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Article

# Developing soft infrastructure for economic growth: The role of intercultural competence and STEM on educational transformation

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**Abstract:** This study explores the role of intercultural communicative competence (ICC) and STEM education in building the soft infrastructure necessary for economic development within Kazakhstan's transforming education system. The authors conducted an interdisciplinary analysis, emphasizing the cognitive and communicative aspects of foreign language education in secondary schools, proposing a model for integrating ICC through the use of information and analytical technologies. The research focuses on personalized education, teacher competencies, and student engagement, with experimental methods applied in a Karaganda-based school. The study aims to identify mechanisms and principles that enhance ICC development, contributing to Kazakhstan's modernization efforts in fostering globally competitive graduates prepared for the demands of the international arena. This research lays the foundation for further practical experimentation in profiled schools, aligning education with national development goals.

**Keywords:** soft infrastructure; educational transformation; intercultural communicative competence; STEM; profiled schools; technologies

## 1. Introduction

Kazakhstan's educational transformation is both a response to global shifts in the economic and technological landscape and a strategic initiative to build the soft infrastructure necessary for sustainable economic growth. To support and enhance STEAM education within Kazakhstan, various regulatory documents lay the groundwork for integrating innovative methods and interdisciplinary learning into educational systems.

Kazakhstan's educational transformation is supported by several key regulatory frameworks that together create a stable foundation for STEAM education. The State Program for the Development of Education and Science of the Republic of Kazakhstan for 2020–2025 outlines priorities for advancing education and science, placing emphasis on digitalization, innovative technologies, and an interdisciplinary educational approach, especially in STEAM fields[1]. Another cornerstone document, the Law of the Republic of Kazakhstan "On Education," provides the foundational regulations governing the education system, setting standards and developmental objectives that integrate modern approaches such as STEAM[2]. Complementing these, the Concept of Digitalization of Kazakhstan ("Digital Kazakhstan") for 2023–2029 aims to embed digital skills across various sectors, with a particular focus on equipping future professionals with competencies in technology and programming[3]. The

National Strategy for the Development of Human Capital and Personnel Training underscores skills development tailored to meet the demands of the modern economy, highlighting the importance of STEAM disciplines in preparing a skilled workforce[4]. The Standards for Secondary and Preschool Education in Kazakhstan further define curricular expectations, integrating STEAM elements to foster critical thinking and problem-solving skills among students from a young age[5]. Finally, guidelines issued by the Ministry of Education and Science on STEAM Implementation provide strategies for incorporating STEAM education in schools, including the establishment of labs, project-based learning initiatives, and the use of digital technologies to enhance learning outcomes[6]. Together, these regulatory frameworks form a robust structure supporting the implementation and growth of STEAM education in Kazakhstan, aligning with the nation's broader economic and technological objectives.

Significant to these reforms is the integration of STEM (Science, Technology, Engineering, and Mathematics) with intercultural communicative competence (ICC), aimed at preparing students for an interconnected world. While there is no uniform model for implementing STEM in Kazakhstan, some private and public schools are integrating elements, such as robotics, ICT-enhanced labs, and project-based research, into their educational practices. Tessema and Nicola -Gavrilă (2023) offer essential insights into the effectiveness of online learning methods, alongside the challenges and opportunities for improvement. Their findings underscore a critical belief: The future trajectory of most developing countries hinges on the pace and efficacy with which national education systems are developed.

The concept of soft infrastructure-comprising systems like education, healthcare, and governance-plays an important role in supporting Kazakhstan's broader economic and industrial frameworks. Educational reforms are a main component of this infrastructure, particularly as they address the need for a workforce capable of aligning local expertise with international standards. Integrating STEM into curricula fosters innovation, bridging the gap between traditional education models and the demands of a modern, globally integrated economy.

In this context, intercultural competence has gained significance as a key skill in preparing students for effective communication and collaboration across multicultural and multilingual environments. Kazakhstan's expanding international relations and emphasis on human capital development necessitate a workforce that is technically skilled and culturally aware. This alignment of STEM education with ICC represents a holistic approach to workforce preparation, equipping future professionals for roles in global markets.

Kazakhstan's educational reforms also reflect broader national economic goals, with curriculum updates, teaching methodologies, and new technologies driving long-term development. Specialized schools focusing on tailored training and individualized learning paths are crucial in this transformation, fostering adaptability, critical thinking, and cross-cultural communication in the emerging workforce.

Globalization continues to reshape Kazakhstan's educational landscape, increasing the importance of independent thinking and problem-solving (Agbo and Pak, 2017). As Kazakhstan strengthens its international relations, developing competitive, multilingual professionals for global cooperation becomes paramount, supported by modern language education methodologies (Finch et al., 2018).

Furthermore, transitioning to a 12-year education model is part of this modernization effort, as outlined in the State Program for Education Development (2011–2020) (Colleen et al., 2021).

This paper focuses on the development of intercultural communicative competence (ICC) within specialized schools, examining theories, concepts, and methodologies for effective communication in multicultural settings (Sarwari et al., 2024). The premise is that successful ICC development requires an individualized approach that considers each student's cultural context and learning needs. Teachers' professional skills, cultural literacy, and ability to create multi-level educational scenarios are vital, as is the integration of modern information and analytical technologies to enhance ICC learning (Sims et al., 2023). Personalized education, delivered by skilled educators and supported by technology, is fundamental to developing ICC (Tetzlaff et al., 2020).

This paper is organized to highlight these key assumptions. The Introduction outlines the focus on specialized schools as the setting for ICC development. The Literature review analyzes major ICC theories, identifies essential components, and examines various pedagogical approaches. The research methodology details the methods and data collection techniques used (Sarwari et al., 2024b). The analysis of results interprets findings and highlights significant trends, while the conclusions and recommendations summarize key insights and discuss their practical significance for specialized schools.

## 2. Literature review

Intercultural competencies are essential for collaborative problem-solving across diverse contexts (Alcaraz-Marmol, 2020; Dierdorf, 2020). Programs like Beyindik Mektep exemplify Kazakhstan's response to these challenges by offering specialized education for 11th and 12th graders, with 10% of study time dedicated to applied subjects, helping students deepen their knowledge and prepare for post-secondary success.

These concepts include the development of a "secondary language personality" or "dialogue of cultures personality", achieving proficiency that enables students to communicate effectively in another language and act as cultural intermediaries (Lin and Tsai, 2020). Specialized senior-level training in Kazakhstan prompts a re-examination of foreign language teaching goals and methods to align with the demands of an increasingly globalized world.

The ongoing technological revolution has made STEM and STEAM education more relevant than ever in Kazakhstan (Datta, 2021). This integrated approach links academic knowledge to real-world applications, reinforcing connections between education, society, and the global community (Perales and Aróstegui, 2021). Consequently, the development of intercultural and communicative competence has become essential to meet these new demands. Researchers have proposed concepts ranging from "secondary language personality" formation to the minimum competency needed for cross-cultural communication. Specialized training programs for senior students in Kazakhstan are thus prompting a reassessment of foreign

language teaching methodologies, with the Kazakh methodological school leading in innovative approaches to professional foreign language education (Gerfanova, 2018).

Developing skills in science, technology, engineering, arts, and mathematics (STEAM) during school education is important for the country's innovative progress. The state's effective functioning relies on high human capital qualifications. Promoting an entrepreneurial and innovative culture among students will enhance educational achievements and school prestige (Perales and Aróstegui, 2021).

Globally, STEAM education, integrating science, technology, engineering, art, and mathematics, is trending. It combines educational and developmental potential across various knowledge areas, emphasizing interdisciplinarity and practical orientation. STEAM education creates an environment where the scientific method is practiced, reflecting the rapid digital and innovative advances of our times (Belbase et al., 2021). This methodology represents a new stage in innovative and motivating teaching approaches. The concept of STEAM education has seen rapid expansion over the past decades. This approach is of great interest in a variety of instructional practices (Bush et al., 2020). In the context of the rapid development of digital devices and the rapid pace at which innovations in electronics are being integrated into everyday life, this methodology marks a new era in the use of innovative and motivating methods in education (Lucena et al., 2020). Both domestic and foreign publications highlight computerization as a key factor in organizing education. Modern literature increasingly calls for detailed studies on the capabilities of computer and information technologies in foreign language training. Computerization can enhance access to new tools for independent learning and reduce language learning time. Improving education quality also involves shifting from traditional methods to personalized, self-directed learning, thereby activating students' independent cognitive activities, especially in language learning. The cognitive process relies on the purposeful acquisition of knowledge, with language as the primary tool for communication (Audrin and Audrin, 2022).

The Common European Framework of Reference for Foreign Languages (CEFR) is a Council of Europe document that standardizes language teaching approaches and proficiency assessments. Established in 1971, it defines competencies for effective communication and outlines skills needed for language proficiency across basic, intermediate, and advanced levels.

While educational teams may create their own level systems, CEFR's standardized categories ensure transparency and objective assessment criteria, leading to recognized qualifications for students. In the area of learning theory, information and communication technologies (ICT) play an essential role, facilitating information exchange through computers and telecommunications. The integration of technology and data analytics in education offers significant opportunities to enhance learning outcomes, personalize educational experiences, and inform strategic decision-making (Nicola-Gavrilă, 2023). As digital technologies and globalization shape education, curricula increasingly integrate global and intercultural perspectives. A recent National Communication Association (NCA) survey found intercultural communication is the fourth most popular course in the United States (Sattarov and Khaidarova, 2020).

The concept of intercultural communication emphasizes the interconnectedness of affective, cognitive and behavioural aspects of interaction between cultures. The affective dimension involves the willingness to acknowledge and appreciate cultural differences. The cognitive aspect involves understanding the cultural traditions that influence people's interpretation and behaviour. The behavioural aspect implies the presence of the necessary skills for successful interaction in intercultural situations (Myers et al., 2021). Many educators identify three different, but sometimes interrelated approaches to the study and teaching of intercultural communication (Anderson-Lain, 2017; Zhang and Zhou, 2019). Intercultural growth is a gradual and long-term process (Suen and Suen, 2019). To achieve intercultural competence, one must be open-minded, have an interest in other cultures, be aware of cultural universals and diversity, resist stereotypes and ambiguities, and have sufficient competence to interact effectively with representatives of other cultures (Wagner et al., 2017).

## Theoretical approaches to intercultural competence

Intercultural competence is broadly defined as the ability to interact effectively and appropriately with individuals from diverse cultural backgrounds. In international academic literature, this concept has been explored across various disciplines, including psychology, sociology, linguistics, and pedagogy. Below is an overview of prominent theoretical models that provide insight into the components and developmental processes of intercultural competence.

Deardorff (2006), a leading scholar in the field, conceptualizes intercultural competence as a dynamic process built upon a foundation of respect, openness, and knowledge about cultural differences. Her model[7] identifies four core components: (1) Relationships: characterized by respect, openness, and curiosity toward others; (2) Knowledge and Understanding: encompassing cultural self-identification and awareness; (3) Skills: including active listening, observation, and analytical skills; (4) Internal and External Competence: referring to the effectiveness and appropriateness of behavior in intercultural contexts.

Deardorff (2009) emphasizes that intercultural competence is not a static state but rather a continuous developmental process. Her model is instrumental for designing professional development programs in Kazakhstan, enabling teachers and students to build cultural awareness and respect. Integrating this framework into educational curricula can facilitate students' adaptation to a multicultural environment, which is increasingly important in Kazakhstan's globalized context.

Bennett's (1993) DMIS outlines a progression from ethnocentric (seeing other cultures from one's own perspective) to ethnorelative stages (recognizing and valuing other cultures from their own viewpoints). The six stages include denial, defense, minimization, acceptance, adaptation, and integration. According to Bennett (2004), advancing through these stages enhances an individual's capacity for constructive intercultural interaction. In Kazakhstan's educational system, this model provides a valuable framework for curriculum development that fosters intercultural understanding. The DMIS stages offer a roadmap for creating educational programs that encourage students to perceive cultural diversity as enriching rather than challenging.

Byram (1997), focusing on intercultural competence within educational contexts, identifies five key components: 1) Knowledge: Understanding cultural differences and their underlying values; 2) Interpretive and comparative skills: The ability to understand and explain cultural differences; 3) Openness and flexibility: willingness to learn from representatives of other cultures; 4) Critical cultural awareness: The capacity to critically analyze cultural values, including one's own; 5) Relationships: respectful recognition of cultural differences and their significance.

Byram's model is particularly relevant to foreign language education in Kazakhstan, as it supports the development of both linguistic and cultural competence. Emphasizing these components in foreign language curricula can enhance students' ability to understand and navigate cultural diversity, which is essential for those planning to study or work abroad (Bryam and Wagner, 2018).

Hofstede's (2001) model defines intercultural competence as an understanding of specific cultural characteristics, such as individualism vs. collectivism, power distance, and long-term vs. short-term orientation. This approach suggests that intercultural competence includes knowledge of these dimensions to interact effectively within international settings. In the context of Kazakhstan, Hofstede's model provides a basis for adapting curricula and teaching methods to suit the cultural characteristics of Kazakhstani students. This framework is particularly valuable for educators working in multicultural classrooms, where awareness of cultural dimensions can enhance teacher-student interactions and foster a more inclusive learning environment (Hofstede and Hofstede, 2010).

Hall (1976, 1966) introduced the concept of cultural context-high-context (implicit communication) and low-context (explicit communication)-and regarded intercultural competence as the ability to interpret communication within these varying contexts. Hall's model emphasizes the importance of understanding non-verbal communication, cultural norms, and values.

In Kazakhstan, which combines elements of both high-context and low-context cultures, Hall's model is applicable for designing educational programs that reflect this duality. Incorporating Hall's insights into training programs can enhance teaching methodologies in both technical and humanities disciplines by fostering greater cultural adaptability.

In summary, Western literature presents intercultural competence as a composite of knowledge, skills, and personal qualities that enable individuals to interact effectively and appropriately with people from different cultural backgrounds. Given Kazakhstan's status as a multicultural nation actively engaged in global educational and economic integration, the applicability of these theoretical models is high. Implementing these frameworks within Kazakhstan's educational system can support the development of interculturally competent students who are better prepared for participation in an interconnected world.

## 3. Research methodology

Tools for studying theoretical aspects of the development of intercultural communicative competence in specialized schools include several methods. The choice of specific tools depends on the goals and objectives of the study, as well as the

availability of resources. Combining various methods allows for a more complete and in-depth understanding of the theoretical aspects of the development of intercultural communicative competence in specialized schools. This multifaceted approach ensures that the study captures both theoretical foundations and practical implementations, providing a robust framework for future research and application.

The research methodology employs a comprehensive suite of methods to study the theoretical aspects of developing intercultural communicative competence in specialized schools. Literary analysis is utilized to conduct an extensive review of academic literature, encompassing scientific articles, books, and teaching aids related to intercultural communicative competence and its development in specialized schools. This method helps to map the existing knowledge landscape and identify research gaps. Theoretical review involves a detailed analysis of existing theories, concepts, and approaches to intercultural communicative competence, focusing on their application within educational contexts and their relevance to specialized schools. The analysis of programs and curricula examines the curricula and plans of specialized schools to identify the methods, strategies, and components used to develop intercultural communicative competence. This aids in understanding the practical implementation of theoretical concepts. Interviews with teachers provide qualitative insights by capturing the views, methodologies, and practices of experienced educators in specialized schools. These interviews reveal the practical challenges and successful strategies in developing intercultural communicative competence. The student survey involves distributing questionnaires to students in specialized schools to assess their perception, experience, and level of intercultural communicative competence. This method brings a student-centered perspective to the research. Expert analysis enlists experts in education and intercultural communication to critically assess the methods and concepts applied in the study, ensuring a high level of professional scrutiny and validation. Lastly, documentation analysis studies the educational materials, lesson plans, and assessment reports from specialized schools. This analysis provides a detailed view of how intercultural communicative competence is developed and assessed in practice. By combining these methods, the research gains a thorough and nuanced understanding of both the theoretical foundations and practical implementations of intercultural communicative competence in specialized schools.

## 3.1. Model for developing intercultural communicative competence in profiled schools

This model incorporates a variety of strategies, approaches, and techniques specifically designed to enhance students' abilities to interact successfully in diverse cultural environments. The details of these methods are outlined in **Table 1** which highlights a many-sided approach that integrates theoretical and practical elements to effectively build students' intercultural communication skills.

**Table 1.** Methods, approaches and practices aimed at developing students' skills for effective interaction in a multicultural environment.

| No | Methods, approaches and practices | Peculiarity |
|---|---|---|
| 1 | Integration into the educational process | The model for the development of intercultural communicative competence is being introduced into the curricula and programs of profiled schools. It can be built into subject courses or be the subject of separate lessons aimed at mastering intercultural communication skills |
| 2 | Interdisciplinary approach | Allows to integrate aspects of intercultural communication into various subjects, for example, history, literature, art, which contributes to a deeper understanding of cultural aspects |
| 3 | Culturally oriented projects | Students can participate in projects related to the study of cultural aspects of different countries and peoples. This helps to expand their cultural understanding and intercultural adaptation abilities |
| 4 | Profiled courses and seminars | Schools may provide additional courses and workshops aimed at teaching intercultural communication. This may include training in cross-cultural navigation skills, conflict management, exploring cultural differences, etc. |
| 5 | Multimedia resources | The use of multimedia resources such as films, videos, interactive learning platforms allows students to immerse themselves in authentic intercultural situations and develop communication skills |
| 6 | Intercultural exchanges and partnerships | Organizing exchanges with other schools or institutions abroad, as well as participating in international projects, allows students to practice intercultural communication in practice and enrich their experience |
| 7 | Role-playing games and simulations | Organizing role-playing games where students can impersonate representatives of other cultures helps develop skills in understanding and adapting to diverse cultural contexts |
| 8 | Communication trainings | Organizing training in intercultural communication, which includes practical exercises, role-playing games, case analysis and feedback, contributes to the development of students in this area |

Source: Prepared by the author (2024).

The presented vision of the model of intercultural communicative competence development in a profiled school is focused on providing students with practical skills that will enable them to communicate successfully in a multinational society and global context.

## 3.2. Formation of intercultural communicative competence

The goal of developing intercultural communication competence is to make people more flexible and successful in communicating with representatives of different cultures, promoting understanding and cooperation in a global context (**Figure 1**).

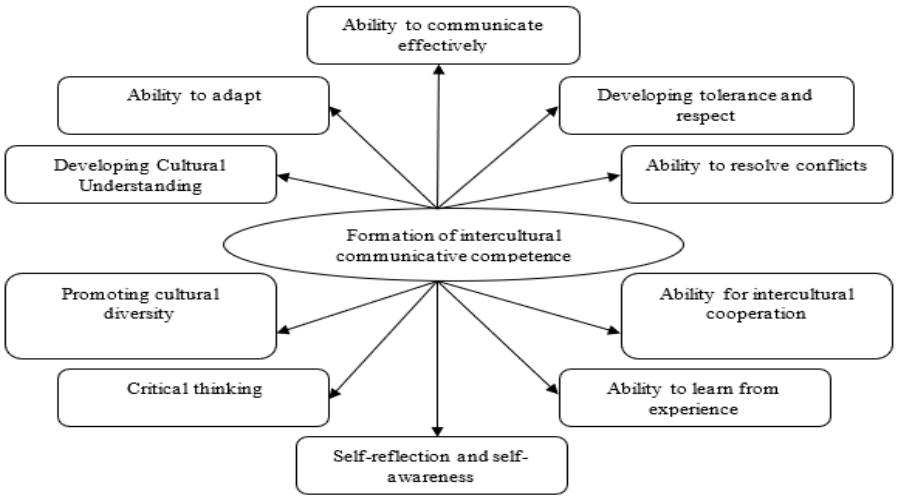


**Figure 1.** Formation of intercultural communicative competence.

**Figure 1** outlines a model for developing intercultural communicative competence, starting with cultural understanding and culminating in the promotion of cultural diversity.

Firstly, developing cultural understanding is important, which involves awareness and understanding of cultural differences, norms, values, customs, and traditions. Adaptability is also important, requiring the ability to adapt to different cultural contexts and interlocutors' characteristics and expectations. Effective communication is another key aspect, involving mastering active listening, clear and concise speech, and non-verbal communication with cultural nuances. Additionally, tolerance and respect are necessary, involving developing a respectful attitude towards different cultures and combating bias and stereotypes. Conflict resolution skills are also important, enabling individuals to constructively resolve conflicts arising from cultural differences. Intercultural cooperation is another critical aspect, requiring skills for cooperation with representatives of different cultures in various environments.

Critical thinking is also essential, involving learning to analyze information and assess cultural aspects and situations consciously. Self-reflection and self-awareness are also vital, involving developing the ability to critically examine one's own prejudices and cultural ideas, understanding one's cultural identity. Learning from experience and applying it to future communications is also important.

Finally, promoting cultural diversity and supporting positive attitudes towards it contributes to societal enrichment the study of the model for developing intercultural communicative competence in profiled schools (hereinafter referred to as ICCS) is important and timely. Here are some aspects that highlight its significance, as presented in **Table 2**. Overall, the ICCS model addresses the need for educational strategies that support effective communication, conflict resolution, and cultural understanding in a multicultural society, preparing students for global professional environments and aligning with evolving educational standards.

**Table 2.** Significance of the ICCCS study.

| No | Provisions | Peculiarities |
|---|---|---|
| 1 | Multicultural society | The modern world is becoming increasingly globalized and multinational. Profiled schools offering profiled education often attract students from different cultures and ethnic groups. |
| 2 | Effective communication | The ability to communicate effectively with people from different cultures and nationalities is becoming a key skill in the modern world, especially in the work and interpersonal spheres. |
| 3 | Conflict Prevention | Differences in cultural values and customs can lead to misunderstandings and conflicts. Developing intercultural communicative competence helps prevent and resolve such situations. |
| 4 | Preparing for the Global Job Market | International corporations and organizations value specialists who are able to work effectively in an intercultural environment, which makes this study relevant for the training of future professionals. |
| 5 | Educational standards | In many countries, intercultural communicative competence is becoming part of educational standards, which requires the development of appropriate methods and models for its development. |
| 6 | Teacher training | Developing intercultural communicative competence also requires training teachers and educators so that they can effectively teach these skills to students. |

Source: Prepared by the author (2024).

Research into the development model of intercultural communicative competence in profiled schools can help develop effective teaching methods and strategies that promote the development of this important skill in students and prepare

them for successful integration into a global society (Cushner, 2015). Recently, there's been increased recognition of the importance of developing intercultural communicative competence (ICC) in foreign language teaching. Language teachers are now expected to foster ICC in their students. This study investigates Kazakh EFL teachers' perceptions of ICC and how these beliefs influence their teaching practices (Smakova and Paulsrud, 2020). In communication, communicative competence refers to the ability to choose and apply appropriate linguistic behaviour to solve communication problems in real-life situations. Therefore, it can be defined as the capacity to use both verbal and non-verbal communication effectively in typical professional scenarios.

According to (Kuzmina, 2018) five main components can be distinguished in modelling: gnostic component, related to the teacher's knowledge, as well as own self-knowledge; design component, covering the tasks of teaching and education, as well as strategies and methods of their achievement; constructive component, covering the peculiarities of the development of the teacher's and students' activities; communicative component, covering the features of the teacher's communicative activity and the specifics of his/her interaction with students.

Emphasis is placed on the relationship between communication and the effectiveness of pedagogical activities aimed at achieving educational goals. The system model proposed by (Ginetsinsky, 2018) emphasizes four functional components: Presentational-presentation of educational material to students, regardless of specific teaching methods, where attention is paid to the very process of presenting the material; stimulating-arousing students' interest in assimilating information, realized through tasks, questions and evaluation of answers; corrective-related to correction and comparison of students' performance results; diagnostic-provides feedback.

## 3.2. Information and analytical technologies (IAT)

Information and analytical technologies (IAT) encompass knowledge, methods, operations, and rules to optimize various activities using diverse resources. They systematize information, enabling data integration to predict future events and interactions, useful for academic and practical research to optimize management decisions. Modelling incorporates principles guiding the achievement of design goals. Key principles underpinning the formation of intercultural and communicative competence in specialized school students using IAT include:

- Cognitivism in intercultural communication, emphasizing the management of subject formation through visual aids, logical diagrams, interactive methods, and problem-solving scenarios.
- Reflexivity, focusing on individual education and promoting self-knowledge and development strategies for students to tailor their learning paths.
- Problem-solving, involving a logical sequence in educational content creation based on students' research activities. 4. Interdisciplinary integrations, fostering specific competencies through tasks, educational process organization, and results monitoring.

### 3.3. Conceptual-reflexive stage

During the conceptual-reflective learning stage, students analyse linguistic forms and expression modes within communication contexts. They explore communication elements like situational context, purpose, speaker intentions, and social dynamics. This phase enhances cognitive subcompetence, deepening students' grasp of intercultural and communication technologies and refining their strategic thinking. Students cultivate goal-setting skills and predictive abilities to bridge gaps in linguistic and social experience within foreign language contexts.

### 3.4. Conceptual and accumulating stage

The conceptual-accumulative learning stage involves analytical and semantic processing of information with evaluation and critical view of it. This stage includes abductive sub-competence, which helps to analyse the current state of a problem or phenomenon. As a result, students are able to identify key aspects that require further study and research and can analyse information, organize knowledge, compare facts and draw conclusions. In addition, they can critically evaluate the information presented.

### 3.5. Integrative-representative stage

At the stage of integrative and representational learning, skills of adequate oral and written response are developed, taking into account the conditions of the communicative act. Pragmatic competence contributes to the objective evaluation of the work done and justification of its results, helping to argue the importance of the results obtained and apply new knowledge in practice.

### 3.6. Communicative-modelling stage

At the communicative-modelling stage, language forms and expressions are selected strategically to suit the conditions of the communicative act. The integration of information-analytical technologies, this stage facilitates the development of key subcompetences, such as polemic-argumentation and verification, fostering systematic thinking, evaluation, self-assessment, information analysis, and effective problem-solving in communication.

This study establishes an important framework for enhancing intercultural communication skills within Kazakhstan's secondary education system, a crucial component of the nation's soft infrastructure for economic growth. By equipping students with strong intercultural competencies, we can contribute to breaking down cultural barriers, dispelling stereotypes, and fostering a deeper global understanding. These skills not only prepare students for success in an increasingly interconnected world but also enhance their ability to collaborate across borders.

The potential benefits extend far beyond education, influencing sectors such as international relations, global business, cultural exchange, and social cohesion. Implementing this framework allows educators to play a pivotal role in nurturing a generation capable of driving Kazakhstan's educational transformation and contributing to global progress. The importance of this research lies in its capacity to

reshape approaches to cultural diversity and intercultural competence in a STEM-driven world.

The implications of this research for promoting intercultural understanding, tolerance, and cooperation are far-reaching, making it a valuable contribution to both educational and economic discourse fostering greater innovation, and support the nation's broader goals of economic modernization and integration into the global economy.

## 4. Results and discussion

The purpose of the experiment was to test the developed model for developing intercultural and communicative competence (ICC) among 10th-grade students in natural and mathematical sciences classes at "Gymnasium No. 3" in Karaganda.

The experiment spanned 32 academic hours, divided into sessions aligned with the school's schedule, and consisted of four key stages: 1) Group formation; 2) Development and implementation of the training program; 3) Testing and assessment; 4) Quantitative ANALYSIS methods.

Control (CG) and experimental (EG) groups were established, each comprising 30–33 students. The control group followed the standard curriculum, while the experimental group participated in our model, which was integrated with digital resources. The primary distinction between the groups lay in the teaching methodology: The experimental group employed a three-stage model incorporating elements of STEM education.

Educational content for the experimental group was tailored to develop intercultural and communicative competence (ICC) through the proposed model. This program encompassed various stages and activities intended to incrementally build specific ICC skills, such as cognitive (understanding of cultural knowledge), strategic (formulating communication strategies), abductive (inferring meanings in intercultural contexts), pragmatic (effective language use), polemical-argumentative (engaging in cultural discussions), and verification (validating intercultural understanding). Each stage included specific tasks: cognitive tasks (cultural case studies), strategic tasks (role-playing scenarios), abductive tasks (interpreting cultural cues), and pragmatic tasks (simulated cross-cultural dialogues).

Pre- and post-experiment assessments were conducted in both groups to evaluate ICC development. Tasks in these assessments focused on measuring each ICC sub-competence: for instance, cognitive and strategic skills were tested through scenario analysis, abduction and pragmatics through real-life intercultural simulations, and polemical-argumentative and verification skills through structured debate exercises. Student performance was scored as a percentage, calculated by dividing the number of correct responses by the total number of completed tasks.

Data analysis focused on identifying changes in ICC development levels across both groups, enabling us to determine the efficacy of the proposed model in enhancing students' ICC.

In the second research approach, we experimentally verified our model with $10^{th}$ grade students from the natural-mathematical profile at "Gymnasium No. 3" in Karaganda city. The lessons spanned 32 academic hours, with two groups formed:

control and experimental, each comprising 30–33 pupils. The experimental group implemented our digital resource-based model, while the control group followed standard methods. The experimental program, based on our model, consisted of three stages and various exercises. Statistical analysis and quantitative prediction methods were employed to assess the percentage of students entering profiled universities and forming intercultural and communicative competence: $X$ = C.a.*100/Tn, where X is the level of ICC formation in%; *C.a.* is the number of correct answers and *Tn* is the number of students who took part in the test multiplied by the number of tasks).

According to the **Tables 3** and **4**, we have identified the Criteria-parameter indications according to the formed sub-competencies of the four above mentioned stages.

**Table 3.** Criteria-parameter indications.

| Criteria-parameter indications | Grades in points |
|---|---|
| Cognitive | 10 |
| Strategic | 10 |
| Abductive | 20 |
| Pragmatic | 20 |
| Polemic and argumentation | 20 |
| Verification | 20 |
| Total | 100 |

Source: Prepared by the author (2024).

**Table 4.** Levels of assessment for the ICC.

| Level | Points |
|---|---|
| Optimal | 100–95 |
| High | 94–85 |
| Middle | 84–75 |
| Minimum | 74–55 |
| Low | 54–50 |

Source: Prepared by the author (2024).

The results presented in **Table 3** outline the criteria-parameter indications used for assessing the formation of intercultural communicative competence (ICC). These indications are categorized into cognitive, strategic, abductive, pragmatic, polemic and argumentation, and verification aspects, each assigned a specific number of points. The total points allocated across these criteria sum up to 100, reflecting a comprehensive evaluation framework. This table serves as a guideline for evaluating ICC formation, providing a structured approach to assess various competency levels. **Table 4** further elucidates the levels of assessment for ICC, delineating specific point ranges corresponding to different competency levels. These levels include optimal, high, middle, minimum, and low, each associated with a distinct point range. The optimal level represents the highest competency level, while the low level indicates the lowest level of proficiency in ICC. By categorizing ICC assessment into these levels, educators and evaluators can effectively gauge students' competency levels and

identify areas for improvement. These levels serve as benchmarks for evaluating ICC development, facilitating targeted interventions to enhance students' intercultural communication skills.

Experimental tasks were conducted sequentially, followed by diagnostic assessments to measure research skill development in both experimental and control groups. Post-experimental diagnostics relied on mathematical data analysis. A significant contrast emerged in the development of intercultural and communicative skills between the experimental and control groups. While the control group showed minimal improvement, the experimental group exhibited enhancements across all assessment parameters. To assess the effectiveness of our approach in the experimental groups, STEM education components were integrated into material and course development.

## 5. Discussion

The **Tables 5** and **6** and **Figure 2** below show the levels of different sub-competencies in intercultural communicative competence (ICC) among students in the Experimental Group (EG) and the Control Group (CG) before and after the experiment.

**Table 5.** Sub competencies within the ICC.

| **Sub competencies within the ICC** | | | | | | |
|---|---|---|---|---|---|---|
| **EG** | **Cognitive** | **Strategic** | **Abductive** | **Pragmatic** | **Polemic-argumentation** | **Verification** |
| Before | 6% | 10% | 18% | 14% | 18% | 15% |
| After | 21% | 41% | 35% | 39% | 44% | 38% |

Source: Prepared by the author (2024).

**Table 6.** Sub competencies within the ICC.

| **Sub competencies within the ICC** | | | | | | |
|---|---|---|---|---|---|---|
| **CG** | **Cognitive** | **Strategic** | **Abductive** | **Pragmatic** | **Polemic-argumentation** | **Verification** |
| Before | 7% | 8% | 18% | 19% | 12% | 15% |
| After | 11% | 23% | 29% | 31% | 25% | 28% |

Source: Prepared by the author (2024).

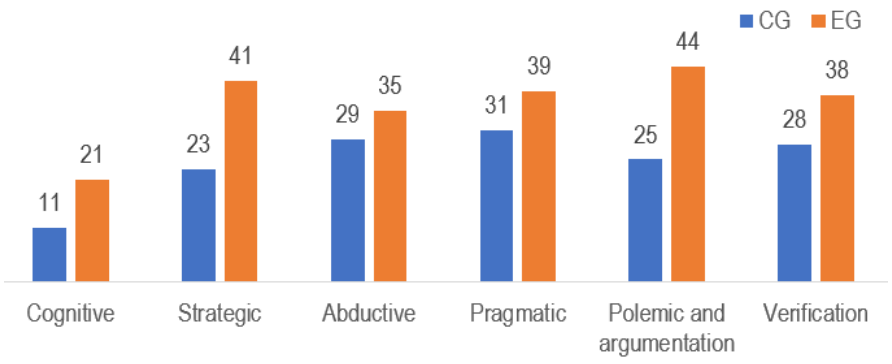


**Figure 2.** Correlation of the level of ICC formation in the EG and CG.

The sub-competencies of the EG showed relatively low levels, ranging from 6% to 18%, indicating that students had limited initial proficiency in ICC-related skills. After the experiment, there was a significant increase across all sub-competencies, with improvements ranging from 21% in cognitive competence to 44% in polemic-argumentation. This demonstrates the effectiveness of the experimental approach in developing students' intercultural communicative competencies. The most substantial improvement occurred in the strategic and polemic-argumentation sub-competencies, highlighting the students' enhanced ability to plan and engage in argumentation with intercultural understanding.

In **Table 6**, the CG had similarly low levels of sub-competencies, though slightly higher than the EG in some areas (e.g., Pragmatic 19%, Abductive 18%). After the experiment, while there was improvement in the CG as well, the increases were much smaller compared to the EG. The highest gains were observed in pragmatic (31%) and abductive (29%) sub-competencies. However, the overall improvement was modest, indicating that the traditional teaching methods employed in the control group were less effective in fostering ICC development.

**Figure 2** provides compelling evidence, based on the data from both tables, that the experimental approach-centered on practical, interactive, and technology-driven learning-is significantly more effective in fostering the development of intercultural communicative competence (ICC) in students compared to traditional methods. The results strongly suggest that the integration of innovative educational practices is essential for equipping students with the necessary skills to succeed in diverse, intercultural environments.

## Methods and approaches in STEM education applied in the experiment

To enhance intercultural and communicative competence within the experimental group, we integrated a structured STEM education framework that utilized various instructional methods, approaches, and digital resources aligned with our educational model. Project-based learning was a core approach, emphasizing real-world applications through cross-disciplinary projects that required students to collaborate on solving practical issues. These projects were designed to encourage critical thinking and intercultural understanding, as students explored how scientific and technological advancements affect diverse cultures.

Collaborative problem-solving activities further supported intercultural competence development, as students worked in diverse teams to address complex challenges. Through teamwork, students learned to appreciate different perspectives and to communicate effectively. For instance, group activities involved designing STEM-related solutions, where students had to negotiate ideas and respect cultural differences within their teams. Inquiry-based learning was another approach that fostered curiosity and independent exploration of STEM concepts. Instructors provided scenarios that required students to investigate how scientific principles and technologies are applied in different cultural contexts, thereby promoting open-mindedness and cultural sensitivity.

To create an engaging and flexible learning environment, we incorporated digital resources such as online simulations, interactive software, and multimedia content.

Virtual labs, for example, allowed students to perform experiments that would otherwise be difficult to conduct in a traditional classroom. These digital tools were selected not only to enhance STEM learning but also to foster a global perspective, as they exposed students to diverse scientific contributions from around the world.

The program was also designed around competency-based learning activities that targeted specific skills essential for intercultural and communicative competence. Activities focused on developing cognitive skills for analyzing scientific content from diverse cultural perspectives, strategic skills for solving problems within intercultural contexts, and abductive reasoning for drawing conclusions based on cross-cultural scenarios. Additionally, pragmatic skills were emphasized to encourage the practical application of scientific knowledge with cultural awareness. Students were also guided to build polemical-argumentative skills for constructing and defending arguments with cultural sensitivity, as well as verification skills for critically assessing information sources and experimental outcomes.

Interdisciplinary connections played an essential role in the program, as STEM education was integrated with discussions on global issues, helping students see science and technology as universal languages that bridge cultural gaps. Case studies and problem-solving exercises were enriched with historical and cultural contexts, demonstrating how STEM innovations are both influenced by and impactful on cultural practices worldwide.

Formative assessments, including reflective exercises, peer assessments, and instructor feedback, were conducted throughout the program to evaluate and provide feedback on students' intercultural and communicative competence in STEM contexts. These evaluations focused not only on technical content mastery but also on the demonstration of cultural awareness and sensitivity.

In summary, this STEM-oriented educational approach aimed to advance technical skills and cultivate intercultural competence by encouraging students to engage thoughtfully with scientific concepts through diverse cultural perspectives. By applying these methods, the experimental group experienced a comprehensive learning approach that enhanced both STEM proficiency and intercultural understanding.

The results of the experiment confirm the effectiveness of the proposed model and approaches for developing ICC in schoolchildren. The use of digital resources and elements of STEM education within the experimental program gave a positive effect, demonstrating a significant improvement in ICC indicators in students of the experimental group compared to the control group. An experimental program aimed at developing intercultural and communicative competence (ICC) using digital resources was developed and implemented within 32 lessons for 10th graders in natural and mathematical sciences. The experimental program was divided into three stages, each of which was focused on the gradual development of key skills and competencies necessary for the formation of ICC. The use of digital resources and specially designed exercises allowed the development of important competencies in the field of intercultural and communicative communication in students in the experimental group. The final results of the experiment demonstrated higher ICC rates among participants in the experimental group compared to the control group, which confirms the effectiveness of the proposed model and approach.

Based on our research, we observe the following sub-competences:

- Cognitive sub-competence involves understanding concepts and categories relevant to communication.
- Strategic sub-competence encompasses goal formulation, prognostic skills, and compensating for communication gaps, including linguistic and cultural aspects. Abductive sub-competence entails analysing problems, identifying areas for further research, systematizing knowledge, comparing facts, drawing conclusions, and critically evaluating information.
- Pragmatic sub-competence includes objectively assessing work, justifying results, applying knowledge practically, and demonstrating its significance.
- Polemical-argumentative sub-competence involves systemic thinking, critical evaluation, problem-solving, and the ability to engage in argumentative discussions and conversations to address communicative tasks.

All participants in the pedagogical experiment willingly participated and provided consent. Parents and school administration also approved and permitted the study. Importantly, the experiment did not disrupt the normal educational process or affect participants' grades. No personal data of participants were collected, analysed, or stored. The discussion of the theoretical aspects of developing intercultural communicative competence in specialized schools underscores its importance for modern education. It involves thorough analysis of existing theories, emphasizing the role of teachers, individualized learning strategies, and integration of information technology. Factors facilitating or hindering competence development are identified, along with successful practices for emulation in other institutions. Valuable recommendations for optimizing educational programs are provided, alongside prospects for future research. This discussion offers practical insights for enhancing educational practices in this domain.

## 6. Conclusion

This paper examined the role of education as soft infrastructure in Kazakhstan's economic growth, with particular attention to the development of intercultural competence and STEM education. It explores the integration of these components into the national educational framework, drawing on both theoretical models and practical case studies to highlight their significance for sustainable development and global competitiveness.

The experimental results demonstrate that the ICC model, which was rigorously tested with students in Karaganda city, provides a structured and effective framework for enhancing both the cognitive and practical aspects of intercultural communication. By employing a diverse set of research methods—ranging from theoretical reviews to practical exercises, surveys, and expert analysis—the study has offered a holistic understanding of how intercultural competence can be developed in educational settings.

A key takeaway is the clear advantage of the experimental group, which followed the model-based approach incorporating digital resources and STEM education elements. The significant improvement across all sub-competencies-cognitive, strategic, abductive, pragmatic, polemic-argumentation, and verification-compared to

the control group, underlines the model's effectiveness in shaping globally competent citizens. The criteria-parameter indications used for assessment further validate the robustness of the ICC model, providing a measurable and practical tool for educators.

The findings suggest that educational systems, especially in Kazakhstan, can benefit from adopting this comprehensive ICC model to promote cultural diversity, prevent conflict, and prepare students for the global job market. The interdisciplinary integration of ICC into various subjects, alongside specialized intercultural communication courses and experiential learning opportunities such as cultural exchanges, has proven to be a key element in student development.

In conclusion, the ICC model developed in this study not only addresses the specific educational needs of Kazakhstan's transforming education system but also contributes to broader discussions on intercultural competence as a fundamental soft infrastructure for economic growth. Future research could expand on these findings by exploring the long-term impact of such educational models on students' professional success and their ability to contribute to global intercultural dialogue and cooperation.

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**Conflict of interest:** The authors declare that there is no conflict of interest.

## Note

1 https://adilet.zan.kz/rus/docs/P1900000988
2 https://online.zakon.kz/Document/?doc_id=30118747
3 https://adilet.zan.kz/rus/docs/P2300000269
4 https://adilet.zan.kz/rus/docs/U1800000636
5 https://adilet.zan.kz/rus/docs/V2200029031
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