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EDITED BY
Wang-Kin Chiu,
The Hong Kong Polytechnic University, China

REVIEWED BY
Raquel Fernández-Cézar,
University of Castilla-La Mancha, Spain
Marta Segura,
International University of Catalonia, Spain

*CORRESPONDENCE
Aziza Kenzhe
✉ kenzhe.aziza@okmpu.kz
Ainur Zhorabekova
✉ ainur.zhorabekova@auezov.edu.kz

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Integrated teaching methodology in the development of foreign language professional communicative competence on the discipline "organic chemistry" at Kazakhstan University

Aziza Kenzhe[1]*, Aliya Bitemirova[1], Ualikhanova Bayan[2], Saule Bitursyn[1] and Ainur Zhorabekova[3]

[1]Department of Chemistry, South Kazakhstan State Pedagogical University, Shymkent, Kazakhstan, [2]Department of Physics, South Kazakhstan State Pedagogical University, Shymkent, Kazakhstan, [3]Department of Foreign Language for Technical Specialties, M. Auezov South Kazakhstan University, Shymkent, Kazakhstan

Introduction: In Kazakhstan, acquiring a foreign language is a prerequisite for advancing chemistry education, enabling students to access global scientific advancements, establish international professional connections, and exchange knowledge. This study examines the implementation of CLIL/ICLHE to enhance foreign language professional communicative competence (FLPCC) in chemistry. Based on this approach, a training model and a set of exercises were developed.

Methods: A quasi-experimental design was employed to compare the results among third-year students enrolled in the "Chemistry Teacher Training" educational program divided into experimental and control groups through pre-test and post-test assessments. The experimental group received training based on modeling, while the control group received traditional teaching. The experimental set of exercises was implemented during the 5 and 6th semesters of the academic year. The experiment consisted of three stages: preparation stage, forming stage and verifying stage.

Results: All data were analyzed using the independent samples t-test. The mean values and standard deviations for each criterion were evaluated in the control and experimental groups. The initial pre-test analysis indicated no significant differences between the groups, validating the equivalence of their baseline levels. However, after conducting the experiment, the results showed that the experimental group outperformed the control group across all measured criteria. These findings suggest that the proposed methodology positively influenced the development of various skills in students.

Discussion: The set of exercises was piloted during the experiment, and its effectiveness was evaluated through a comparison of pre-test and post-test results. The analysis using the t-test revealed a developmental trend across all criteria for the FLPCC components compared to the initial levels. However, one limitation of CLIL/ICLHE approach is that a single lesson may be insufficient to fully cover a single topic due to the extensive number of tasks involved. This limitation highlights the need for additional instructional time.

KEYWORDS

professional-communicative competence, foreign language competence, CLIL, model, methodology of teaching chemistry

1 Introduction

The study of developing students' foreign language professional communicative competence (FLPCC) in higher education is closely tied to the social demands of contemporary society, particularly in fostering the ability to apply communication skills in professional contexts. In 1995, The European Commission (1995) emphasized the importance of multilingual communication skills in modern society. Moreover, the Commission highlighted the significance of bilingual education, referring to the teaching of various subjects in a foreign language (Eurydice, 2006).

Additionally, Yrsaliyev et al. (2017), citing the platform The World's Largest Ranking of Countries and Regions by English Skills, reported that over 150 studies conducted in the past 50 years have demonstrated that students who study two or more languages at school acquire a deeper understanding of language and develop more effective communication skills.

Aligned with its national language policy in education, Kazakhstan became the first country in Central Asia to introduce Content and Language Integrated Learning (CLIL), which incorporates the use of three languages as mediums of instruction for certain subjects (Karabassova, 2018). However, globally, Kazakhstan is ranked at a "Very Low Proficiency" level according to the The World's largest ranking of countries and regions by English skills (2024).

Furthermore, Gimeno et al. (2010) concluded that there is a growing global demand for English language acquisition due to its status as the language of the international scientific community, technology, multimedia, and its utility for professional mobility and cultural exchange. This trend underscores the need for further research into the implementation of CLIL, also referred to as ICLHE (Integrated Content and Language in Higher Education), as an effective and appropriate approach for developing the future chemistry teachers' FLPCC in higher education institutions, particularly in the context of the modern job market.

The former President of Kazakhstan, Nazarbayev (2015) consistently emphasized the importance and the role of language policy development in a multinational Kazakh society during his speeches and addresses. As part of the "100 concrete steps" National Plan, the President of the Republic of Kazakhstan mandated the transition to English-average instruction in higher educational institutions, specifically at the 79th step.

During the analysis of scientific and methodological materials, several crucial issues have emerged, underscoring the need for scientific research work. These issues include:

- Insufficient research dedicated to substantiating and developing models for the formation of students' FLPCC in higher education institutions through integrated training.
- Inadequate systematic investigation into the effectiveness of CLIL courses in non-linguistic university settings.
- Limited development of educational tools aimed at the formation of future chemical specialists' FLPCC.

Moreover, our research aims to explore effective methods for the formation of foreign language professional communicative competence of students, specifically within English or multilingual instructional settings. The aim is to equip students with the necessary skills to excel in their future professions.

Aligned with the aim of our study, the following research questions were formulated:

Q1: What are the challenges associated with implementing CLIL in higher education institutions in Kazakhstan?

Q2: What is the impact of the methodology developed based on the ICLHE approach?

2 Literature review

Communicative competence is one of the key components of effective interaction in the process of learning and teaching foreign languages. This competence, according to Hymes, is elucidated as "the speaker's ability to participate in a society not only as a speaking member but also as a communicative member," as cited in Remache (2016). Moreover, it is "a feature of a language user's knowledge of the language that allows the user to know "when, where, and how to use language appropriately" (Diaz-Rico and Weed, 2010).

According to Kuluşaklı and Genç (2024), communication in a foreign language requires proficiency in speaking skills, which is crucial to enhance the effectiveness of communication tools and methods. Shemshurenko et al. (2019) underscore the effectiveness of transition from practice-oriented activities, such as exercises, to theory, from real-life examples to rules, rather than adopting a theoretical-to-practical approach, to cultivate self-directed learning based on communicative teaching. By engaging in tasks that present challenges, students develop critical thinking skills through the analysis of authentic situations, enhance their motivation, and become accustomed to conducting independent research. Consequently, linguistic self-organization is fostered by emphasizing the ability to proficiently employ the rules of the target language, rather than solely focusing on declarative knowledge of those rules.

Shishova (2015) believes that communicative competence holds a special place in the description of a teacher's professional personality. This is because it encompasses a comprehensive set of pedagogical knowledge, skills, and abilities that are manifested through pedagogical communication. Indeed, the process of communication during instruction fosters the development of competencies that assist students in their future professional endeavors.

Furthermore, according to the research conducted by Elbers (2012), language-integrated learning is essential for stimulating the development of learners' content language, i.e., their professional communicative skills. This approach entails subject teachers integrating language and content instruction within their subject-based teaching.

Kovacikova (2019) explains that in English as a foreign language (EFL) lessons, the language itself becomes the subject matter. Additionally, CLIL is a methodology that serves multiple objectives in

terms of the interplay between language and non-linguistic subjects, providing room for education. The author highlights that a well-prepared and organized CLIL lesson significantly contributes to the development of speaking skills.

Numerous technologies for teaching foreign languages within an integrated approach have been identified. However, an extensive examination of scholarly literature leads us to assert that among these methods, CLIL stands out as one of the most effective approaches for cultivating the fluency of future chemists in their professional field. Consequently, our research highlights the imperative to investigate the significance of CLIL teaching technology and its implementation in universities.

Ruiz-Madrid and Fortanet-Gómez (2023) note that research on content and language integration began to flourish at the turn of the millennium, driven by significant transformations in some European universities. The researchers describe how the language of instruction often functions as a *lingua franca*—a common language used among speakers with different native tongues. Furthermore, the language learning process extends beyond traditional language courses to include content-based subjects taught in English, thereby integrating language acquisition with disciplinary knowledge.

In the work of Marsh et al. (2001), the authors describe how the concept of CLIL was introduced in 1994 to characterize educational settings where subjects are taught in a foreign language. This approach is presented as a dual-focused methodology, integrating content and language instruction to be taught simultaneously.

Furthermore, Coyle et al. (2010) have developed the "5Cs Framework" as a key feature of the CLIL methodology, which provides a comprehensive perspective of CLIL pedagogy on its fundamental elements. This framework encompasses the interplay of content, cognition, communication, culture, and competence ('can-do' statements). Content pertains to the subject matter being taught, cognition relates to the cognitive processes involved in learning, communication focuses on language acquisition and usage, and culture emphasizes the role of learning in fostering cross-cultural and interpersonal understanding. Therefore, CLIL extends beyond language acquisition and content knowledge alone. As highlighted by Cimermanová's research (Cimermanová, 2021), communication in a foreign language is considered a core competence in lifelong learning and has been a subject of instruction for centuries. The aim of CLIL is not simply to teach a foreign language, but rather to develop a methodology that promotes language learning and long-term retention as a means of effective communication. This approach is based on both subject-specific objectives and language learning objectives. In accordance with Smit and Finker (2022) definition, CLIL has become an integral component of most European school systems due to the multilingual demands of globalization and mobility. It involves the adaptation of teaching content subjects such as biology, history, or mathematics in English or, occasionally, another language that is not the first language of teachers and students.

According to the definition provided by the Language Network for Quality Assurance (LANQUA) project, 2007–2010, CLIL was initially conceptualized as a dual-focused pedagogical approach that integrates the study of a second, foreign, or target language with subject-specific knowledge delivered in that language. However, as noted earlier, CLIL is associated with numerous definitions and terms. Furthermore, since CLIL has become a well-established concept in European primary and secondary education, it has been proposed to add the designation "HE" (Higher Education) for its application in university contexts. This addition aims to serve as an umbrella term encompassing specialized and academic instructional approaches within higher education (LANQUA, 2010).

The term ICLHE was first introduced during a 2003 conference in Maastricht, specifically to address content and language integration in higher education. The idea was to provide CLIL with a unique designation for use in universities (Smit, 2009). Moreover, the intention was to establish a broader term that could distinguish higher education practices from those in primary and secondary education, as well as from the European context (Fortanet-Gómez, 2013).

Through theoretical research, de Zarobe (2017) identified the growing international adoption of ICLHE in diverse contexts, including Israel, Japan, and Indonesia. Similarly, Ruiz-Madrid and Fortanet-Gómez (2023) concluded that the ICLHE approach should encompass not only language acquisition and pedagogical preparation but also comprehensive methodological strategies that effectively integrate content and language within higher education teaching practices.

A comprehensive review of 21 studies conducted by Goris et al. (2019) examined the evaluation of CLIL's contribution to English language competencies over the past two decades. This review's hypothesis that CLIL students develop stronger EFL skills compared to non-CLIL students did not receive unequivocal support. According to the scholars (Goris et al., 2019), while null effects were predominantly observed in Germany and other Nordic countries, significant effects were more prevalent in Spain. Additionally, the research of CLIL implementation in Japan, conducted by Godfrey (2016) and Yamano (2019), demonstrates the positive impact of CLIL approaches on student achievement, such as development of various cognitive skills, learning authentic content, increased English language use for communication purposes, and improved understanding of different cultures.

In another study, Jalal and Nawab (2022) investigated the opportunities and challenges of implementing CLIL approach in the chemistry class at school in Pakistan. The CLIL lesson involved introducing chemical concepts in English, followed by tasks aimed at engaging students with the four Cs: content, communication, cognition, and culture. However, this study noted that both the researcher and the students focused more on language aspects, somewhat neglecting the content, that indicated a low level of mastery of the subject matter. However, the research, conducted by Tsang (2020), included teaching chemistry through CLIL at a secondary school in Hong Kong, which demonstrated positive learning outcomes among students with low English proficiency.

A language teacher demonstrates to students what it means to think within a specific subject area, provides examples of language usage in different professional contexts, and assists students in selecting and utilizing appropriate language for thinking and communicating about specific professional subjects.

2.1 Research findings on CLIL/ICLHE in Kazakhstan

Yrsaliyev et al. (2017), based on their research findings and the recommendations of leading experts in multilingual education, describe the framework for training multilingual educators in

Kazakhstani universities. This framework encompasses the following key components:

- Language Instruction: During the 1st and 2nd semesters, 6 credits are allocated to learning a second (L2) and third (L3) language. Professional language courses in L2 and L3 are recommended in the 5th semester.
- Subject Teaching: According to the curriculum, 50% of subjects are taught in L1, 20% in L2, and 30% in L3. Subjects delivered in a foreign language are organized using integrated content and language instruction methodologies, such as CLIL/ICLHE.
- Teaching Methodologies: Students are recommended to study CLIL/ICLHE as a separate subject to acquire the necessary technological and pedagogical skills (Yrsaliyev et al., 2017).

A study by Huertas-Abril and Shashken (2021) utilized SWOT analysis to assess perceptions of CLIL implementation through open-ended questions directed at both CLIL and non-CLIL instructors in Kazakhstan. The findings revealed the strengths, such as CLIL increases student engagement, encourages diversity in task design, enables students to simultaneously acquire linguistic competence and subject knowledge. Among the opportunities, the scholars emphasize that CLIL improves the quality of education, facilitates further development of the CLIL approach. As the weaknesses, they highlight that students' low language proficiency can hinder their ability to grasp subject content and teachers require significant time to prepare lessons in the target language. Furthermore, the reasons of threats they considered lack of dedicated instructional resources and insufficient availability of educational materials.

In their study, Winter et al. (2017) analyzed the perspectives of participants in Kazakhstani nationwide reform initiative aimed at teaching biology, chemistry, physics, and computer science in English. The study focused on general education school teachers who had begun participating in professional development courses designed to enhance their qualifications for teaching core subjects in English. These findings revealed notable regional differences in teacher expectations regarding their students' learning process and teachers' perspectives on assessments of learning outcomes, and their ability to teach their subjects in English.

Kuzembayeva (2022) analyzed teachers' reflections on their experiences and challenges in implementing the CLIL approach in Kazakhstani trilingual schools during the pandemic in the context of distance learning. This study classified data based on several factors: preparation for teaching, resources utilized by teachers, student interaction during lessons, and the attitudes of stakeholders toward the approach. The findings underscored some significant challenges in fully implementing CLIL, such as inadequate language proficiency (many students were unprepared to fully engage with content taught in a foreign language, necessitating the occasional use of the native language (L1) during lessons) and insufficient teaching resources (a shortage of CLIL-specific instructional materials and methodological guides hampers effective lesson delivery).

Above, we discussed the state of CLIL implementation in Kazakhstani secondary schools. Now, let us turn to the application of CLIL, specifically ICLHE, in universities.

Satayev et al. (2022) investigated the effectiveness of integrating the CLIL approach into a biology course at a university in Kazakhstan. The study aimed not only to facilitate language acquisition but also to enhance contemporary understanding through ICLHE and collaborative learning methods. During the experiment, the researchers observed that teaching a subject in English was a challenging process for a single instructor. As a result, the course was co-taught by a subject instructor and a language teacher, which is not yet a widely adopted practice in the context of Kazakhstan's higher education system.

Analyzing the scholarly work of Arynova et al. (2020), the authors conducted research aimed at activating students' cognitive creativity and developing communication skills through practical engagement. Their study focused on applying ICLHE technology to the course "Chemistry of Elements of the Periodic Table." This approach was structured around the four core elements of CLIL: content, communication, cognition, and culture. The findings demonstrated that the methodology successfully met its objectives, as students actively participated in the learning process, exhibited increased interest in the subject, and expanded their vocabulary with English chemical terminology.

Similarly, the article by Nurdillayeva and Zhuman (2021) explored the application of CLIL (ICLHE) in teaching "Inorganic Chemistry" in English within a higher education context. During the study, course content was delivered in English, with a glossary provided to aid in mastering terminology. A variety of tasks supported learning, including discussions to develop speaking skills, problem-solving questions to enhance cognitive abilities, and exercises involving the writing of chemical reactions. The effectiveness of this methodology was evaluated through student surveys, which revealed increased engagement and interest in the CLIL approach. The comprehensive study further demonstrated significant improvement in both students' linguistic and subject-specific competencies.

3 Methods

This study's main objective is to equip students with the necessary skills to excel in their future professions. By implementing a quasi-experimental process, the study aims to explore effective methods for the formation of foreign language professional communicative competence of students, specifically within English or multilingual instructional settings.

3.1 The model for the formation of FLPCC among perspective chemists based on ICLHE

We developed a model of the learning process designed to develop FLPCC among the students enrolled in the educational programs 6B01504 - "Chemistry Teacher Training" and 6B01507 - "Chemistry-Biology Teacher Training" based on ICLHE (see Figure 1). This model encompasses various components: target, organizational and content, diagnostic, outcome.

The target component of the model is characterized by goals and objectives. Firstly, it aims to foster students' foreign language competence. Secondly, it focuses on the simultaneous enhancement of their professional knowledge. This highlights that during CLIL lessons, students not only acquire subject-specific content but also learn professional English vocabulary, enhance their communication

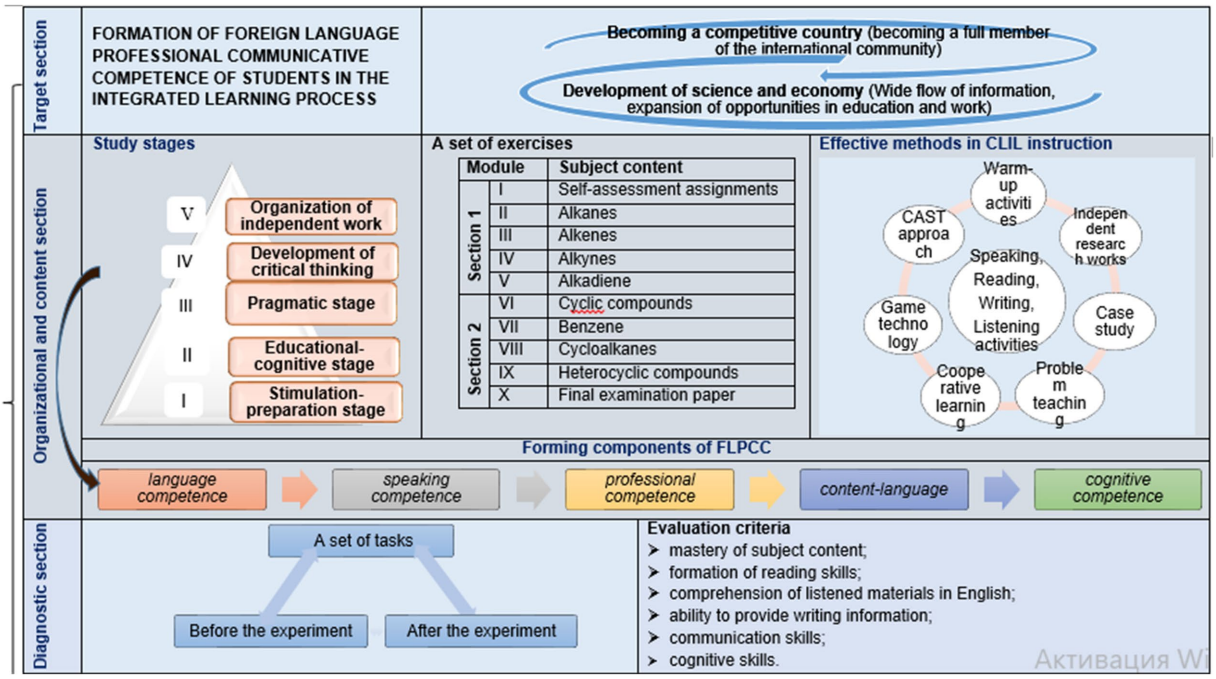

FIGURE 1
A model for the formation of FLPCC among perspective chemistry teachers based on CLIL.

skills, and improve their overall capability to effectively communicate in the realm of chemistry.

The organizational and content component comprises the collaborative training of students through the integrated teaching efforts of two educators: a language specialist and a subject- specific expert. This collaboration occurs within the framework of the "Foreign Language" and "Organic Chemistry" courses. The organizational component includes selecting effective teaching methods, defining the key stages of the instructional process, and structuring the content to align seamlessly with these stages. Specifically, the organizational section of the model provides a set of exercises (an excerpt from the exercise set developed for the topic "Alkanes" is depicted in Appendix) containing 10 modules and 5 stages of teaching these topics and the teaching methods. The instructional process for each lesson within the module consists of five stages, such as: stimulation-preparation stage, educational-cognitive stage, pragmatic stage, development of critical thinking stage, and organization of independent research work stage.

The diagnostic component of the proposed model encompasses monitoring the development of students' FLPCC through a set of exercises designed using a modeling approach. To evaluate the outcomes of the experiment, a two-part assessment was administered, comprising a pre-experiment test and a post-experiment control test. The evaluation criteria and indicators were aligned with the FLPCC components (Figure 2) to ensure comprehensive and accurate measurement.

3.2 Research design

A quasi-experimental design was identified as the most efficient and suitable method for organizing the experiment. As discussed in the works of Cohen et al. (2018) and Shadish et al. (2002), quasi-experimental design allows for the study of real-world experimental conditions without the element of randomization. This approach is particularly useful when participants in the research environment cannot be randomly assigned. In quasi-experiments, the researchers draw conclusions by comparing the results of an experimental group and a control group through pre-test and post-test assessments. This design enables the evaluation of intervention outcomes while maintaining a practical and context-sensitive approach to the research setting.

According to the quasi-experimental design, the set of exercises is intended for students specializing in "Chemistry Teacher Training," the experiment should be conducted with students studying chemistry at the Pedagogical University. Additionally, we took into account the fact that the experimental group and the control group had the same teacher for teaching organic chemistry and the same level of education, based on the nonequivalent design. The participants in both groups also study in a multilingual environment. In this study, the experimental group received training based on modeling, while the control group received traditional teaching. During the training, the experimental group received more language support compared to the control group.

The experiment consisted of three stages: preparation stage, forming stage and verifying stage.

Preparation Stage: In this stage, a pre-test was designed following the principles of quasi-experimental design to assess students' FLPCC. The evaluation criteria included mastery of subject content, reading comprehension, listening comprehension, writing skills, speaking skills, and cognitive development. The pre-test was administered to participants in both the experimental and control groups.

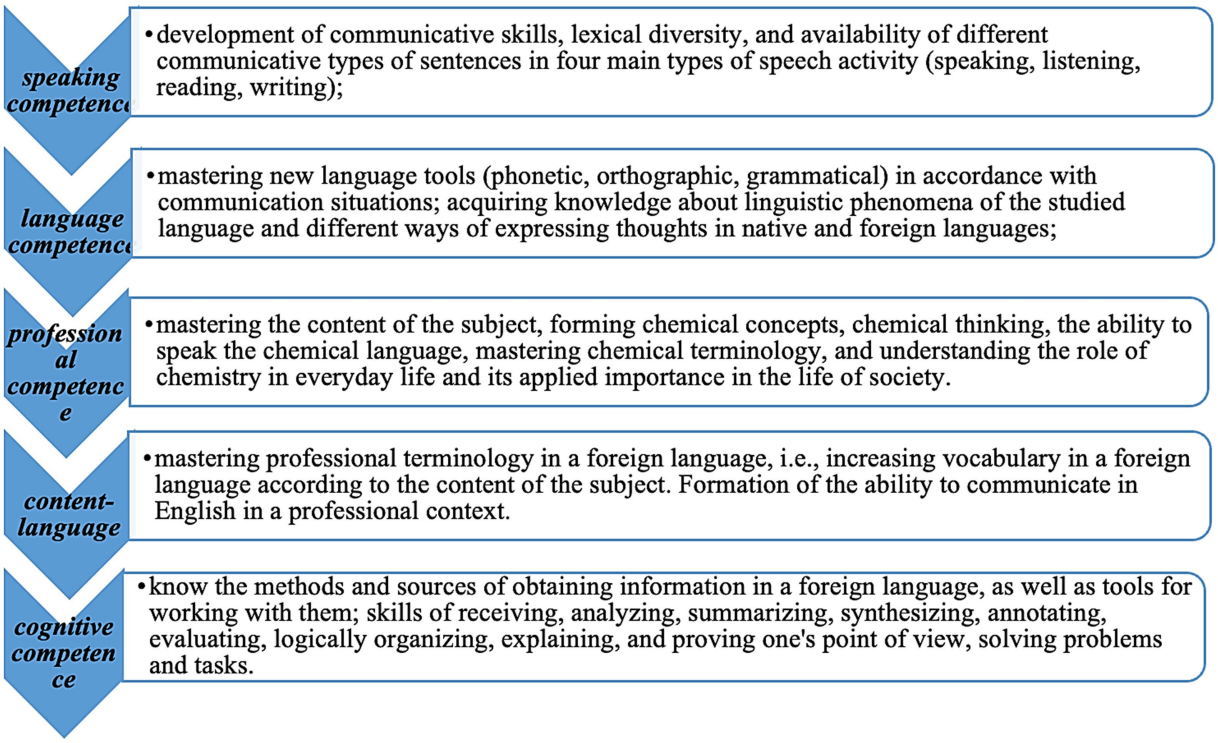

FIGURE 2
Chemistry students' FLPCC components.

TABLE 1 Participants' information.

Study period	Experimental group		Control group	
	Student number	Age	Student number	Age
5-semester	20	19–21	20	19–21
6-semester	20	19–21	20	19–21

Forming Stage: During this stage, the learning process for the experimental group was organized based on the ICLHE framework to enhance students' FLPCC, broaden their understanding of the subject, and increase their interest in using the language of chemistry. The experimental process involved the implementation of a set of model-based exercises designed to foster active participation and motivation among students. Throughout the stage, student engagement and enthusiasm during lessons were closely monitored.

Verifying Stage: In the final stage, the effectiveness of the FLPCC formation model and the instructional system was evaluated by administering a post-test to both groups. The post-test, aligned with six specific criteria, provided data to compare the outcomes of the experimental and control groups. Statistical analysis using the t-Student test was conducted to draw conclusions based on the results obtained.

3.3 Participants

The participants of the experiment were selected among third-year students enrolled in the 6B01504-"Chemistry Teacher Training" educational program at the Faculty of Natural Sciences, Chemistry Department, South Kazakhstan State Pedagogical University. As shown in Table 1, the total number of participants was 40, with 20 students in the Experimental Group (EG) and 20 in the Control Group (CG). The participants' ages ranged from 19 to 21 years. The experimental set of exercises was implemented in two sections: Section I during the 5th semester (first half of the academic year) and Section II during the 6th semester (second half of the academic year).

4 Results

To evaluate the effectiveness of the proposed methodology, pre-tests and post-tests were conducted, as mentioned earlier. Statistical analysis of the results was performed using the independent samples Student's t-test,[1] as both control and experimental groups participated in the experiment. This test was conducted using resources available on the Stanly Statistics Website. The independent

1 https://stanly.statpsy.ru

t-test is suitable for determining statistically significant differences between two groups, enabling reliable conclusions to be drawn.

If the significance level (p-value) of the independent t-test is below 0.05, it indicates a statistically significant difference between the mean scores of the two groups. Conversely, a p-value above 0.05 suggests no significant difference between the groups.

Table 2 presents the differences between the control and experimental groups across various skills. All data were analyzed using the independent samples t-test. The table includes mean values and standard deviations for each criterion evaluated in the control and experimental groups.

As shown in Table 2, the p-values for all criteria exceed 0.05, indicating no statistically significant differences between the control and experimental groups prior to the experiment. For instance, the p-value for Mastery of Subject Content is 0.973, demonstrating no notable differences in students' baseline knowledge levels between the groups.

In contrast, the post-test results (Table 3) reveal statistically significant differences across all measured scales between the control and experimental groups. For example, in the Mastery of Subject Content scale, the empirical t-value is −2.226, and the p-value is 0.032, which is below the threshold of 0.05, confirming significant differences.

Thus, the initial pre-test analysis indicated no significant differences between the groups, validating the equivalence of their baseline levels. However, after conducting the experiment, the results showed that the experimental group outperformed the control group across all measured criteria. These findings suggest that the proposed methodology positively influenced the development of various skills in students.

Despite the promising results, it is important to note that the sample size may have affected the statistical power of the analysis. Therefore, additional research with a larger sample size is recommended to further validate these findings.

5 Discussion

The theoretical framework, based on studies by Arynova et al. (2020) and Nurdillayeva and Zhuman (2021) on CLIL practices in higher education institutions in Kazakhstan, highlights a notable lack of methodological resources for ICLHE lessons. Additionally, in experiments conducted on CLIL lessons in chemistry, tasks designed according to the 4Cs (Content, Communication, Cognition, and Culture) framework were utilized. While these tasks included activities focused on learning subject content, engaging in communication, and developing cognitive skills in English, they placed insufficient emphasis on key language proficiency components, particularly writing and listening skills.

In this context, Ramiro and Perez (2014) argues in their research that writing is a skill requiring significant improvement, especially in higher education, due to its importance in both educational and professional contexts. To address this, he investigated the use of the CLIL approach to enhance students' understanding of text genres in a Spanish university's chemistry program.

The observed gaps in the development of writing and listening skills in CLIL lessons may be attributed to time constraints, as comprehensive coverage of subject content and language development demands considerable time and effort.

TABLE 2 Pre-experimental FLPCC levels in the control and experimental groups assessed using the student's t-test.

Scale	Mean (Control group)	Mean (Experimental group)	Empirical t-value	Significance level (p)
Mastery of subject content	55.75 ± 22.842	55.5 ± 23.164	0,034	0,973
Formation of reading skills	40.5 ± 18.057	40.25 ± 18.601	0,043	0,966
Comprehension of listened materials in English	31.75 ± 17.112	31.5 ± 13.387	0,051	0,959
Ability to provide written information	37.9 ± 20.269	37.65 ± 18.508	0,041	0,968
Communication skills	41 ± 18.18	41.25 ± 20.253	-0,041	0,967
Cognitive skills	45.5 ± 19.752	45.25 ± 19.833	0,04	0,968

TABLE 3 Post-experimental FLPCC levels in the control and experimental groups assessed using the student's t-test.

Scale	Mean (Control group)	Mean (Experimental group)	Empirical t-value	Significance level (p)
Mastery of subject content	64.5 ± 21.207	79 ± 19.974	−2,226	0,032
Formation of reading skills	49.25 ± 21.044	64.75 ± 23.702	−2,187	0,035
Comprehension of listened materials in English	39 ± 16.827	56.45 ± 19.882	-2,996	0,005
Ability to provide written information	44.5 ± 21.392	62.25 ± 17.583	-2,867	0,007
Communication skills	47.5 ± 19.433	70.75 ± 19.282	−3,798	0,001
Cognitive skills	66.65 ± 21.721	79.75 ± 18.601	−2,049	0,048

Moreover, studies indicate that adequate methodologies for integrating the CLIL approach into chemistry content topics have yet to be fully developed. In our research, we addressed this gap by designing a custom methodology based on the CLIL framework, specifically the 4Cs (Content, Communication, Cognition, and Culture) proposed by Coyle et al. (2010). This methodology was applied to the subject Organic Chemistry through a step-by-step organization of lessons, incorporating exercises aimed at developing the following skills: subject content mastery, reading, writing, listening, communication in English, and critical thinking.

The set of exercises was piloted during the experiment, and its effectiveness was evaluated through a comparison of pre-test and post-test results. The analysis using the Student's t-test revealed a developmental trend across all six criteria for the FLPCC components compared to the initial levels.

Furthermore, according to the study by Skinnari and Bovellan (2016), students learning a subject in a language other than their native tongue may exhibit reduced content mastery. However, our observations and research findings indicate the opposite. Specifically, when students engage in completing various exercises aligned with chemistry subject texts, their content retention significantly improves. Even if some details are forgotten, the ability to recall information quickly is enhanced.

This contrasts with traditional teaching methods, where students either listen to or read a plain text, often resulting in rapid memory decay over time. In contrast, conducting lessons in a foreign language, coupled with diverse exercises for each topic, fosters long-term retention of content.

For this reason, the proposed methodology is particularly suited for teaching chemistry in English or to multilingual groups. Notably, the participants in our experiment were also part of multilingual cohorts, further demonstrating the approach's applicability and effectiveness in such contexts.

Marsh et al. (2009) concluded that it is unnecessary to allocate separate time for mastering content and language. The distinctive feature of CLIL lies in its efficient use of time, simultaneously fostering subject content mastery and language skills development. In our study, the set of exercises was specifically designed to concurrently develop both subject-specific and professional English communicative competencies.

However, one limitation of this approach is that a single lesson may be insufficient to fully cover a single topic due to the extensive number of tasks involved. This limitation highlights the need for additional instructional time. Moreover, given the presence of students with lower English proficiency, a contrasting perspective emerged: teaching chemistry in English through CLIL may require twice the usual number of hours to ensure effective learning outcomes.

6 Conclusion

Thus, according to first research question of this paper, the findings revealed several challenges, including the unpreparedness of students and instructors, limited use of English as the primary language during lessons, and the reliance on native (L1 – Kazakh) or secondary (L2 – Russian) languages when necessary. Additionally, the lack of specialized methodological and instructional resources tailored to the ICLHE approach for teaching chemistry at the university level presented significant difficulties. Consequently, the importance of developing students' FLPCC was emphasized, and a methodological framework (modeling) for organizing ICLHE lessons was proposed. Based on this framework, a set of exercises for the Organic Chemistry course was developed.

Moreover, this study aligned with the second research question, investigating the implementation of CLIL/ICLHE to enhance English communicative competence in chemistry. The experiment was conducted based on modeling and utilized a five-stage set of exercises designed within the framework of ICLHE for organizing lessons in Organic Chemistry. Additionally, the effectiveness of the implemented methodology was determined through statistical analysis. Upon further analysis, the findings (t-test) revealed improvements in students' subject-specific and linguistic skills across six identified FLPCC components compared to baseline levels. A deeper analysis of the results showed that, initially, the empirical t-test value for independent samples between the two groups was less than 0.5, with a significance level $p>0.5$, indicating no statistically significant difference. Furthermore, the negative sign of the empirical value indicates that the mean of the first group was slightly lower than that of the second group; however, the difference (e.g., −0.041) was not statistically significant.

Post-experiment results, however, demonstrated notable changes. Among the evaluated criteria, Communication skills showed the lowest p-value (0.001), signifying a substantial improvement in participants' communication (speaking) abilities. In contrast, Cognitive skills exhibited the highest p-value (0.048), indicating relatively less improvement compared to other skills.

However, a limitation of this study was the insufficient time allocated for lessons, which constrained the comprehensive coverage of topics. The results highlight the need for extended instructional time in ICLHE lessons to achieve domain-specific objectives and ensure thorough integration of content and language learning.

According to the findings of this study and related research, while ICLHE lessons often employ criteria-based assessment, it is not consistently recommended for evaluating all subjects in the curriculum of multilingual or English-language chemistry students at universities in Kazakhstan. This is because students with advanced language skills may underperform in content mastery, while those with strong content knowledge but weaker language proficiency may struggle to demonstrate their abilities. This discrepancy presents challenges in ensuring fair evaluation.

To address this issue, the study proposes implementing the developed methodology (modeling) as part of a preparatory course, such as Professionally Oriented Organic Chemistry in English, during the first year. This course would be integrated alongside general education subjects before students undertake specialized courses. Evaluating student performance based on the described criteria during this preparatory phase would better prepare them for understanding and engaging with core chemistry subjects taught in English from the second year onward. By doing so, students would be equipped to fully comprehend the course content, communicate

effectively on subject-related matters, and discuss complex topics confidently.

Moreover, the set of exercises developed using the proposed methodology is suggested as a versatile resource for teaching any subject in a foreign language within an integrated learning framework. The study's findings indicate that the exercises not only enhance language skills but also significantly improve subject-specific competencies. This highlights the potential for broader application of these techniques in content and language integrated learning environments.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the study involving human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation in the study was not required from the participants in accordance with the local legislation and institutional requirements.

Author contributions

AK: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft. AB: Conceptualization, Methodology, Supervision, Validation, Writing – review & editing. UB: Writing – review & editing. SB: Writing – review & editing. AZ: Writing – review & editing, Methodology, Conceptualization, Formal analysis, Investigation.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2025.1374165/full#supplementary-material

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