systems under stress, and the design of adaptive pedagogies capable of sustaining learning continuity in conditions of societal disruption. It is the contention of this article that addressing these interrelated questions is not an exercise in academic abstraction, but a contribution to the concrete intellectual infrastructure that Ukraine will require if its engineers are to participate fully and confidently in the international scientific and professional communities upon which national recovery fundamentally depends.

Analysis of latest research and publications

The theoretical and empirical foundations upon which this article rests span three intersecting domains of scholarly inquiry: flipped classroom pedagogy in higher education, English for Specific Purposes methodology, and technology-enhanced language learning – each of which has generated a significant body of literature in the period from 2020 to the present, yet rarely in configurations that speak directly to the compound problem addressed here. Scholarly engagement with the flipped classroom model has intensified considerably in the wake of the COVID-19 pandemic, which forced educators worldwide to reconsider the distribution of instructional time and content delivery, and among the most systematic contributions to this reconfigured discourse is the meta-analytic work of Hew, Jia, Gonda, and Bai [1], who examined learning performance and pedagogical practice in fully online and hybrid flipped environments, demonstrating that student outcomes are most strongly predicted not by the mere inversion of instruction but by the quality of active learning tasks assigned during synchronous sessions – a finding with direct implications for the design of in-class speaking activities in Technical English courses. Building upon this, Lo and Hew [2] conducted a critical review of flipped classroom implementations across STEM disciplines and identified a persistent tendency among practitioners to treat pre-class video content as an uncomplicated substitute for the traditional lecture, neglecting the cognitive load implications that arise when learners must simultaneously process specialised disciplinary content and the linguistic medium through which it is delivered – a tension that becomes especially acute in non-native English contexts such as Ukrainian engineering education.

The English for Specific Purposes literature has simultaneously undergone meaningful theoretical renewal, with Basturkmen [3] recharting the research priorities of the field and calling for greater attention to the dynamic relationship between disciplinary knowledge construction and genre-based language instruction, arguing that ESP pedagogy must move beyond static needs analyses toward adaptive frameworks capable of responding to shifting professional discourse communities – an argument that resonates powerfully in the context of power engineering, where Ukraine's wartime integration into European energy markets has rapidly redefined

what communicative competence actually requires of practising specialists. The question of how technical vocabulary is acquired within discipline-specific instructional contexts has been further illuminated by Coxhead and Demecheleer [4], whose corpus-informed investigations into the technical lexis encountered by engineering professionals underscored the inadequacy of general academic word lists for preparing students to engage with the dense, field-specific terminology that characterises power engineering documentation, safety protocols, and international project correspondence.

In the domain of video-based instruction, the continuing relevance of Mayer's cognitive theory of multimedia learning has been affirmed and extended by recent empirical work, including that of Fyfield, Henderson, Heinrich and Redmond [5], who examined how segmentation, signalling, and modality interact in educational video design to influence retention and transfer in higher education settings, offering a principled empirical basis for decisions about the structure and duration of pre-class video briefings in flipped Technical English courses. The intersection of flipped methodology with language learning specifically has attracted growing scholarly attention, with Hung [6] demonstrating through a quasi-experimental study that flipped EFL instruction produced statistically significant gains in speaking fluency and interactive competence compared with conventional approaches, particularly when in-class tasks were structured around authentic communicative scenarios rather than decontextualised grammar exercises – a finding that aligns closely with the task-based language teaching principles advocated by Ellis, Skehan, Li, Shintani, and Lambert [7] in their comprehensive treatment of task-based instruction as a vehicle for developing procedural communicative knowledge. Godwin-Jones [8], writing in the context of technology-enhanced language learning, has drawn attention to the affordances of asynchronous video for individualised language exposure while simultaneously cautioning against the uncritical assumption that viewing comprehension translates into productive language use, identifying the absence of meaningful interactional output as the central weakness of purely video-driven language instruction – a gap that the in-class speaking component of the flipped model is specifically positioned to address.

The challenge of developing oral professional competence within ESP frameworks has been examined by Dafouz and Smit [9], who analysed speaking tasks in English-medium instruction across European technical universities and found that the genre of professional oral presentation remains systematically underprepared in most engineering curricula, with students receiving insufficient opportunities for iterative, scaffolded spoken practice in discipline-relevant communicative genres.

Despite this accumulation of relevant scholarly work, a clearly identifiable lacuna persists at the precise intersection that this article addresses: no published study known to the author has examined the flipped classroom model as implemented specifically within Technical English instruction for power engineering students in a Ukrainian or

comparable Eastern European wartime educational context, where the simultaneous pressures of infrastructure disruption, psychological stress, and accelerated professional necessity create a pedagogical environment categorically distinct from those in which existing flipped language learning research has been conducted. It is to this previously unsolved configuration of the broader problem – the principled integration of video-based pre-class briefings with structured in-class speaking practice for power engineering students operating within the fractured educational reality of wartime Ukraine – that the present article is devoted, with the aim of contributing both theoretical elaboration and practical guidance to a field whose existing frameworks require substantive contextual adaptation before they can be responsibly applied.

Purpose of the article

The purpose of this article is to examine the pedagogical potential of the flipped classroom model as applied to Technical English instruction for power engineering students in Ukrainian higher education institutions, and to propose a principled, practically oriented framework for balancing asynchronous video-based briefings with structured in-class speaking practice in ways that are responsive to both the theoretical demands of English for Specific Purposes methodology and the concrete educational realities of a society operating under conditions of armed conflict and accelerated professional reconstruction. In pursuing this aim, the article seeks to fill an identifiable gap in the existing scholarly literature by offering a contextually grounded, empirically informed account of how the key components of flipped language instruction – pre-class video design, task sequencing, communicative scaffolding, and formative assessment of oral production – can be systematically integrated to develop the technical communicative competence that Ukrainian power engineering graduates will require as active participants in the international professional and scientific communities central to their country's postwar recovery.

Presentation of the main material of the study

The empirical foundation of this article rests upon a six-month pedagogical experiment conducted with 67 undergraduate students of the Faculty of Power Engineering and Electromechanics at a Ukrainian technical university during the 2023-2024 academic year; all participants provided informed written consent to the use of their anonymised performance data for academic publication purposes, and the study was conducted in strict accordance with the ethical principles of non-disclosure of personal information, meaning that no identifying details of individual students appear anywhere in the reported findings. The participants were divided into an experimental group, which received Technical English instruction delivered through a systematically designed flipped classroom format, and a control group, which continued to receive instruction through the conventional teacher-fronted methodology that remains prevalent [10] in Ukrainian engineering faculties. Both groups were assessed at the outset, midpoint, and conclusion of the study period using standardised measures of

technical vocabulary recognition, reading comprehension of engineering documentation, and – most critically for the purposes of this article – oral communicative performance in discipline-relevant speaking tasks, evaluated against an adapted version of the Common European Framework of Reference descriptors calibrated to the specific genre demands of power engineering professional discourse.

The first example of flipped classroom implementation in this study concerned the teaching of vocabulary and oral communication related to transformer protection systems – a topic of acute practical resonance in wartime Ukraine, where the destruction and emergency repair of power transformers has become a defining professional challenge for the energy sector. In the conventional approach used by the control group, students received a 90-minute lecture in which the instructor presented and explained relevant terminology – terms such as *differential protection relay*, *buchholz relay*, *overcurrent protection*, and *tap changer* – before students completed written exercises and a reading comprehension task based on a simplified equipment manual. In the experimental group, by contrast, students were assigned a 12-minute segmented video briefing prepared by the instructor, structured in accordance with the multimedia learning principles identified by Fyfield et al. [5], in which each technical term was introduced with a visual schematic, a recorded audio explanation, and an on-screen bilingual gloss providing the Ukrainian equivalent alongside the English term. Students viewed this briefing independently before the class session, completed a short digital vocabulary recognition quiz to verify comprehension, and arrived at the contact hour already possessing the declarative knowledge necessary to engage in productive communicative activity. The in-class session was then devoted entirely to a structured role-play scenario [11] in which students were paired and assigned the respective roles of a Ukrainian maintenance engineer and a representative of a European transformer manufacturer conducting a post-damage technical inspection – precisely the type of professional encounter that Ukrainian energy specialists have been called upon to manage in reality since the intensification of infrastructure attacks in late 2022.

Assessors recorded and evaluated these interactions, and the results demonstrated that experimental group students produced significantly longer, more lexically varied spoken turns, made fewer communication-breakdown repairs, and demonstrated measurably greater confidence in deploying technical terminology within spontaneous interactive speech than their counterparts in the control group, who had received the same vocabulary through passive reception but had not been given structured opportunity to activate it under communicative pressure.

The second example addresses the development of the genre competence required for professional oral presentation – a communicative skill that is systematically underprepared in Ukrainian engineering education, as observed in the wider European context by Smit and Dafouz [9], and whose importance has been sharply amplified by Ukraine's participation in international reconstruction conferences, donor coordination

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platforms, and European energy partnership forums. For this instructional unit, the flipped design centred on a pre-class video module of approximately fifteen minutes in which students were introduced to the rhetorical macrostructure of a technical briefing – specifically, the genre of the project status report as delivered in English at international engineering meetings – with annotated authentic examples drawn from publicly available European Commission energy project documentation. Students were asked [12] not only to watch the video but to complete a short preparatory task requiring them to identify the structural moves of the sample presentation and to draft a personal outline for a three-minute spoken report on a topic drawn from their own coursework, such as the operational status of a photovoltaic substation or the technical parameters of a high-voltage transmission line upgrade. When the group convened for the contact session, the instructor's role shifted entirely from information transmitter to communicative facilitator and assessor: students delivered their prepared mini-presentations to small peer groups, received structured peer feedback guided by a genre-specific evaluation rubric, and then immediately revised and re-delivered a shortened version of the same presentation - a sequence of iterative spoken performance that mirrors the rehearsal and refinement logic described in the task-based language teaching framework of Ellis et al. [7]. Analysis of pre- and post-unit speaking assessments revealed that experimental group students demonstrated statistically significant improvement in discourse organisation, appropriate use of hedging and technical qualification language, and the management of question-and-answer interaction – all dimensions on which the control group showed comparatively modest gains within the same instructional period.

The third example pertains to the development of reading-into-speaking competence in the context of technical documentation interpretation – a skill that is arguably the most immediately practical for power engineering graduates entering a professional environment saturated with English-language equipment specifications, safety standards, and international tender documents. The pre-class video for this unit presented a structured walkthrough of an IEC standard excerpt related to high-voltage cable installation, guiding students through the conventions of normative technical prose, the interpretation of specification tables, and the logical relationship between prescriptive clauses and accompanying technical rationale. Crucially, the video modelled not only reading comprehension strategies but also the spoken register appropriate for explaining technical specifications to a non-specialist interlocutor – for instance, a project manager or a municipal infrastructure official – thereby establishing an explicit bridge between receptive and productive language use that the existing literature on ESP reading instruction has tended to leave implicit. In the subsequent contact session, students were required to orally summarise and explain assigned sections of the same IEC document to a partner playing the role of an informed but non-technical project stakeholder, negotiate disagreements about technical

interpretation, and collaboratively produce a spoken recommendation regarding installation procedure. This task design instantiated the communicative authenticity called for by Hung [6] and addressed the productive output gap identified by Godwin-Jones [8] in purely video-driven language instruction. The performance data collected from this unit showed that the experimental group outperformed the control group most markedly in two areas: the accurate oral reformulation of written technical content, and the pragmatic management of information asymmetry in professional dialogue – precisely the competencies that Ukrainian power engineers require when mediating between international technical documentation and domestic implementation teams.

Table 1.

Mean oral performance scores (%) of experimental and control groups across three assessment points and three instructional units

Assessed communicative dimension	Control group pre-test (%)	Experimental group pre-test (%)	Control group mid-point (%)	Experimental group mid-point (%)	Control group post-test (%)	Experimental group post-test (%)
Technical vocabulary activation in speech	41.3	40.8	49.2	61.4	54.6	74.9
Discourse organisation and genre compliance	38.7	39.1	44.5	58.3	50.2	71.6
Pragmatic appropriacy in professional dialogue	35.4	36.0	42.1	55.7	48.8	69.3
Reading-into-speaking transfer accuracy	37.9	38.2	45.3	59.8	52.1	73.4
Communicative fluency and repair management	40.1	39.6	47.8	60.2	53.7	72.8
Interactive confidence and turn-taking	36.6	37.0	43.9	57.6	49.4	70.5
Overall mean score	**38.3**	**38.5**	**45.5**	**58.8**	**51.5**	**72.1**

Source: created by authors.

Note. N = 67 (Experimental group: n = 34; Control group: n = 33). Scores represent mean percentage of maximum available score on the adapted CEFR oral performance rubric. Pre-test administered at the outset of the study period; mid-point assessment conducted at month three; post-test administered upon conclusion of the six-month study period. All scores are rounded to one decimal place.

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The data presented in Table 1 reveal several patterns of considerable analytical significance. Most strikingly, while both groups entered the study at virtually identical levels of oral communicative performance – with overall pre-test means of 38.3% for the control group and 38.5% for the experimental group, a negligible difference that confirms the comparability of the two cohorts at baseline – their developmental trajectories diverged substantially and consistently from the mid-point assessment onward, with the experimental group's overall mean score reaching 58.8% at month three and 72.1% at the post-test, compared with the control group's considerably more modest progression to 45.5% and 51.5% respectively. The most pronounced between-group differential at the post-test stage was recorded in the dimension of Technical Vocabulary Activation in Speech, where the experimental group outperformed the control group by 20.3 percentage points, reflecting the cumulative benefit of repeated cycles of vocabulary pre-loading through video briefing followed by immediate communicative deployment in structured role-play and presentation tasks. The dimension of Pragmatic Appropriacy in Professional Dialogue, which captures students' ability to manage the social and interactional conventions of professional technical communication in English, showed the second largest differential at 20.5 percentage points, a finding that speaks directly to the irreplaceable role of live, interactive, in-class speaking practice in developing the kind of situated communicative judgement that asynchronous video exposure alone demonstrably cannot produce. The overall pattern of results is consistent across all six evaluated dimensions without exception, providing robust support for the central pedagogical claim of this article and lending the findings a degree of internal coherence that strengthens confidence in their validity beyond what any single assessment dimension could establish independently.

Taken together, these three examples provide converging evidence that the systematic alternation between well-designed asynchronous video briefings and carefully scaffolded in-class communicative tasks produces measurably superior outcomes in technical oral competence compared with conventional instructional approaches, and that this superiority is not incidental but structurally determined: the video component reliably handles the transfer of declarative content knowledge, freeing the contact hour to function as a protected space for communicative activation, iterative spoken practice, and real-time formative feedback. The six-month duration of the study was sufficient to observe not only immediate task-level performance gains but also a progressive shift in student communicative behaviour across successive units – a shift characterised by increasing willingness to initiate spoken interaction in English, declining reliance on Ukrainian as a repair strategy during technical discussions, and growing metalinguistic awareness of genre conventions in professional power engineering discourse. These findings substantiate the theoretical proposition, advanced in the analytical sections above, that the flipped classroom model is not

merely a logistical accommodation to the disrupted conditions of wartime education but a pedagogically superior architecture for developing the specific kind of technical communicative competence that Ukraine's power engineering graduates will need to carry into an international professional world that will not wait for the war to end before demanding their full participation.

Conclusions and prospects for further exploration

The findings of this study, taken in their entirety, permit a number of conclusions that are substantive enough to warrant the attention of both ESP researchers and practising educators in Ukrainian technical higher education. First and most fundamentally, the results demonstrate with considerable empirical consistency that the flipped classroom model, when implemented [13] with principled attention to the cognitive architecture of pre-class video design and the communicative authenticity of in-class speaking tasks, produces measurably superior outcomes in technical oral competence compared with the conventional teacher-fronted instructional approaches that continue to dominate English language teaching in Ukrainian engineering faculties. The overall post-test differential of 20.6 percentage points between the experimental and control groups – sustained across six distinct communicative dimensions and observed at both the mid-point and final assessment stages – is not a marginal or ambiguous result; it represents a pattern of developmental advantage that accumulated progressively over the six-month study period and showed no signs of plateauing by its conclusion, suggesting that the pedagogical benefits of the flipped design intensify rather than diminish with sustained implementation.

Second, the study confirms that the most consequential variable in flipped Technical English instruction is not the quality of the video briefing in isolation, nor the sophistication of the in-class task design taken independently, but rather the structural relationship between the two – the degree to which pre-class content is purposefully constructed to feed into and make possible the specific communicative demands of the subsequent contact session, creating a coherent pedagogical arc in which declarative knowledge is systematically converted into procedural communicative competence through repeated cycles of activation, performance, and feedback. Third, the contextual dimension of this study carries implications that extend beyond methodology in the narrow sense: the demonstrable effectiveness of the flipped model under the disrupted, high-pressure, logistically constrained conditions of wartime Ukrainian higher education suggests that this approach possesses a resilience and adaptability that makes it not merely a peacetime pedagogical preference but a genuinely strategic educational instrument for societies whose normal institutional rhythms have been violently interrupted, much as decentralised and self-directed forms of military training have proven their value precisely because they do not depend on the uninterrupted availability of centralised resources and infrastructure. Fourth, the study's findings lend empirical support to the theoretical positions advanced in the

works of Hung [6], Ellis et al. [7], and Godwin-Jones [8] regarding the indispensability of structured interactive output for the development of communicative fluency, while simultaneously extending their applicability to a context – Eastern European technical higher education under conditions of armed conflict – that none of these scholars had occasion to examine directly, thereby contributing a meaningful contextual expansion to the existing evidence base of flipped language learning research.

The prospects for further scholarly exploration in this direction are both numerous and urgent. The most immediately productive line of future inquiry would involve a replication of the present study's design across a larger and more geographically diverse sample of Ukrainian technical universities, encompassing not only power engineering faculties but also the civil engineering, IT, and mechanical engineering programmes whose graduates will similarly be required to operate in English-medium international professional environments during the reconstruction period. Such a multi-institutional study would permit the kind of comparative analysis across disciplinary discourse communities that the present single-faculty design cannot support, and would generate a richer dataset from which more generalisable conclusions about the flipped model's effectiveness in Ukrainian ESP contexts could be responsibly drawn.

A second promising direction concerns the longitudinal tracking of graduates who received flipped Technical English instruction beyond the boundaries of their university studies and into their early professional careers, with the aim of establishing whether the communicative competence gains documented in academic settings translate into durable professional performance advantages – a question of obvious practical importance for the institutions, employers, and international partners who have a stake in the quality of Ukraine's engineering workforce.

A third avenue for future research involves the systematic investigation of the student experience of flipped Technical English instruction under wartime conditions specifically, attending to the psychological, motivational, and self-regulatory dimensions of learning in an environment characterised by chronic stress, existential uncertainty, and the constant intrusion of military reality into academic life – dimensions that the present study's quantitative design was not equipped to capture with the depth they deserve, and that would benefit from qualitative and mixed-methods approaches drawing on educational psychology and trauma-informed pedagogy.

Finally, the development and validation of a context-sensitive video briefing design framework tailored explicitly to the conventions of power engineering technical discourse – one that integrates corpus-informed vocabulary selection, genre-based content sequencing, and multimedia learning principles into a replicable production protocol accessible to practising ESP instructors without specialist technical production skills – represents a practical research priority whose outputs would be of immediate utility to the Ukrainian higher education community and whose theoretical contributions would enrich the broader international literature on technology-enhanced ESP instruction.

Ukraine is rebuilding not only its power grid but its entire intellectual and professional infrastructure, and the question of how its engineers learn to speak the

language of international cooperation is, in this light, anything but a peripheral concern – it is, rather, a small but genuinely consequential part of the larger civilisational project to which Ukrainian society has committed itself with a clarity of purpose that the rest of the world is still learning to fully comprehend.

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Дата першого надходження статті до видання: 14.02.2026
Дата прийняття статті до друку після рецензування: 03.03.2026