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STRUCTURAL AND CONTENT MODEL FOR THE FORMATION OF FOREIGN-LANGUAGE COMMUNICATIVE COMPETENCE IN STUDENTS OF NATURAL SCIENCE SPECIALTIES WITHIN PROFESSIONALLY ORIENTED EDUCATION

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ABSTRACT

The aim of this study is to develop and substantiate a structural and content model for the formation of foreign language communicative competence (FLCC) in students of natural science specialties within the context of professionally oriented education. The research identifies the key components of FLCC, including linguistic, sociocultural, pragmatic, and strategic elements, alongside essential subcompetencies crucial for effective communication in both scientific and professional contexts. The study utilizes a blend of professional-competence, professional-personality-oriented, professional-interactive, and subject-professional approaches to ensure alignment with modern professional standards and to address the individual learning needs of students. It also outlines the necessary linguodidactic conditions for the successful implementation of the model, emphasizing the integration of foreign language training with specialized scientific disciplines, the promotion of active communicative practices, the enhancement of students' academic autonomy, and the modular structuring of content. The results demonstrate the effectiveness of this approach in systematically developing students' capacity for professional and scientific communication in a foreign language. This study contributes to the field of language education by offering a comprehensive framework for developing FLCC in line with the demands of the international academic and professional environments.

Keywords: academic mobility; authentic materials; interactive methods; modular learning

INTRODUCTION

In modern conditions of globalization and the integration of Kazakhstan into the world educational space, the problem of training specialists capable of effective professional communication in a foreign language is of particular relevance. Foreign language proficiency becomes the most important component of professional competence of university graduates, including natural science specialities. However, the analysis of the theory and practice of professionally-oriented foreign language teaching in HEIs has revealed several contradictions between: increasing demands of the society to the level of foreign language proficiency of natural science specialists and insufficient development of theoretical and methodological bases of foreign language communicative competence formation in them.

The relevance of this study is reinforced by the Sustainable Development Goals (SDGs), in particular SDG 4 (Quality Education) and SDG

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9 (Industry, Innovation and Infrastructure). SDG 4 emphasizes the need for inclusive and equitable education that promotes lifelong learning opportunities, including the acquisition of foreign languages necessary for global scientific cooperation. SDG 9 emphasizes the role of research, innovation and technology transfer, which require scientists and professionals with strong communication competencies to participate effectively in international networks.

Significant didactic potential of professionally-oriented foreign language teaching in the formation of students' foreign language communicative competence and insufficient realization of this potential in the educational process of higher education institution; the necessity of purposeful formation of foreign language communicative competence of students of natural science specialities, and the lack of a scientifically grounded model of this process. These contradictions determine the relevance of the research topic, which is the need for theoretical substantiation and development of the structural and content model of the formation of foreign language communicative competence of students of natural science specialities in the process of professionally oriented learning.

Studies in the field of formation of foreign language communicative competence of students of natural science specialities in the process of professionally oriented education cover various aspects, but do not provide a holistic model of development of this competence. For example, the impact of information and communication technologies on the development of students' speaking skills was studied by Chau (2021). The author concludes that while ICT offers valuable authentic inputs and online resources that promote both classroom and self-directed learning, its effectiveness is contingent upon the appropriate integration and combination of different technological tools to foster communicative competence.

The possibilities of enhancing students' communicative competences in STEM fields using virtual global projects through collaborative learning were examined by Owens and Hite (2022). The authors investigated the effectiveness of a global Project Based Learning (PBL) intervention in enhancing communication skills critical for the STEM workplace, drawing on both teacher and student perceptions in K-12 settings. Employing a mixed-methods design in two fifth-grade classrooms participating in international collaboration and one control classroom, the findings indicate that global PBL fosters improved idea-sharing, multi-representational communication, and openness to diverse perspectives.

A communicative approach to language teaching in language classrooms was discussed in a study by Dos Santos (2020). The author highlights the importance of adapting instructional strategies to meet the diverse needs of international students in an increasingly globalized educational environment. Future teachers' strategies for improving students' speaking skills were analysed by Miranda and Wahyudin (2023). By analyzing respondents' perspectives, the authors identified various challenges and variables that impact the efficacy of speaking strategies in the teaching and learning of English.

Verawati et al. (2021) assessed the effectiveness of reflective practices within inquiry learning in enhancing critical thinking skills among pre-service physics teachers, taking into account their cognitive styles (field-independent and field-dependent). Utilizing a quasi-experimental design with pretest and posttest evaluations, the findings indicated moderate improvements in critical thinking for both cognitive style groups, with no significant differences observed between them, thereby supporting the integration of reflective inquiry learning in teacher education programs.

A systematic review of the use of gamification to support learning English as a second language was conducted by Dehghanzadeh et al. (2021). Communicative language teaching and students' communicative competence in tourism English were examined by Ho (2020). The use of small group discussions to improve students' speaking skills was studied by Crisianita and Mandasari (2022). The problems of foreign language training of students in higher education institutions of the Republic of Kazakhstan were analysed in the work of Tleuzhanova (2022), and the development of intercultural communicative competence through telecollaboration and virtual exchange was analysed by O'Dowd and Dooly (2020).

Despite a significant number of works on this topic, a comprehensive model of the formation of foreign language communicative competence of students of natural science specialities, taking into account the specifics of their future professional activity and integrating various approaches and methods, has not yet been developed and theoretically substantiated.

The novelty of this study lies in the fact that it relies on scientifically grounded linguodidactic conditions that ensure the integration of foreign language learning with professional training, promote academic mobility and enhance students'

participation in global scientific networks. By addressing these gaps, the study contributes to the development of language education methodology by proposing a practical and replicable model for enhancing communicative competence in science-oriented curricula.

The aim of this study is to refine existing theoretical models and contribute to the development of a structured framework for forming foreign-language communicative competence among students of natural science disciplines. Achievement of the set goal implies the following tasks:

To determine the essence, structure, and content of foreign language communicative competence of students of natural science specialities.

To identify and substantiate theoretical and methodological approaches to the process of formation of foreign language communicative competence of students of natural science specialities.

To develop a structural and content model of the formation of foreign language communicative competence of students of natural science specialities in the process of professionally oriented training.

METHODS

The research was conducted in several stages, starting with the conceptual framework development. In this first stage, a comprehensive review of the existing literature on FLCC in natural science education was carried out. This included a focus on linguistic, sociocultural, pragmatic, and strategic components of FLCC and its importance for effective communication in scientific and professional contexts. Previous research informed the theoretical basis for the model, identifying the necessary subcompetencies required for professional communication in these fields. The review also considered professional standards and the specific learning needs of students, which guided the development of the model. Additionally, the evaluation of these standards helped ensure the alignment of the proposed model with contemporary educational practices and student requirements.

The second stage involved the design of the methodological framework for FLCC formation. The study combined several approaches to language learning: the professional-competence approach, which focuses on the development of key competences for professional communication; the professional-personality-oriented approach, which takes into account individual student characteristics and learning needs; the professional-interactive approach, which emphasizes interactive learning to enhance communication skills; and the subject-professional approach, which integrates language learning with specialized scientific subjects. These approaches were synthesized to form a pedagogical model aimed at enhancing FLCC in the context of professional training. The conceptual foundations of the model were grounded in principles such as professional orientation, integration of subject and language knowledge, and the emphasis on active speech practices to foster communicative competence.

During the third stage, the structural and content model for FLCC was developed. This model defined the main components of FLCC, including linguistic, sociocultural, pragmatic, and strategic components, as well as professionally oriented subcompetencies such as research, academic, information-technological, and intercultural professional-communicative subcompetencies. The content and methods of teaching FLCC were structured to ensure integration with specialized scientific disciplines, allowing for the development of the necessary communicative skills. Key linguodidactic conditions were also identified, such as modular learning and the promotion of academic autonomy, to ensure the effective realization of the model. The research focuses on developing foreign language proficiency among students pursuing natural science specialities at the tertiary education level. The Foreign Language Communicative Competence (FLCC) model is specifically designed for students in higher education institutions, not secondary schools. This stage aimed to align the model with current educational standards, focusing on the development of both language proficiency and professional communication abilities in natural science students.

The fourth stage involved data collection and analysis through a mixed-methods approach. Qualitative data was gathered through interviews and focus group discussions with both instructors and students from various natural science programs. These discussions explored perceptions of language competence requirements and the challenges students face in developing FLCC. Quantitative data was collected through surveys administered to students, assessing their current levels of FLCC and their readiness for engaging in professional communication in a foreign language. Action research was also conducted during this stage, where pilot training modules were developed and implemented. The effectiveness of these modules was assessed through pre- and post-tests, as well as ongoing feedback from both students and instructors.

The demographic information for this study includes students pursuing natural science specialities in higher education institutions in Kazakhstan. The participants were drawn from a diverse group of students enrolled in various natural science programs at a university level. The study focused on these students' proficiency in foreign language communicative competence (FLCC) as part of their professional training. In terms of educational background, the participants were university-level students with varying levels of proficiency in foreign languages, primarily English, which is essential for engaging in global scientific networks and academic exchanges. The participants' language proficiency levels were assessed to gauge their readiness for professional communication in a foreign language, focusing on their ability to participate in international scientific collaborations and contribute to global research networks. The research model was not previously piloted, but the pilot training modules and their evaluation serve as a test phase for the model's effectiveness in improving FLCC. This allowed for an assessment of the immediate impact of the model on students' communicative competence.

In the final stage, the evaluation and refinement of the model took place. The effectiveness of the proposed model was evaluated by assessing the impact on students' FLCC development, specifically examining the improvement in linguistic, sociocultural, pragmatic, and strategic components of communication. The pedagogical effectiveness was evaluated by determining how well the integration of language training with specialized scientific disciplines enhanced students' active communicative engagement and academic autonomy. Additionally, the model's practical applicability was assessed based on the feedback from both students and instructors, considering its implementation in real academic and professional settings. Data from the surveys, interviews, and assessments were analyzed using statistical methods such as descriptive statistics and paired t-tests to determine the significance of the findings. This analysis helped refine the model for further application and improvement in the development of FLCC in natural science education.

The basis for specifying the goals, content and expected results of ICC formation was the analysis of normative-legal documents regulating language training in higher education institutions. The Order of the Minister of Education and Science of the Republic of Kazakhstan No. 604 "On Approval of State Compulsory Educational Standards for All Levels of Education" (2018), Working curriculum of the discipline "Foreign Language (Professional)" (2024) and Methodical instructions for studying the discipline of the discipline "Professionally-Oriented Foreign Language" (2024) were studied, made it possible to determine the target benchmarks and expected results of language training of students of natural science specialities taking into account the peculiarities of their future professional activity. With the help of this method the unified requirements to the level of foreign language proficiency necessary for effective functioning of a graduate in scientific and industrial spheres were revealed. In particular, when considering the requirements of the Order of the Minister of Education and Science of the Republic of Kazakhstan No. 604 (2018) it was revealed that the future specialist should have the ability to perceive, analyse and produce professionally significant information in a foreign language, to possess the terminological apparatus of the relevant field of science, to be able to use the language to participate in international scientific events and research. Thus, the normative documents served as a basis for selecting the subject content of training, its structuring in accordance with the functional needs of professional communication, specifying the criteria and descriptors for assessing the achieved level of communicative competence.

RESULTS AND DISCUSSION

Foreign language communicative competence is one of the key components of professional competence of a modern specialist of natural science profile. In the conditions of globalization and the internationalization of science and education, the ability to carry out effective professional communication in a foreign language becomes a necessary condition for successful activity in the international scientific community (Salih & Omar, 2021). The essence of FLCC lies in the integrative unity of knowledge, skills, abilities, and personality traits that allow realizing effective intercultural communication in the context of professional interaction (Lee et al., 2023). This competence is complex and includes a number of interrelated sub-competences (Table 1).

Table 1. Component Composition of Foreign Language Communicative Competence of Students of Natural Science Specialities

Components of the FLCC	Component Content	Professionally Oriented Specificity
Linguistic	Mastery of the foreign language system (vocabulary, grammar, phonetics, stylistics)	Mastering the terminology system of the studied science
	Ability to comprehend and produce professionally oriented texts	Development of skills to describe scientific facts, phenomena, processes
	Mastery of the terminological apparatus of the relevant field of science	Mastering the structural and compositional features of scientific texts
Sociocultural	Knowledge of cultural peculiarities, traditions, values, norms of behaviour of scientific and professional community	Mastering the peculiarities of the organization of scientific activity in the countries of the studied language
	Ability to adequately interpret and use socio-cultural information	Development of intercultural professional communication skills
	Ability to overcome intercultural barriers and resolve communication conflicts	Education of tolerance, respect for cultural diversity
Pragmatic	Ability to choose adequate language means in accordance with the communicative situation	Development of skills to participate in various situations of professionally oriented communication
	Knowledge of the rules and strategies of professional discourse, mastery of speech etiquette	Mastering clichéd phrases and expressions used in scientific speech
	Ability to build a logical and coherent statement, to argue a point of view	Development of scientific discussion, argumentation, presentation skills
Strategic	Ability to compensate for lack of language skills by using verbal and non-verbal strategies	Development of skills of independent search and processing of foreign-language scientific information
	Ability to draw on additional resources (dictionaries, reference books, online sources)	Using online resources and technologies for professional self-development
	Development of learning skills and strategies for independent work on foreign language acquisition	Development of skills of compensatory use of non-verbal means of scientific communication

Source: compiled by the authors based on Benharoun (2022), Idris & Widyantoro (2019), Taguchi (2019)

Thus, the FLCC of science students is a complex integrative formation, including linguistic, sociocultural, pragmatic and strategic components. These components are in close interrelation and interaction. Their complex development in the process of professionally oriented foreign language training is a necessary condition for the formation of future specialists' ability to full-fledged intercultural professional communication (Nugroho, 2019). Along with the considered components in Table 1, in the structure of FLCC of students of natural science profile it is reasonable to identify several professionally oriented sub-competences reflecting the specifics of their future activities (Table 2).

Table 2. Professionally Oriented Sub-Competences in the Structure of FLCC of Students of Natural Science Specialities

FLCC sub-competencies	Sub-Competence Content	Professionally Oriented Specificity
Research	Ability to carry out research activities by means of a foreign language	Development of skills of searching, analysing, interpreting foreign-language scientific information
	Ability to maintain research documentation in a foreign language	Mastering the genre and stylistic features of foreign-language scientific discourse
	Ability to write and publish scientific articles in foreign journals	Development of critical thinking skills, argumentation of conclusions in a foreign language
Academic	Willingness to engage in various forms of academic interaction	Mastering the speech etiquette of academic communication
	Listening to lecture material and note-taking skills	Mastering the specifics of the organization of the educational process in foreign higher schools
	Ability to deliver scientific papers and presentations	Development of skills to participate in seminar discussions in a foreign language
Information Technology	Ability to use digital tools and resources to solve professional problems	Mastering subject-oriented software tools and databases
	Ability to search for scientific information in the foreign-language segment of the Internet	Developing skills in preparing multimedia presentations and infographics in a foreign language
	Knowledge of netiquette and effective online communication in professional communities	Training in effective online communication in professional online communities
Intercultural professional-communicative	Knowledge of norms and traditions of business and scientific communication in the countries of the learnt language	Development of skills to overcome intercultural barriers in the professional environment
	Ability to anticipate and resolve communicative conflicts in a multicultural environment	Mastering strategies for effective interaction in international scientific teams
	Development of qualities of tolerance, empathy, respect for cultural diversity	Ability to adapt to a different culture of professional communication

Source: compiled by the authors based on Herrero (2019), Shapiro and. Keller (2006), Lazzat (2018)

The structure of foreign language communicative competence of natural science students includes both general components (linguistic, sociocultural, pragmatic, strategic) and special professionally oriented sub-competences (research, academic, information-technological, intercultural professional-communicative) (Sylenko, 2024). All of them are closely interrelated and comprehensively realized in various situations of scientific and professional interaction.

The content of each FLCC component and sub-competence is determined by the specifics of students' future professional activity and correlates with the requirements of educational standards and employers' demands. It is necessary to take into account the dynamic nature of professional foreign-language communication due to the development of science and technology, the emergence of new forms and means of communicative interaction. This requires regular updating of the content of training and technologies of FLCC formation in accordance with the current needs of the scientific and professional sphere. The identification of the essence, component composition and sub-competences of students of natural science specialities serves as a basis for building a methodological system of its formation. The complex nature of this competen-

ce implies the necessity to apply an integrative approach that ensures the interrelated development of all components and sub-competences in the process of professionally oriented foreign language training. It is important to take into account students' personal characteristics and individual needs, their initial level of foreign language proficiency, actual and prospective tasks of professional development (Adilzhanova et al., 2024).

The formation of FLCC should be gradual and systematic, involving gradual complication of students' learning and cognitive activity, and transition from educational and professional situations to real scientific and professional communication. It is necessary to widely use active and interactive teaching methods, modelling the context of future professional activity, involving authentic scientific materials and multimedia teaching tools, and creating conditions for foreign language immersion and intercultural interaction of students (Karamyshev et al., 2024). The effectiveness of the process of FLCC formation depends largely on the level of motivation and involvement of students (Paudel, 2021). It is necessary to develop their value attitude to a foreign language as a means of professional development and international scientific communication, to stimulate cognitive activity and independence in language acquisition. An important role is also played by the organization of students' reflexive activities aimed at reflecting on the results achieved, understanding the difficulties encountered and identifying further prospects for language and professional growth.

A significant factor of successful FLCC formation is the creation of a favourable educational environment that provides language and socio-cultural support for students (Mavuru & Ramnarain, 2020). This involves the organization of various forms of extracurricular activities in a foreign language (study groups, clubs, conferences, Olympiads), the involvement of native speakers and foreign specialists in the educational process, the development of academic mobility programmes and international exchanges. An important resource is also the use of the digital environment, which provides access to authentic materials and online courses, participation in network projects and professional online communities (Lavrysh et al., 2021). Undoubtedly, the leading role in the formation of students' FLCC belongs to the foreign language teacher. He acts not only as a translator of knowledge and skills, but also as a facilitator, counsellor, moderator of intercultural professional communication. This requires from the teacher a high level of linguistic and methodological competence, readiness for continuous professional development, mastering innovative technologies and teaching tools. Important qualities are also communication skills, empathy, tolerance, and the ability to create a favourable psychological atmosphere in the classroom, to support students' motivation and interest in learning the language and culture (Bocheliuk et al., 2023; 2019).

The formation of foreign language communicative competence of students of natural sciences is a complex, multidimensional process that requires a comprehensive approach and consideration of various linguistic, psychological, pedagogical and methodological factors. The effectiveness of this process depends on the scientifically-based definition of the essence, structure, and content of FLCC, the development of an adequate methodological system, the creation of favourable organizational and pedagogical conditions and educational environment, and the active position and involvement of all subjects of training. The result of the successful formation of FLCC should be the ability of a graduate of a natural science profile to effectively use a foreign language to solve a variety of communicative tasks in scientific and professional activities, his readiness for continuous language self-education and professional and personal growth in the conditions of intercultural interaction. This will allow the specialist to be competitive and in demand in the international labour market, to actively participate in global processes of scientific and technological development and knowledge exchange.

In conclusion, it should be noted that the problem of FLCC formation of students of natural science specialities requires further theoretical understanding and practical development. Prospective directions of research in this area are related to the clarification of the structure and content of FLCC in accordance with the new requirements of the scientific and professional sphere, the development of innovative models and teaching technologies, the search for effective forms of integration of language training into the system of professional education. An important task is also the development of diagnostic tools for assessing the level of FLCC formation, and identifying difficulties and needs of students in the process of mastering a foreign language. The solution of these problems requires the consolidation of efforts of specialists in linguistics, pedagogy, psychology, and foreign language teaching methods, as well as active interaction of universities with employers and the international scienti-

fic community. Only on the basis of such an interdisciplinary approach and social partnership, it is possible to ensure the training of specialists with a high level of foreign language communicative competence and ready for effective professional self-realization in the global scientific and educational space.

The formation of foreign-language communicative competence (FLCC) in students of natural science specialties requires a specific set of theoretical and methodological approaches that emphasize the development of scientific communication skills. These skills are critical for students to effectively engage in international scientific research, academic exchanges, and professional collaborations.

One of the primary approaches used in this study is the professional-competence approach, which centers on the integration of language learning with the development of professional communication skills necessary for success in scientific and research environments. This approach highlights the importance of mastering not only the technical language of specific scientific disciplines but also the ability to articulate complex ideas and engage in discussions with international colleagues. It encourages the acquisition of the linguistic tools required for understanding and producing scientific texts, participating in academic conferences, and contributing to global research initiatives. The professional-competence approach also ensures that students are prepared to navigate the intercultural dimensions of scientific communication, understanding the norms and expectations of scientific discourse in different cultural contexts (Rustamova, 2022).

In addition, the scientific communication approach was specifically integrated into the framework of FLCC formation. This approach emphasizes the development of skills related to writing scientific papers, presenting research findings, and participating in professional dialogues, both in written and spoken forms. The study focuses on teaching students the strategies required for constructing logically sound and cohesive scientific arguments, using appropriate terminology and mastering the structures of academic papers. Furthermore, it supports the development of listening and speaking skills crucial for effective participation in academic seminars, peer review processes, and international collaborations (Byram, 2020).

The subject-professional approach complements these by ensuring that language training is directly linked to the specialized knowledge of the students' scientific fields. This approach facilitates the integration of language skills with the students' academic and professional expertise, enabling them to use the foreign language as a tool for professional cognition and scientific exchange. The subject-professional approach is grounded in the belief that language proficiency in the sciences is not only about vocabulary and grammar but also about the ability to communicate complex scientific concepts and collaborate with professionals from diverse linguistic and cultural backgrounds (Khasanova, 2021).

Furthermore, the professional-personality-oriented approach encourages the development of a student's personal motivation and academic autonomy, which are essential for lifelong learning and continuous professional development. This approach is particularly relevant in scientific fields, where the need for continuous engagement with international literature, self-directed research, and professional networking requires high levels of self-motivation and independent communication skills (Kharchenko & Khrystych, 2022).

The professional-interactive approach plays a crucial role by promoting the use of interactive teaching methods, such as group discussions, debates, and project-based learning, which simulate real-world scientific communication scenarios. This approach fosters critical thinking, peer collaboration, and the ability to negotiate and defend scientific viewpoints, which are key competencies in any scientific career (Turko et al., 2021).

The implementation of the professional-competence approach requires the design of training content in accordance with the requirements of Order of the Minister of Education and Science of the Republic of Kazakhstan No. 604 (2018) on the directions of training of natural science profile, professional standards for specialists of natural science industries, developed by the National Chamber of Entrepreneurs of the Republic of Kazakhstan "Atameken", as well as model curricula for disciplines of natural science specialities, approved by the Ministry of Education and Science of the Republic of Kazakhstan. In addition, when designing the content of training it is necessary to take into account international standards and recommendations, such as Washington Accord (1989) and Sydney Accord (2001), recommendations of international professional associations (International Union of Pure and Applied Chemistry (IUPAC) (Everett & Koopal, 2001); International Union of Biological Sciences (IUBS) (Cleland, 1956); Dublin Descriptors (IUPAC) (Cleland, 1956); Dublin

Descriptors (2024); European Qualifications Framework (EQF) (Explaining the European Qualifications…, 2008)), as well as employers' requests and requirements presented in the form of graduate competency models, job descriptions and corporate standards.

Taking into account these requirements and the specifics of students' future professional activity allows ensuring the practice-oriented nature of language training and its focus on the formation of professionally important communicative competences. This implies the selection of authentic materials reflecting the real context of professional foreign language communication, modelling of typical situations of scientific and professional interaction, development of students' knowledge, skills, abilities, and qualities necessary for effective intercultural communication in the professional sphere.

An important condition for the implementation of this approach is the integration of language training with specialized disciplines of the natural science cycle. This ensures the interrelation of linguistic and subject knowledge, and the development of skills to use a foreign language as a means of professional cognition and scientific communication. Integrated learning can be carried out in various forms: subject-linguistic integrated courses, bilingual modules, project activities of interdisciplinary nature. The professional competence approach also implies a wide use of active and interactive teaching methods (business and role-playing games, cases, discussions, projects), which allow simulating real situations of professional communication, developing practical skills of language use to solve professional problems. At the same time, it is important to involve students in quasi-professional activities in the classroom, and stimulate their activity and independence in language acquisition (Mavuru & Ramnarain, 2020).

Another condition for the implementation of the competence approach is the orientation of the control system on the assessment of the practical ability to use the language in simulated professional situations. This requires the development of authentic testing materials that are as close as possible to the real conditions of professional communication, and the use of various forms and methods of assessment (tests, portfolios, projects, interviews). The professional-competence approach is aimed at the formation of students' practical readiness to carry out professional communication in a foreign language. Its implementation provides strengthening of the professional orientation of language training, integration with subject teaching, orientation to the practical use of language in scientific and professional activities.

The professional-personality-oriented approach emphasizes the development of the learner's personality as a subject of future professional activity. It involves taking into account individual characteristics, needs, and interests of students, creating conditions for their professional and personal self-determination by means of a foreign language (Kharchenko & Khrystych, 2022). The implementation of this approach requires studying the initial level of students' FLCC, their motives and expectations from language training, professional plans and intentions. On the basis of diagnostics, differentiation of training, development of individual educational trajectories, selection of appropriate technologies and learning tools are carried out. This allows providing variability and personal significance of the teaching content, taking into account the different levels of students' language training. The person-centred approach implies a change in the teacher's position: he/she turns from a transmitter of knowledge into a facilitator, a consultant, a moderator of students' learning activities. His/her task is to create favourable conditions for the linguistic and professional development of each student, to support his/her independence and initiative, to stimulate reflection of achievements and difficulties in mastering FLCC (Turko et al., 2021).

An important condition for the implementation of the approach is the use of personal-developmental learning technologies that ensure active communicative and cognitive activity of students and the development of their professionally significant qualities. Such technologies include problem-based learning, educational discussions and debates, role-playing and business games, project activities, case method, portfolio. They make it possible to link the process of mastering FLCC with the professional and personal development of students and the formation of their subject position. The professional-personality-oriented approach also requires the creation of situations of free choice and decision-making in the learning process related to goal-setting, planning and organization of their own learning activities to master FLCC. Students should be able to choose topics and problems for discussion, sources of information, forms of work and presentation of results, which promotes the development of autonomy and self-organization skills (Kharchenko & Khrystych, 2022). These and other approaches have been illustrated in the table (Table 3).

Table 3. Comparative Characteristics of Methodological Approaches to the Formation of FLCC of Students of Natural Science Specialities

Approach	Essence	Basic Principles of Implementation	Teaching Methods and Technologies	Role of the Teacher
Professional-competence	Orientation on the formation of key competences ensuring successful professional activity	Compliance with the requirements of standards and employers' demands	Active and interactive methods (cases, business games, projects)	Organizer of quasi-professional activities, expert
		Integration of language training with specialized disciplines	Authentic materials and assignments	
		Modelling situations of professional communication	Interdisciplinary courses and modules	
Professional-personality-oriented	Taking into account individual characteristics, needs, and interests of students in the language training process	Differentiation of learning	Personal-developmental technologies (problem-based learning, discussions, portfolios)	Facilitator, counsellor, moderator
		Variability and personal relevance of content	Individual educational trajectories	
		Supporting students' independence and initiative	Reflexive methods of self-assessment	
Professional-interactive	Organization of active interaction and cooperation of students in solving communicative tasks	Dialogic and situational learning	Interactive forms (discussions, debates, role plays)	Organizer and moderator of interaction, facilitator
		Co-operation and mutual responsibility	Collective forms of work (pair, group, team)	
		Reliance on students' real speech experience	Problematic and creative tasks	
Subject-professional	Student development as a subject of professionally oriented communicative activity	Stimulation of students' subjective activity	Problem-based and heuristic learning	An assistant in language and professional development, a stimulant for self-discovery and self-development
		Development of mechanisms of self-regulation of speech activity	Project activities, creative assignments	
		Building learning autonomy	Reflexive techniques of self-analysis and self-assessment	

Source: compiled by the authors based on Tursunboy oglu (2021), Saleem et al. (2021), Bergman-Pyykkönen et al. (2024)

The considered approaches in Table 3 define the general strategic guidelines of the process of FLCC formation for students of natural science specialities. Their implementation is based on a set of principles reflecting the regularities and specifics of professionally oriented foreign language training:

1. The principle of professional orientation implies the selection of content and organization of the learning process taking into account the specifics of students' future professional activities. It requires the modelling of situations and contexts of scientific and professional communication, the use of authentic materials and tasks aimed at the formation of professionally significant communicative skills (Khasanova, 2021; Bahno & Serhiichuk, 2023).

2. The principle of integrativity implies the interrelated development of all components and sub-competences of FLCC on the basis of interdisciplinary coordination of language training with specialized disciplines. It requires the use of integrated courses and modules, problem-oriented projects, and cases, providing the trans-

fer of linguistic and subject knowledge and skills in the context of professional communication. The communicative principle implies the priority of active speech practice, modelling situations of real professional interaction, involving students in various types of communicative activities. It requires the use of interactive and dialogue forms of teaching, problem and creative tasks, role-playing and business games, group discussions and projects (Amanov & Ganieva, 2021).

3. The principle of autonomy implies the development of students' ability and readiness to independently manage the process of mastering FLCC and to take responsibility for learning outcomes. It requires the involvement of students in setting individual goals, planning learning activities, their implementation, and evaluation, using effective strategies and techniques of independent learning work, reflection of achievements and difficulties (Lin and Reinders, 2019). The principle of dominance of problem and research tasks implies regular inclusion in the learning process of speech and thinking tasks, cases, web quests, and mini-projects that simulate the process of scientific research and require from students active search and cognitive activity, creativity, and independence in decision-making (Everett & Koopal, 2001).

4. The principle of reliance on the language and speech experience of students requires taking into account the real communicative needs and interests of students, their level of language proficiency, the zone of proximal development. It implies differentiation of training, providing students with the opportunity to choose an individual trajectory of mastering the FLCC, the interrelation of classroom and extracurricular, academic and real communicative activities in a foreign language (Ali, 2019). The principle of cultural appropriateness requires the inclusion of a sociocultural component in the teaching content, reflecting the values, norms, and traditions of foreign-language scientific discourse. It involves the simulation of situations of intercultural professional interaction, the use of authentic materials, video fragments, online resources that provide a "dialogue of cultures" in the context of professional communication (Fitria, 2022). The implementation of these principles provides scientific validity and practical effectiveness of the process of FLCC formation of students of natural science specialities. They determine the requirements for the selection of content, choice of methods, forms, and means of professionally oriented foreign language teaching in the logic of the considered approaches.

The conducted theoretical and methodological analysis allowed defining a set of approaches and principles that constitute the conceptual basis of the process of formation of foreign language communicative competence of students of natural science specialities. Professional-competence, professional-personality-oriented, professional-interactive and subject-professional approaches set the general strategy of this process, focused on the development of future specialists' readiness for effective professional communication at the intercultural level. The principles of professional orientation, integrativeness, communicativeness, autonomy, dominance of problem and research tasks, reliance on students' language and speech experience, and cultural appropriateness determine the main requirements for the practical implementation of the identified approaches in the conditions of language education in higher education. The complementary nature of the considered approaches and principles determines the possibility of their complex application in the process of professionally oriented language training of students. This allows ensuring the comprehensive development of FLCC as a holistic integrative quality of personality, ready and able to continuous language self-education and effective professional self-realization in the conditions of intercultural interaction.

The formation of FLCC of students of natural science specialities is a complex, multidimensional process that requires the creation of special organizational and pedagogical conditions. To ensure the effectiveness of this process, it is necessary to develop a scientifically based model reflecting its target orientations, methodological foundations, content-process characteristics and expected results. Based on the analysis of theoretical provisions and practical experience of professionally-oriented foreign language training in higher education, a structural and content model of FLCC formation for students of natural science specialities was developed, including target, theoretical-methodological, content-processual and resultant blocks.

The target block of the model of formation of foreign language communicative competence of students of natural science specialities serves as a kind of navigator, determining the strategic guidelines and final results of this process. The general goal, crowning the hierarchy of goal-setting, is to achieve a high level of FLCC development as an integrative personal new formation, ensuring the readiness of future specialists for effective intercultural professional interaction. To realize this ambitious goal, it is necessary to

solve several interrelated tasks. Firstly, it is necessary to form in students a solid foundation of knowledge, skills, and abilities that constitute the linguistic, sociocultural, pragmatic and strategic basis of FLCC. No less important is the development of professionally-oriented sub-competences (research, academic, information-technological, intercultural professional-communicative), providing the ability to apply a foreign language to solve problems in various contexts of professional activity. It is necessary to ensure a close relationship and integration of language training with the study of specialized disciplines of the natural science cycle, which will help to form a holistic professional language personality of a specialist (Sagalevich, 1976; Ponomarenko, 2022). Achievement of the set goals is impossible without creating conditions for active communicative-cognitive activity and creative self-realization of students by means of the studied language. Finally, the strategic task is the development of students' ability to autonomously manage the trajectory of FLCC acquisition, the formation of readiness for continuous language self-education throughout their professional career. Thus, the realization of the set of the indicated tasks will allow achieving the general goal and providing the formation of a high level of foreign language communicative competence of graduates of natural science specialities.

The expected result of the model implementation is the achievement by students of the level of FLCC sufficient for effective solution of professional-communicative tasks in research, educational and industrial contexts. It implies the possession of a wide range of knowledge, skills, and abilities that allow one to successfully carry out such types of foreign-language professional activities as work with scientific literature, participation in international conferences and projects, academic mobility, professional communication with foreign colleagues and others.

The theoretical and methodological block of the model reflects the conceptual foundations of the process of forming FLCC of students of natural science specialities. It includes methodological approaches and principles that act as guiding ideas and norms of foreign language training organization. The theoretical and methodological foundation of the model of formation of foreign language communicative competence of science students is based on the organic combination of complementary methodological approaches – professional-competence, professional-personality-oriented, professional-interactive and subject-professional. Their synergy provides multidimensionality and purposefulness of language training, orienting it to the formation of key competences necessary for successful professional self-realization (professional-competence approach), taking into account individual characteristics, needs, and aspirations of students, development of their subjectivity and autonomy (professional-personality-oriented approach), in the process of active collaborative interaction in solving professional-communicative tasks (professional-interactive approach), aiming at the development of the learner as a full-fledged subject capable of conscious self-regulation of his/her speech development (subject-professional approach).

The implementation of these approaches in educational practice is subordinated to a system of principles that serve as a link between methodological guidelines and pedagogical reality. These include: principles of professional orientation, ensuring that the content and organizational forms of training correspond to the specifics of future professional activity; principles of integrativity, aimed at the interrelated development of all components of FLCC in the context of interdisciplinary coordination of language and profile training; communicative principles, postulating the priority of active speech practice and modelling situations of real professional communication; principles of autonomy, oriented to the development of students' ability to independently manage the educational trajectory of mastering FLCC; problem-solving principles, which require regular inclusion of speech and thinking tasks that activate search and cognitive activity; the principles of situationality, which prescribes that training should be organized around communicative situations that recreate real contexts of professional interaction; principles of taking into account the language and speech experience of students, justifying the need for differentiation of training according to the initial level of FLCC and the zone of immediate development of students; principles of cultural appropriateness, which postulates the imperative of incorporating the socio-cultural component reflecting the value and normative foundations of foreign-language scientific discourse into the teaching content. Thus, the theoretical and methodological block of the model, integrating a set of complementary approaches and principles, creates a conceptual framework for the process of forming the FLCC of students of natural science specialities, ensuring its scientific validity, systematicity and effectiveness.

The content-processual block reveals the internal organization of the process of FLCC formation for students of natural sciences. It includes the stages of this process, pedagogical technologies and methods, as well as the content of foreign language training. The process of formation of FLCC of students of natural sciences is carried out step by step, taking into account the logic of development of communicative skills and consistent complication of professionally oriented foreign language activity (Anđić et al., 2022). In the Table 4, the authors identified the following stages.

Table 4. Stages of Formation of Foreign Language Communicative Competence of Students of Natural Science Specialities

Stage	Purpose	Main content
Motivational and orientation	Formation of positive motivation and value attitude towards mastering the FLCC	Familiarization with the aims, objectives and expected outcomes of foreign language training
		Awareness of the importance of FLCC for professional development
		Creating conditions for developing intrinsic motivation for language learning
Informational and analytical	Mastering the knowledge system that forms the basis of the FLCC	Formation of linguistic, sociocultural and methodological knowledge
		Development of skills in analysing and interpreting professionally relevant information in a foreign language
		Familiarization with methods and strategies for independent language work
Productive-activity	Development of skills of professionally oriented communicative activity	Active participation of students in various types of speech activities (dialogues, discussions, role-plays, projects)
		Integrated development of all FLCC components based on modelling situations of professional communication
		Use of interactive and problem-seeking teaching methods
Reflexive and evaluative	Reflecting on the results achieved, assessing the level of FLCC development	Reflection of learning activities, analysing difficulties and ways of overcoming them
		Self-assessment of the level of development of individual FLCC components using special assessment tools (scales, questionnaires, language portfolio)
		Determination of individual goals and trajectories of further language self-education

Source: compiled by the authors

The implementation of these stages is cyclical, assuming the possibility of returning to the previous stages to consolidate and improve the formed skills (Table 4). Thus, based on the analysis of theoretical provisions and practical experience of professionally oriented foreign language training in higher education institution, a structural and content model of FLCC formation for students of natural science specialities has been developed. The model is holistic and systemic in nature, reflecting the target orientations, methodological basis, content and technological features and expected results of this process. The graphical representation of the model allows illustrating the interrelation and interdependence of all its structural blocks and components (Table 5).

Table 5. Model of Formation of Foreign-Language Communicative Qualification of Students of Natural Science Specialities in the Process of Professionally Oriented Training

Target block			
Purpose: Formation of students' foreign-language communicative qualifications in the process of professionally oriented training			
Main components (sub-competences) of FLCP of science students			
Professional-oriented linguistic sub-competence	Professional-oriented sociolinguistic sub-competence	Professional-oriented cognitive sub-competence	Professional-oriented reflective-developmental sub-competence
Theoretical and methodological block			
Methodological approaches: professional-competence approach, professional interactive approach, professional-oriented approach, subjective-professional approach		Principles: the principle of problem-based and interactive organization of the educational process; the fundamental principle of fundamental education; the principle of professionalization; the principle of reflexive self-regulation	
Substantive and procedural block			
Training and methodological manual for professionally oriented foreign language		Programme for the elective subject "Formation of foreign language communicative qualifications of students of natural sciences in foreign language education"	
Modern pedagogical technologies of formation of foreign language communicative qualifications of students of natural science direction in the process of professionally oriented training: interactive technologies, role-playing technologies		System of exercises and a set of tasks for the formation of communicative qualification of students of natural sciences in the process of professionally oriented training	
Main stages of formation of foreign language communicative qualification of students of natural science specialities in the foreign language process of professional training			
Motivational stage	Activity stage	Result stage	
Results block			
Criteria of formation of students' foreign-language communicative qualification in the professionally oriented learning process			
Productive participation in communication in solving professional and social tasks (ability to organize the exchange of verbal and non-verbal information)	Ability to solve professional contextual situations in the sphere of communication (develop strategies and tactics of interaction);	Ability to work in a diverse social group (ability to organize joint activities focused on achieving common goals)	Reflexion and adequate self-assessment as a subject of professional activity and interpersonal communication (diagnosis of personal qualities, identification of oneself and the qualities of the interlocutor)
Levels of foreign language communicative qualification of students of natural-oriented professional training process			
Elementary	Effective	Creative	
Result: Student with foreign language communicative qualification in the process of optimal professionally oriented training			
Complex of linguodidactic conditions of realization of foreign language communicative qualification of students of natural science specialities in professionally oriented educational process			
Determination of the structure of formation of foreign language communicative qualifications of students in the process of professionally-oriented training in the analysis of relevant professional activity	Step-by-step formation of students' foreign-language communicative qualifications in the process of professionally oriented training	Intensification of the process of formation of students' foreign language communicative qualifications in the process of professionally oriented training	Entering a foreign environment through role-playing and business games, reading authentic texts, discussions, problem situations, and creative assignments

Source: compiled by the authors

The developed structural and content model of FLCC formation for students of natural science specialities is holistic and systemic in nature. It covers target guidelines, theoretical and methodological bases, content-processual aspects and expected results of foreign language training of future specialists. The effectiveness of the practical implementation of this model is conditioned by the creation of a set of linguodidactic conditions that ensure the integration of language and professional training. The key condition is to ensure interdisciplinary links between language and profile disciplines by coordinating their work programmes, and developing integrative assignments and projects. No less important is the immersion of students in active communicative activity through the modelling of problematic professional situations and cases requiring the creative application of language knowledge and skills. The implementation of the model also implies the strengthening of students' autonomy and responsibility for learning outcomes, which is achieved through their involvement in the process of goal-setting, selection of content and trajectory of language training, use of self-assessment methods and language portfolio.

The important condition is to ensure sociocultural orientation of learning through modelling situations of intercultural professional interaction, development of students' cultural sensitivity and tolerance. Optimization of the process of FLCC formation is facilitated by structuring the content of training in the form of professionally oriented modules reflecting typical spheres and situations of language use in future professional activity. Improving the effectiveness of language training is ensured through the use of a wide range of active methods and information and communication technologies, an organic combination of classroom and independent work of students (Mynbayeva et al., 2019; Balykbayev et al, 2022). An essential component of the process of FLCC formation is extracurricular activities in a foreign language (scientific conferences, seminars, projects), contributing to the development of motivation, and expanding the spheres of practical application of the language. The necessary prerequisite for the effective implementation of the model is the professional development of foreign language teachers in the field of students' subject specialization.

Practical implementation of the developed model, taking into account the set of the identified linguodidactic conditions, will provide an integrative, professionally oriented character of language training of students of natural science specialities. It will contribute to the increase of motivation for language learning, development of the ability to intercultural professional interaction, formation of readiness for continuous language self-education during the whole professional career. As a result of the model implementation, students are predicted to achieve a high level of FLCC, providing the ability to effectively solve a variety of communicative tasks in research, academic and industrial contexts.

A comparative analysis of the theoretical provisions presented in the work of Hoff (2020) and the results of this study reveal commonality in the interpretation of foreign language communicative competence as a multicomponent integrative construct. Both studies recognize the complex nature of FLCC, including linguistic, sociocultural, discursive and strategic aspects. Both studies recognize the multidimensionality and integrativeness of FLCC, considering it as a complex entity that combines knowledge, skills, and abilities from different subject areas. However, while Hoff (2020) focuses mainly on the theoretical understanding and categorization of the structural components of FLCC, this paper takes a step forward by proposing a specific model of its formation. Moreover, this model is not universal, but takes into account the specifics of professional training of students of natural science profile. Thus, the transfer of general theoretical provisions to the plane of real educational practice, their adaptation to the specific conditions and needs of the target audience is provided.

The communicative-oriented approaches to language teaching, which serve as a methodological basis for this study, receive a comprehensive coverage in the work of Dos Santos (2020). The author analyses in detail the essence, principles, and technologies of communicative teaching, assesses its potential in the development of students' foreign language competence. In many ways similar to the position of the researcher, especially in terms of recognizing the priority of communicative goals and active learning methods, the present study, however, has its own specificity. It focuses on the application of the communicative approach in the context of professionally oriented training of students of specific specialities. While the researcher considers its possibilities in the broadest educational context, the present work narrows the scope of analysis to the level of language training of future specialists of natural science profile. This allows concretizing the general didactic provisions and filling them with subject content related to the specifics of professional communication in this field.

Emphasizing the role of the socio-cultural component of FLCC, consistently carried out in the monographic study by Byram (2020), is consonant with the presented model. In the author's interpretation, the intercultural professional-communicative sub-competence appears as an integral and largely determining component of the integral language personality of a modern specialist. The ability to interact effectively with representatives of other cultures in situations of professional communication is recognized as a key factor of success in the conditions of globalization of science and production. Despite the closeness of the initial positions, this study, unlike the work of the researcher, does not limit itself to general theoretical declarations, but traces specific ways of implementing the sociocultural approach in professionally oriented training of students of science specialities. The proposed model demonstrates how the principles of this approach can be embodied in the content, methods, and means of FLCC formation, taking into account subject specifics and educational context.

This study confirms the conclusions about the effectiveness of group forms of work in the formation of communicative skills, experimentally substantiated in the publication by Crisianita and Mandasari (2022). The authors demonstrate that the organization of the learning process in an interactive format, involving active speech interaction of students in pairs and small groups, contributes to the intensive development of speaking skills. Based on these data, the presented study includes interactive methods, such as discussions, role-playing games, and projects, in the arsenal of means of FLCC formation for science students. At the same time, the developed model does not absolutize group forms of work and is not limited only to the interactive format. It assumes complex and flexible use of various teaching technologies, the combination of collective and individual forms of learning activities, variation of methods depending on the goals and stages of work. This approach seems to be more balanced and corresponds to the complex nature of the FLCC formation process itself.

The optimistic findings on the role of mobile apps in language development presented in the meta-analysis by Loewen et al. (2020) are echoed in this study. The authors agree with the idea of the high potential of mobile technologies in intensifying and individualizing students' language training. The possibility of flexible access to learning resources, autonomous control of learning trajectory and pace, and instant feedback make mobile applications an effective tool for FLCC development. At the same time, this paper does not absolutize the role of digital tools and does not consider them as a self-sufficient alternative to traditional learning. In the proposed model, mobile resources act as a component of the learning process, organically combining and interacting with other forms and methods of classroom and independent work of students. This balanced approach allows optimizing the process of FLCC formation without violating its systemic integrity.

The relationship of foreign language communication readiness with affective variables demonstrated in the meta-study by Elahi Shirvan et al. (2019), is taken into account in this paper. The authors recognize that the success of FLCC acquisition depends largely on learners' psychological attitudes, motivation, self-esteem, and emotional states. Considering these individual-personal factors is an important condition for the implementation of the person-centred approach underlying the proposed model. At the same time, unlike the above meta-study focused on the analysis of correlations between affective and communicative variables, this paper focuses on the content-processual aspects of FLCC formation. Psychological factors are considered as significant but not determinants of the success of this process, requiring consideration and pedagogical support, but not replacing the content and methodological components of language training.

Despite the experimentally proven by Chen and Hwang (2020) the effectiveness of concept mapping technology in the development of students' verbal and thinking skills, this strategy of cognitive visualization is not directly applied in the presented model. The latter relies on somewhat different ways of structuring and presenting learning material, such as mind maps, information graphs, conceptual diagrams. This choice is conditioned not so much by didactic considerations as by the specificity of the professional context of science training. These formats of information presentation are more organic for exact and natural sciences, are familiar to students of the corresponding specialities, and are consistent with general scientific methods of systematization and generalization of knowledge. Thus, cognitive-visual teaching strategies are adapted to the peculiarities of professional thinking of future specialists.

The generalized principles of communicative speaking instruction, systematized in the review article by Burns (2019). Based on the analysis and synthesis of numerous studies in this area, the author identifies key concepts and approaches to the development of speaking skills, con-

siders their didactic potential and conditions of effectiveness. This work supplements and concretizes these general didactic provisions, transferring them to the plane of professionally oriented linguistic training of students of natural science profile. The principles of situationality, problematicity, interactivity, autonomy, systematized by the researcher, are filled here with a specific subject content related to the specifics of professional communication in this sphere. In this way, the interrelation of general laws of language education and specific conditions of their realization is ensured, taking into account the target audience and educational context.

To summarize, we can state that the conducted research generally fits into the modern scientific context, correlating with the current theoretical and empirical research in the field of FLCC formation. Its distinctive feature is the aspiration to offer a holistic and at the same time professionally labelled solution to the problem of language training of students of/ natural science profile. The transfer of general pedagogical and linguodidactic provisions into the subject field of specific educational practice determines the theoretical and practical value of this work. At the same time, the identified limitations of the study indicate the need for its further deepening and detailing, taking into account a wider range of organizational, pedagogical and individual-psychological variables affecting the effectiveness of the process of FLCC formation.

CONCLUSIONS

The research successfully established the essence, structure, and content of Foreign Language Communicative Competence (FLCC) for natural science students, defining it as a complex integrative formation with linguistic, sociocultural, pragmatic, and strategic components alongside professionally oriented sub-competences. Through the development of a comprehensive structural-content model incorporating target, theoretical-methodological, content-processual, and resultant blocks, the study identified essential linguodidactic conditions that effectively bridge language training with specialized scientific disciplines. Implementation of this model yields significant impacts by enhancing students' ability to communicate effectively in professional and academic settings, fostering academic autonomy, and preparing graduates for participation in international research and professional networks. This integration of language education with contemporary professional standards directly addresses the growing demand for multilingual competence in global scientific collaboration, ultimately improving higher education outcomes while acknowledging limitations regarding implementation across other professional domains and accounting for students' varying initial FLCC levels.

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