Improving the Methodological Support for Multilingual Education in Technical Higher Education Institutions

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The article presents an instructional model of multilingual education for technical higher education institutions that integrates content and language integrated learning, the Frayer model and trilingual terminology work. The study aimed to substantiate the methodological support of multilingual training for future engineers, to design a six-component model and a set of professionally oriented materials, and to evaluate the model in a pedagogical experiment. The experiment involved 352 first-year students of three higher education institutions of Uzbekistan specialising in the mechanisation of agriculture; the experimental group (170 students) studied under the proposed model, while the control group (182 students) followed the standard curriculum. Multilingual professional competence was assessed through a trilingual terminology test, an interpretation task based on a hydraulic schematic and the oral defence of an engineering case. The share of students at the high level of competence in the experimental group rose from 16.5% to 47.1%, whereas in the control group it rose from 16.5% to 34.1%; the share at the low level in the experimental group fell from 51.7% to 22.3%. The gain of the experimental group at the high level was 1.74 times that of the control group. The article formulates the conditions under which the model can be transferred to other engineering fields and discusses the limitations of the aggregate design of the experiment.

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1 Introduction

The development of multilingual professional competence has become one of the central tasks in the modernisation of higher education. Global technological change, international academic collaboration and the steady demand for engineers able to work in multicultural teams require graduates to communicate effectively across languages and professional cultures. In technical universities language training is not a separate academic service but an instrument of professional socialisation: it is through language that students learn to read engineering documentation, interpret technological processes, negotiate technical solutions with international partners and present the results of their work to a non-specialist audience. Where language teaching is detached from the discipline, graduates acquire general vocabulary and a command of everyday topics, yet remain unable to describe a ma-

chine, explain a fault or defend an engineering decision in a second language. The problem addressed in this article is therefore not the absence of language instruction in technical institutions but its weak integration with the content and the communicative practices of the engineering profession.

The higher education system of Uzbekistan faces this problem in a particularly acute form. The country is training a new generation of specialists who must combine a solid grounding in fundamental and applied engineering with well-developed multilingual communication skills. The rapid modernisation of agricultural machinery, the adoption of imported automated systems and the spread of precision agriculture technologies require future mechanical engineers to use technical terminology confidently in English, Russian and Uzbek. A graduate who cannot relate the English designation of a hydraulic valve to its Russian equivalent and to the physical component on the machine is restricted to the role of an operator of documented procedures; a graduate who can move between the three languages and preserve conceptual accuracy is able to diagnose faults, justify design choices and take part in international technical exchange.

Content and language integrated learning (CLIL) offers a well-developed answer to this problem, since it treats the additional language as the medium of disciplinary work rather than as an object of study [8]. The Common European Framework of Reference for Languages complements this approach by describing plurilingual competence as a single, dynamically organised repertoire from which the speaker selects resources for a concrete communicative task [7]. At the same time, the design of coherent and evidence-based methodological support adapted to the conditions of a technical university remains insufficiently investigated: the combinations of interactive methods that suit engineering content are rarely specified, trilingual instructional resources are seldom described in detail, and the criteria for assessing multilingual professional competence are not agreed upon. The study therefore aimed to substantiate the methodological support of multilingual education in a technical higher education institution, to design a model and a set of professionally oriented materials on its basis, and to evaluate the effectiveness of the model experimentally. Four objectives were formulated.

2 Materials and methods

2.1 Design, participants and instruments

To examine the theoretical and methodological foundations of multilingual education in technical universities and the current trends in its development. To design a six-component instructional model that integrates engineering content, multilingual communication and interactive teaching methods. To develop professionally oriented materials based on CLIL, the Frayer model and case-based learning. To assess the changes in students' multilingual professional competence over the course of the pedagogical experiment. The study employed a pedagogical experiment with an experimental and a control group, combined with theoretical analysis, instructional design and the simulation of professional engineering situations. The approach was designed for students of agricultural mechanisation programmes, since this field concentrates the typical difficulties of trilingual technical communication: the terminology of hydraulic systems, internal combustion engines, transmissions and electronic control units is standardised internationally, but the standards themselves differ, and the same component may carry different designations in the three working languages of the region. The experiment involved 352 first-year students of three higher education institutions of Uzbekistan. The participants were divided into two comparable groups: the experimental group of 170 students studied under the proposed model, and the control group of 182 students followed the standard curriculum with the same number of academic hours.

Three instruments were used to assess multilingual professional competence. The first was a trilingual terminology test requiring the identification of a term in English, its equivalent in Russian and Uzbek, and its correct use in a technical statement. The second was an interpretation task in which students had to read a hydraulic schematic, name its components in the three languages and explain the sequence of oil flow through the circuit. The third was an oral presentation and defence of an engineering case solution, assessed according to the accuracy of terminology, the logic of the diagnostic reasoning and the appropriateness of the language chosen for each communicative purpose. The three instruments were scored on a common scale and the results were reduced to three levels of competence: high, intermediate and low. Both groups were assessed before the experiment and at its completion with the same instruments, which makes the comparison of the distributions admissible.

2.2 The six-component instructional model

The model comprises six interrelated components that jointly connect language instruction with disciplinary engineering training. The first component, objectives, defines the target as multilingual professional competence: the ability to communicate technical knowledge accurately and the readiness for international professional and scientific exchange. The second, content, is built on authentic professionally relevant material: technical documentation, operating manuals for agricultural machinery, engineering terminology and typical workplace communication scenarios. The third, teaching methods and activities, integrates CLIL, the Frayer model, case-based learning, professional role-play, project work and collaborative analytical reading. The fourth, resources, provides English-Uzbek-Russian terminology tables, kinematic and hydraulic diagrams, audiovisual materials, multilingual glossaries and digital learning resources. The fifth, organisation, combines individual tasks, pair work, small project teams, practical seminars and laboratory sessions devoted to engineering problem-solving. The sixth, outcomes and assessment, fixes what is measured: terminology knowledge, professional communication, the processing of multilingual technical information and the practical application of engineering knowledge.

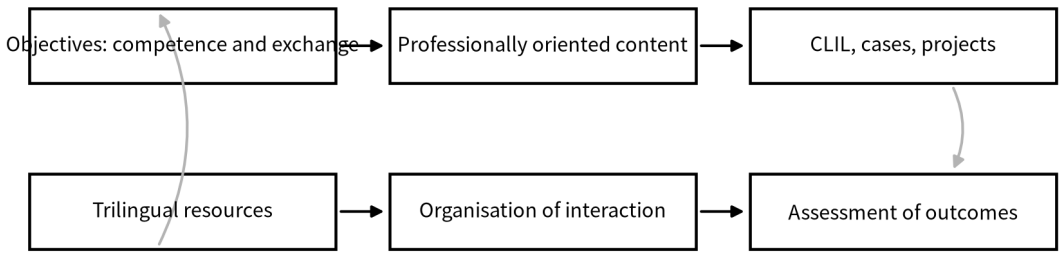


Figure 1 Six-component model of multilingual education in a technical higher education institution
Compiled by the author.

CLIL was implemented in disciplinary modules, of which Hydraulic Systems in Agricultural Machinery may serve as an example. In practical sessions students studied the design and the operating principle of gear and axial-piston pumps, hydraulic cylinders, directional control valves and pressure relief valves, interpreted hydraulic schematics and discussed possible component faults. English served as the primary language of technical communication, while Uzbek and Russian were used to establish accurate conceptual links, to compare technical

standards and to reduce terminological interference. The Frayer model concentrated on key engineering concepts in the three languages. For hydraulic pressure (gidravlik bosim, gidravlicheskoye davleniye) small groups completed four sections of the concept map: a definition describing the pressure transmitted through a nearly incompressible working fluid in a closed system; characteristics, including units of measurement, gauge points, the relation between pressure and load and nominal operating ranges; examples, such as the working pressure in the cylinders of tractor attachments, hydraulic motors, pumps and steering circuits; and non-examples distinguishing hydraulic pressure from mechanical force, electrical voltage and atmospheric pressure.

The same procedure was applied to related concepts, among them pressure limit, relief valve and pressure loss. These activities helped students connect terminology with the engineering concept behind it instead of memorising parallel word lists. Engineering cases reinforced multilingual skills in simulated workplace situations. In the case entitled Troubleshooting Pressure Loss in a Combine Harvester Hydraulic System, students analysed an English-language fault description, identified the components on a trilingual schematic and proposed possible causes: worn cylinder seals, a clogged suction filter, a sticking relief-valve spool. They then presented a diagnostic and repair sequence in English and summarised their recommendations in Russian and Uzbek, reproducing the sequence of communicative acts that service departments of agricultural enterprises actually perform when they work with imported equipment.

3 Results

3.1 Baseline comparability of the groups

The baseline assessment showed that the two groups started from an almost identical distribution. In the experimental group 16.5% of students demonstrated the high level of multilingual professional competence, 31.8% the intermediate level and 51.7% the low level. In the control group the corresponding shares were 16.5%, 31.9% and 51.6%. The difference of one tenth of a percentage point in two categories is a rounding effect and does not indicate a systematic advantage of either group. The structure of the baseline distribution is itself informative: in both groups about half of the first-year students could not yet operate technical terminology in three languages even at the level of recognition and reproduction, while the share of students capable of independent professional communication in an additional language was one in six. This distribution corresponds to the diagnosis made in the introduction: general language training had produced a re-

latively small group of confident users and a large group whose knowledge remained declarative.

3.2 Dynamics of multilingual professional competence

The final assessment registered positive changes in both groups, but their scale differed substantially. In the experimental group the share of students at the high level rose by 30.6 percentage points, from 16.5% to 47.1%, and the share at the low level fell by more than half, from 51.7% to 22.3%. The intermediate share changed only slightly, from 31.8% to 30.6%, which is consistent with the logic of a two-stage movement: students move from the low to the intermediate level and then, within the same period, from the intermediate to the high level, so that the intermediate category is replenished from below and emptied from above. In the control group the high-level share rose by 17.6 percentage points, from 16.5% to 34.1%, and the low-level share fell from 51.6% to 35.1%. The standard curriculum therefore also produced measurable progress, but the experimental group finished with a lead of 13.0 percentage points at the high level and with a visibly smaller residual group at the low level.

Competence level	Experimental group (n = 170): baseline to final	Control group (n = 182): baseline to final	Difference at final assessment, pp
High	16.5 to 47.1	16.5 to 34.1	+13.0
Intermediate	31.8 to 30.6	31.9 to 30.8	-0.2
Low	51.7 to 22.3	51.6 to 35.1	-12.8

Table 1 Distribution of multilingual professional competence in the experimental and control groups, baseline and final assessment, %. Source: computed by the author from the pedagogical experiment (n = 352). The intermediate shares for the control group are derived arithmetically, since the three levels of each distribution sum to 100%. pp - percentage points.

The gain of the experimental group at the high level, 30.6 percentage points, is 1.74 times the gain of the control group, 17.6 percentage points. This ratio is the most compact expression of the effect of the model, because it compares the two groups along the same measure and over the same period. The reduction of the low-level share is equally indicative: in the experimental group it fell to 22.3%, whereas in the control group it remained at 35.1%, so that the experimental model removed more than half of the weakest category while the standard curriculum removed less than a third. At the same time, the persistence of roughly one fifth of students at the low level in the experimental group shows that the model does not compensate for very limited baseline proficiency within a single semester; for these stu-

dents the gradual introduction of foreign-language communication and additional visual support remain necessary.

4 Discussion and conclusion

4.1 Interpretation of the outcomes

The results are consistent with the hypothesis that the integration of content and language instruction with concept-based terminology work improves multilingual professional competence in technical higher education. Three findings deserve separate interpretation. First, the near-tripling of the high-level share in the experimental group supports the design in which technical vocabulary is acquired through the interpretation of kinematic and hydraulic diagrams, the comparison of machinery specifications and the drafting of maintenance procedures rather than through word lists. This finding corresponds to the emphasis of Meyer and colleagues on building disciplinary literacy through active meaning-making [10] and to Krylov's account of engineering bilingualism as the accurate use of technical concepts across languages [4].

Second, the sharp reduction of the low-level share supports the use of the Frayer model with students who enter the course with limited language proficiency. The baseline assessment identified two dominant difficulties: an insufficient understanding of the physical processes behind the terminology and a tendency toward literal translation. Completing definitions, characteristics, examples and non-examples obliged students to separate a concept from its label, and the deliberate contrast of hydraulic pressure with mechanical force, or of a relief valve with a check valve, reduced terminological interference and established conceptual links between English, Uzbek and Russian [2, 3]. Third, engineering cases and collaborative work sustained motivation and generated genuine communicative need. The diagnosis of a pressure drop in a combine harvester's hydraulic system created the conditions for cross-linguistic mediation described in the CEFR Companion Volume [7]: students read a fault description in English, discussed causes in mixed groups and presented recommendations in Russian and Uzbek.

4.2 Conditions for transfer and limitations of the study

The implementation identified three conditions that determine whether the model can be applied in other technical institutions. Language teachers and engineering instructors must collaborate in the selection of authentic technical resources and in the verification of trilingual ter-

minology; otherwise the terminology tables reproduce the errors of machine translation and the credibility of the materials collapses. The proportion of foreign-language communication must increase gradually, since the early use of diagrams, drawings and Frayer models reduces cognitive overload and allows students to reach the language of the discipline through visual support [6]. Multilingual digital glossaries and interactive assessments must be used systematically, so that feedback reaches students between sessions rather than at the end of the module. These conditions are organisational as much as methodological, and their neglect is the most probable cause of failure when CLIL is introduced as a change of language rather than as a change of activity.

The study has limitations that must be stated explicitly. The analysis relied on aggregate group distributions and therefore could not trace the individual trajectories of students; consequently, the observed differences characterise the cohorts rather than the trajectories of particular learners. The sample was drawn from three institutions offering agricultural mechanisation programmes, so the transfer of the conclusions to other engineering fields requires additional verification. Statistical significance was not estimated within the framework of this study, and the separate contributions of CLIL, the Frayer model and case-based learning were not isolated. Future research could apply non-parametric tests to the observed differences, design a factorial comparison of the three methodological components and adapt the six-component model to power engineering, water infrastructure construction and process automation, where the structure of technical discourse differs in terminology but not in communicative function.

4.3 Conclusion

Systematic methodological support can convert language training in a technical university from a parallel subject into an instrument of engineering education. The proposed six-component model combines CLIL, the Frayer model, case-based learning and trilingual terminology work through its objectives, content, methods and activities, resources, organisation, and outcomes and assessment. In the experiment involving 352 students the share of participants at the high level of multilingual professional competence in the experimental group rose from 16.5% to 47.1%, while the corresponding share in the control group reached 34.1%; the share at the low level in the experimental group fell by more than half. The model therefore offers a reproducible way of preparing engineering graduates for professional communication in international settings, provided that the three conditions formulated above are observed and that the terminology resources are verified jointly by language and engineering staff.

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