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Research Article

ICT-Supported CLIL in Computer Science: Enhancing Learning Through Digital Tools and Resources

Gulmira Kussaiynkyzy[1]*, Ida Dringó-Horváth[2]

[1]*Faculty of Education, Eötvös Loránd University, Budapest, Hungary; gulmira.kusajynkyzy@gmail.com*
[2]*ICT Research Center, Educational Technology Training Centre, Károli Gáspár University of the Reformed Church in Hungary, Budapest, Hungary; dringo.horvath.ida@kre.hu*

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corresponding author

Abstract
This study explores the role of Information and Communication Technology (ICT) in enhancing content delivery and supporting language acquisition in Content and Language Integrated Learning (CLIL)-based computer science education within a network of elite schools in Kazakhstan, which implements a trilingual education system. The study aims to identify the most frequently used ICT tools and resources by teachers and students, as well as how they were integrated into the CLIL classroom. A convergent parallel mixed-methods approach was employed, combining quantitative data from surveys with qualitative data from interviews and document analysis. The study found that curriculum-aligned, custom ICT resources were the most frequently used and valued. The development and sharing of resources within the network demonstrated a collaborative educational model that could benefit other institutions. This study contributes to understanding how ICT can enhance CLIL-based computer science education, offering valuable resources for English-medium instruction. Expanding the use of underutilized collaboration tools could further strengthen CLIL-based computer science education, providing important insights for educators in bilingual and trilingual settings.

Keywords: CLIL, English-medium instruction, ICT, computer science education resources, digital learning tools

INTRODUCTION

Content and language integrated learning (CLIL) is an educational approach in which a subject is taught through an additional language, with an emphasis on both content mastery and language development (Coyle et al., 2010). Since the 1990s, this innovative approach has spread across Europe and beyond. Kazakhstan was the first post-Soviet country to implement CLIL, mandating that science teachers instruct in English (Karabassova & San Isidro, 2020).

Previous research in the Kazakhstani context indicates that, among STEM subjects (chemistry, physics, biology, and computer science), computer science teachers are particularly supportive of using English as the medium of instruction, as it plays a significant role in achieving subject-specific learning outcomes

(Zhamaleddinova, 2020). This aligns with the findings of Molina et al. (2024), who emphasized that English is deeply embedded in the discipline of computer science, with the most widely used programming languages employing English for their syntax and keywords. Furthermore, the vast majority of learning resources, including documentation, tutorials, and community forums, are also primarily available in English. This linguistic dominance makes English proficiency not only beneficial but increasingly essential for successfully learning and teaching computer science. Given the strong correlation between English proficiency and programming performance, implementing English-medium instruction through CLIL in computer science offers a strategic advantage. It enables students to simultaneously develop domain-specific knowledge and language skills, addressing both content and linguistic challenges in an integrated manner.

While CLIL has gained growing attention in educational research, its application within the field of computer science remains underexplored, revealing a significant gap in scholarly and pedagogical understanding. In contrast, the integration of ICT into CLIL instruction has been more extensively investigated, with numerous studies highlighting its positive impact. Research has shown that incorporating ICT into CLIL can enhance student motivation (Abaunza et al., 2020; Martínez-Soto & Prendes-Espinosa, 2023), provide access to authentic, real-world input (Zhu & Chan, 2023), and foster interactive, student-centered learning environments (Martínez-Soto & Prendes-Espinosa, 2023). These technologies promote active participation, collaboration, and learner autonomy, contributing to more engaging and effective instructional practices.

Therefore, teaching computer science within a CLIL framework, supported by digital technologies, presents a powerful synergy for advancing both content mastery and language development. However, as noted in a systematic literature review by Kussaiynkyzy and Dringó-Horváth (2022), empirical research on the practical implementation of ICT-supported CLIL in computer science education remains scarce, underscoring the need for further investigation in this area.

This article presents the results of research on the implementation of ICT-supported CLIL in computer science at a network of elite schools in Kazakhstan, Nazarbayev Intellectual Schools (NIS), which provide instruction to gifted students in three languages. Given that computer science teachers are typically advanced users of ICT and prefer teaching in English, examining their approaches to CLIL can provide valuable insights into effective practices and meaningful resources for integrating ICT into CLIL instruction. Therefore, this study aimed to explore the experiences reported by teachers and students regarding the use of ICT to enhance the teaching and learning of computer science in a foreign language. To achieve this, it investigated the following key questions:

1. Which ICT tools and resources are used in CLIL computer science classes?
2. How are these ICT tools integrated into the teaching of computer science within a CLIL framework?

LITERATURE REVIEW

Enhancing CLIL Instruction through Technology

CLIL has been defined as "a dual-focused educational approach in which an additional language is used for the learning and teaching of both content and language" (Coyle et al. 2010, p.1). In most cases, this additional language is English, serving as the target language that students aim to acquire while engaging with subject-specific content. CLIL helps students learn content, think critically, and engage more deeply by supporting their understanding and use of a target language (Reid, 2021). A key aspect of this approach is helping students process input (reading and listening/watching) and develop productive skills such as speaking and writing. This support is crucial, as students need to clearly express their understanding in the target language to demonstrate their learning, both to themselves and to their teachers (Ball et al., 2015). Thus, CLIL applies Vygotsky's (1978) concept of the zone of proximal development (ZPD) by providing learners with structured support to engage with complex content in a targeted language. This support is provided through a process called "scaffolding", where learning takes place in the space between the learner's current level of development and the higher level they can reach with guidance from a more experienced or knowledgeable facilitator.

Through scaffolding, learners receive the necessary support to bridge the gap between their current and potential development, with technology playing a crucial role in this process. According to Nunan's (2010) framework, technology serves three pivotal functions in second-language instruction: as a content provider, a learning management tool, and a communication facilitator. A systematic review of research trends on the application of ICT in CLIL, structured according to these roles, has been presented in a separate publication (Kussaiynkyzy & Dringó-Horváth, 2022). Building on these findings, the present study further examines how ICT tools are implemented in CLIL classrooms, with a specific focus on their practical applications and pedagogical impact.

Technology as a Provider of Content and Instructional Tool in CLIL

According to Nunan (2010), technology serves as a carrier of content when it provides learners with reading and listening (or watching) input and acts as an instructional tool when it facilitates interactive learning activities. In this regard, ICT tools play a crucial role by granting access to authentic materials available on the web (Navarro-Pablo et al., 2019; Budiastuti et al., 2023), while also offering deeper explanations through visual aids, which support students in understanding complex concepts (Martínez-Soto & Prendes-Espinosa, 2023).

Furthermore, Karabassova and Oralbayeva (2024) emphasized the critical importance of selecting materials that include multimodal input in CLIL. Incorporating diverse types of input—such as texts, charts, maps, and video clips—throughout a CLIL unit enhances differentiation, caters to various learning styles, and activates multiple language skills. Digital resources, particularly websites, offer ample opportunities for self-directed learning, enabling students to independently prepare for lessons, review content in multiple formats, and engage in personalized portfolio work.

Zaparucha (2019) highlights that multimedia in CLIL settings should be guided to enhance content accessibility. For example, mini-films with commentary can convey concepts more effectively than textbooks. To maintain engagement, teacher-designed tasks should accompany the multimedia, promoting active interaction instead of passive observation. Furthermore, presentation tools help structure and visually present complex information, making it more accessible and enhancing linguistic comprehension (Arynova et al., 2020; Saad et al., 2023).

Beyond visual media, web-based activities such as WebQuests foster inquiry-based learning and develop higher-order thinking skills. Zhu and Chan (2023) note that when adapted for CLIL, WebQuests (or

CLILQuests) promote the active processing of information, integrating language and content learning in meaningful ways.

Importantly, in CLIL, learning content through a foreign language does not require simplifying knowledge. Instead, students should be appropriately challenged to deepen their understanding. The cognition aspect of the 4Cs framework supports progressing from lower-order thinking skills (remembering, understanding, and applying) to higher-order skills such as analyzing, evaluating, and creating (Hemmi & Banegas, 2021).

However, Kolb (2017) argues that it is a fallacy to believe students must always engage hands-on with technology, such as writing blogs, creating podcasts, or designing infographics, to develop higher cognitive skills. While hands-on activities can foster higher-level thinking, it can also occur with more passive or teacher-centered technology use. For example, in a PowerPoint lecture, students can analyze and share their observations on an image, engaging higher-level thinking without directly creating content.

Technology as a Learning Management Tool in CLIL

According to Nunan (2010), Learning Management Systems (LMS) enable teachers to efficiently manage tasks such as posting course materials, grading assignments electronically, and tracking student progress. Albero-Posac (2019) advocates for the integration of digital tools in CLIL subjects, highlighting platforms such as Moodle, which allow students to review materials, access additional support, and deepen their understanding of both language and content.

Building on the role of LMS in CLIL settings, the integration of flipped classroom methodologies offers an innovative approach that enhances the effectiveness of these platforms. The flipped classroom model, which inverts traditional teaching by having students engage with new content at home while using class time for interactive learning, aligns seamlessly with the capabilities of modern LMS platforms. According to Kone (2022), combining the flipped classroom and CLIL methodologies creates an optimal environment for deep learning, fostering student autonomy and promoting active engagement. This approach transforms the classroom into a collaborative space where the teacher acts as a facilitator, placing students at the center of their own learning process.

Technology as a Communication and Collaboration Tool in CLIL

With the growing emphasis on improving communication skills in language learning, CLIL classes provide an ideal context for integrating ICT, as these communication tasks and situations can be easily completed and replicated using digital media (Navarro-Pablo et al., 2019). Microsoft (MS) Teams exemplifies a versatile collaboration platform for CLIL environments. With features such as document sharing, online meetings, persistent chat, audio and video calls, and extensive file storage, MS Teams supports seamless communication and collaboration (Tunjera & Chigona, 2022).

Collaboration tools such as blogs and wikis encourage students to create and share content, enabling them to develop competencies in constructing and communicating their understanding of concepts (Onojah et al., 2022). Li (2021) identified wikis as effective tools for collaboration. Students who participated in the study found wikis convenient for collaborative writing and reported increased motivation due to the platform's transparency. They also appreciated the ability to negotiate writing tasks with peers using features such as the "discussion" and "comments" functions. Additionally, wikis enable teachers to monitor individual and group contributions, providing valuable data on student progress and collaboration (Gao et al., 2021). Shared documents, such as Google Docs and Google Slides, help make students' individual contributions transparent in collaborative tasks, as highlighted by Dringó-Horváth and Pintér (2021).

In light of the findings discussed, it is evident that the integration of ICT in CLIL classrooms has the potential to enhance both content and language learning when applied with a pedagogical focus. By serving as a content provider, a learning management tool, and a communication facilitator, technology can foster meaningful learning experiences, encourage collaboration, and support student autonomy. As Özkan and Aşık (2023) caution, if technology is not integrated through pedagogy-driven approaches in education and is used merely to follow contemporary trends, such an instructional environment offers no educational benefits and fails to foster the potential learning practices of students.

METHODS

Research Setting

The research presented here is part of a larger study examining teachers' and students' perceptions and practices concerning the use of ICT-supported CLIL in computer science within the network of Nazarbayev Intellectual Schools (NIS). Established in 2008, NIS aims to transform Kazakhstan's educational system by testing innovative programs and sharing these best practices nationwide. A central element of the NIS educational framework is trilingual education, which emphasizes CLIL. In this context, Kazakh, Russian, and English are not only taught as separate language subjects but also serve as mediums of instruction for various disciplines, such as physics, geography, and history. Specifically, in computer science, the subject is taught in Russian from grades 7 to 10, regardless of students' native language, and in English in grades 11 and 12.

The assessment requirements for NIS students in grades 11 and 12 align with AS- and A-level standards (AEO NIS, 2019). Graduates of Intellectual Schools undergo an external, independent assessment of their achievements. To further promote a trilingual environment and improve local teachers' English proficiency, NIS also employs foreign teachers. Additionally, the Intellectual Schools practice team-teaching, in which both Kazakhstani and international teachers collaboratively deliver lessons.

Data Collection

Using methodological triangulation, the study employed a convergent parallel mixed methods design, in which quantitative and qualitative data were collected simultaneously, analyzed separately, and then integrated for interpretation.
Data were collected using questionnaires, semi-structured interviews, and document analysis. Two versions of the questionnaire were developed: one for teachers, consisting of five thematic sections, and one for students, comprising four sections.

The validity of the instruments was assessed through expert-driven and respondent-driven pretests. In the expert-driven phase, the Content Validity Index (CVI) was used to evaluate each item's relevance and clarity (Polit & Beck, 2006). A panel of three experts (two professors and one computer science teacher) rated items on a 4-point scale. Items with an Item-Level CVI (I-CVI) below the threshold of 1.00 were either removed or revised. Respondent-driven pretests, conducted using the Think Aloud Protocol with one teacher and two students (in Kazakh, Russian, and English), led to further adjustments to tool examples and wording. Internal consistency was assessed using Cronbach's alpha, with the "ICT in CLIL Computer Science" section showing high reliability: $\alpha = .893$ (teachers) and $\alpha = .833$ (students). This study reports findings from that section, which includes 18 items per version. Based on Nunan's (2010) framework, the section is divided into three parts and uses a 5-point scale (1 = never, 5 = always) to measure the frequency of ICT tool use in CLIL computer science classes.

The survey was distributed online via Qualtrics, while interviews took place in person at one NIS school and online for others using Google Meet from March to May 2023. The study employed partially purposeful convenience sampling (Dörnyei, 2007) for both quantitative and qualitative components. Participants were selected based on availability and willingness, with key criteria including:

1. NIS computer science teachers instructing grades 11 and 12 in English
2. Students in grades 11 and 12 who chose computer science as their profile subject.

The quantitative study involved 35 teachers and 142 students from 13 of the 21 NIS schools, while interviews were conducted with 19 teachers and 12 students from 9 of these schools. At the end of the interviews, teachers were asked to provide lesson plans and materials for the computer science courses they teach. Materials sent by teachers included lesson plans, presentations, worksheets, and other supplementary materials.

Data Analysis

Quantitative data analysis included descriptive statistics to summarize central tendencies and variability. The distribution of the data was examined using the Shapiro–Wilk test, which indicated a significant departure from normality ($p < .05$) across most items. As the data were not normally distributed and derived from Likert-scale responses (ordinal in nature), nonparametric methods were employed. Specifically, the Mann–Whitney U test was used to assess differences between teachers' and students' responses.

For each item, the null hypothesis (H_0) stated that there is no difference in the distribution of responses between teachers and students. The alternative hypothesis (H_1) posited a significant difference in the distributions. Statistical significance was determined at the $p < .05$ level. Where significant differences were found, effect sizes (r) were calculated to assess the magnitude of those differences.

RESULTS

Since this study is grounded in Nunan's (2010) framework outlining three roles of ICT in CLIL education, the survey was designed accordingly, and the results are likewise structured around these roles: "ICT as a provider of content and instructional tool", "ICT as a learning management system", and "ICT as a collaboration and communication tool". Within each of these sections, the two research questions are addressed. To answer the first research question, findings from the quantitative survey are presented. To address the second question, insights from semi-structured interviews with participants, along with analysis of lesson plans and instructional materials, are provided.

It is important to note that the integration of ICT is essential in teaching computer science. Given the subject's inherent reliance on digital tools and resources, both online and offline, ICT forms the backbone of the instructional methods. These tools not only facilitate the teaching of core concepts but also play a crucial role in enhancing the learning experience through CLIL. As one teacher noted:

"*We systematically utilize ICT resources, particularly since we have the subject of computer science. Using various ICT tools significantly aids us in CLIL teaching*" *(T8).*

ICT as a Provider of Content and an Instructional Tool in CLIL Computer Science Classes

According to the results of the first part of the survey, the most frequently used materials and resources are presentation tools and computer science-related websites. Meanwhile, videos, quizzes, online interactive training platforms, and visualization tools are moderately used. Bilingual dictionaries/translation software, rubric generators, monolingual dictionaries, and WebQuests are used less frequently.

Significant differences between groups were found for six items, indicating that the null hypothesis (H_0) was rejected in those cases. Specifically, teachers and students differed significantly in their reported use of computer science websites ($U = 1858$, $p = .009$, $r = .193$), quizzes for testing ($U = 1624$, $p = .001$, $r = .241$), online interactive platforms ($U = 1836$, $p = .013$, $r = .184$), visualization tools ($U = 1609$, $p = .001$, $r = .243$), rubric generators ($U = 1792$, $p = .007$, $r = .200$), and monolingual dictionaries ($U = 1796$, $p = .007$, $r = .199$). For all other items, no statistically significant differences were observed ($p > .05$), and the null hypothesis was therefore retained. Teachers generally rated their usage of these tools higher than students; however, an exception was noted for computer science websites, where students rated their usage higher than teachers (see Table 1).

The discrepancy between teachers' and students' reported use of various ICT tools may arise from the fact that teachers often include the preparation and planning phases (e.g., creating presentations or quizzes) as part of their frequent ICT use. In contrast, students only interact with these tools during classroom delivery, which may seem less frequent to them. Students reporting more frequent usage of computer science websites could be attributed to the considerable time they spend studying and revising independently.

Table 1: Descriptive statistics and Mann-Whitney U test results for content providers and instructional tools

Item	Mean		SD		U	Z	p	r
	Teachers	Students	Teachers	Students				
Presentation tools (e.g., PowerPoint, Google Slides)	4.51	4.25	0.742	0.939	2122	-1.477	.140	.110
Computer science websites	4.23	4.54	0.690	0.626	1858	-2.621	.009*	.193
Videos (e.g., YouTube)	3.89	3.68	0.758	0.942	2163	-1.271	.204	.095
Quizzes for testing (e.g., Kahoot, Quizlet)	3.83	3.15	0.822	1.119	1624	-3.296	.001*	.241
Online interactive platforms for training (e.g., LearningApps)	3.69	3.17	0.932	1.148	1836	-2.486	.013*	.184
Visualization tools (e.g., posters, concept maps, word clouds)	3.46	2.77	0.980	1.146	1609	-3.328	.001*	.243
Bilingual dictionaries / Translation software (e.g., English-Russian, Google Translate)	2.51	2.32	0.981	1.218	2170	-1.200	.230	.090
Rubrics generators (e.g., RubiStar)	2.34	1.85	1.083	1.058	1792	-2.717	.007*	.200
Monolingual dictionaries (e.g., Cambridge/Oxford)	2.31	1.89	0.993	1.189	1796	-2.711	.007*	.199
WebQuests (e.g., Zunal, QuestGarden)	2.11	1.85	1.105	1.054	2100	-1.519	.129	.114

*Note: 1 = Never, 5 = Always, *p < .05.*

During the interviews, participants were asked which tools and resources they found useful and how they typically utilize them. Given the nature of computer science, students primarily engage in computer-based activities that focus on practical tasks and programming. They utilize a range of tools, including online compilers and integrated development environments (IDEs), to write and test code. Additionally, they work with databases and develop websites and mobile applications. Participants also highlighted the use of simulations. While various tools, such as compilers and simulations, play a crucial role in helping students engage with practical programming tasks and conceptual understanding, the effectiveness of learning is further enhanced by using content-providing tools, instructional tools, and resources.

The results highlight that a variety of multimedia and organizational tools, including PowerPoint presentations, videos, and visual aids, play an important role in enhancing both teaching practices and student learning outcomes in CLIL classrooms.

Presentation Tools. The interviews highlighted that presentations play a crucial role in the learning process for both teachers and students. Teachers reported that they regularly prepare PowerPoint slides for each lesson, aiming to present essential information such as key terms, code examples, and relevant resources in a concise and structured format. These slides are often designed to include definitions, task settings, and discussion prompts, supporting the delivery of complex content. Students emphasized that these presentations significantly aid their understanding by organizing material in a clear, accessible way. Many found them particularly helpful for exam preparation, as they consolidate the most important content. Additionally, students appreciated how presentations support learning when topics are challenging or when explanations in English are difficult to follow. Especially for teachers who struggle with explaining content in English, PowerPoint is an invaluable support tool. As one teacher explained:

"I prepare myself to explain the topic in English. For the most part, I try to memorize the material and prepare a presentation to support myself. When there are places where I get a little stuck, I can refer to a slide" (T15).

In addition to PowerPoint presentations, teachers also utilize online presentation tools such as Canva, Google Slides, and interactive platforms such as Quizizz and Nearpod. Interactive presentations facilitate real-time participation and instant feedback. Teachers especially value receiving immediate statistics of the correct and incorrect answers.

A review of the PowerPoint presentations submitted by teachers reveals that they are well-structured and enriched with diverse interactive activities. The activities range from lower-order thinking tasks, such as comprehension exercises and key term memorization, to higher-order cognitive processes, including research, discussion, collaboration, and reflective evaluation.

Furthermore, the slides incorporate thought-provoking questions designed to activate prior knowledge and foster cognitive engagement. For instance, a PowerPoint presentation on 'RAM and ROM memory' begins with inquiry-based prompts that encourage students to connect new content with their experiences:

"*(1) What happens when a large number of programs run on a computer? (2) Have you ever had a situation where you could not run a program on your computer? (3) Why is this happening?*"

Similarly, a presentation on the 'Generations of Programming Languages' utilizes a visual-based inquiry approach. Students analyze three images representing different programming language generations and respond to guiding questions such as:

"What do you see? What differences can you identify between the three images?"

The theoretical content in the slides is presented clearly and concisely, with key points emphasized through visual aids, ensuring accessibility and engagement.

Videos. The use of video resources, particularly YouTube, has emerged as a significant tool for enhancing students' understanding and learning. Several students highlighted YouTube tutorials and video lessons as their preferred resources for quickly and effectively grasping complex topics. These materials are often favored for their accessibility, clarity, and the opportunity to explore alternative explanations and approaches to the same concept. According to the students, teachers support the use of video resources by recommending or sharing links to relevant YouTube content, thereby reinforcing classroom instruction and providing additional pathways for students to engage with the subject matter.

Interviews with teachers revealed that videos are frequently integrated into the main part of lessons to help explain complex concepts through clear visual aids and authentic auditory input. To ensure effectiveness, teachers typically select short videos, usually under three to five minutes, that closely align with lesson objectives. The importance of using high-quality content that is understandable for students was consistently emphasized. To promote active learning, some teachers employ a pause-and-discuss approach, stopping the video at key moments to clarify ideas and pose questions to students. This strategy helps prevent passive viewing and fosters deeper comprehension. Videos are commonly accompanied by follow-up tasks to enhance student engagement and comprehension, and are often replayed with varying instructional focuses. In some cases, teachers produce their own video lessons or record class instruction and upload them to platforms like YouTube, ensuring consistent access to content for different student groups.

Visualization Tools. Teachers also stated that various visual and organizational tools are used to enhance student engagement and comprehension. Mind mapping tools help organize information visually. Teachers also noted the effectiveness of visual organizers in revising previous topics and activating prior knowledge. In addition to mind maps, tools such as tree maps, fishbone diagrams, and graphs are selected based on their relevance to specific topics, while word clouds are used to engage students with terminology.

Computer Science Websites. In the interviews, participants referenced several websites related to computer science education (Figure 1).

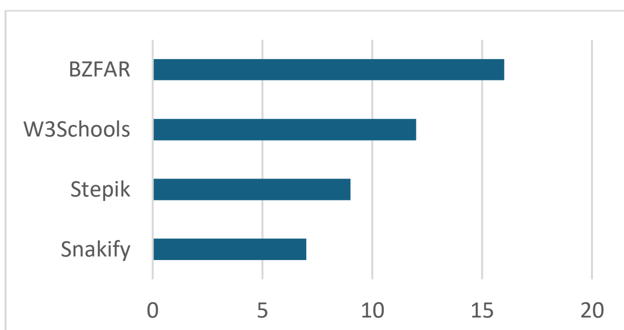

Figure 1: Online learning resources and websites for computer science frequently mentioned by participants

The most frequently mentioned resource, cited by 16 participants, was the BZFAR platform (https://bzfar.org), a site developed by Boris Zelenov, a teacher at NIS in Kostanay. This website has become an indispensable tool for both computer science teachers and students throughout the NIS network. The platform offers purpose-built materials that are aligned with the objectives of the NIS computer science curriculum, making it a key resource for educators and learners. The content on BZFAR is noted for being concise and accessible, offering clear definitions of terms and explaining topics in very easy language, which enhances its value as a comprehensive resource. In addition to its well-written theoretical sections, BZFAR includes practical elements such as assignments at the end of each topic.

W3Schools (https://www.w3schools.com) is another widely respected and frequently used resource for learning programming and web development. Teachers noted that it aligns closely with many topics in the curriculum and is valued for its concise and accessible presentation of information. One student noted:

"*If I am struggling with a topic now, it is often because I have forgotten what I learned in grades 10 or 11. I find W3Schools to be a faster way to understand and review all the necessary information"* (S4).

Another frequently mentioned educational platform was Stepik (https://stepik.org), a Russian platform designed for creating and delivering free open online courses and lessons. Stepik allows any registered user to create interactive training modules and online courses using videos, texts, and various tasks, including programming, with automatic verification and instant feedback. Students can participate in discussions and ask questions on the forum, while teachers have the option to create their own courses or utilize those developed by their colleagues from other NIS. T6 stated that they created a course on Stepik using student-friendly language to simplify complex academic content. These resources help students prepare for tests, essays, and exams. She also highlighted the collaborative aspect of content creation, noting that students often contribute by creating videos, which, if of high quality, are uploaded to the platform. This co-creation process not only enriches the content but also deeply engages students in their learning. S8 confirmed this:

"I would say Stepik is one of the most effective tools because it combines information and problems to solve, like a two-in-one resource, and we really like that. The materials we create during our group research work are uploaded there too, which is fun, especially when we use materials that we explored two or three months ago."

T1 shared her experience of using an online course on Stepik developed by a colleague from another NIS school:

"Then, we have a course on Stepik. It was designed by one of our teachers from NIS in Oral. He has created an excellent course on C++. There are non-standard tasks in this course. For instance, after covering a conditional algorithm in one lesson, there are Olympic problems and some easier ones. Thus, we can solve interesting tasks there" (T1).

Participants believe that Stepik is highly beneficial, as the platform's 'Teaching' section provides detailed insights into student activity. Teachers can see which students have logged in, how many tasks they have completed, and what errors occurred. Additionally, they can track how long it took students to solve problems and whether they revisited them at home. This functionality allows teachers to monitor student progress and provide necessary support, making the learning process more efficient:

"For example, in a section on Conditional algorithms, where 20 problems are given along with an additional four Olympiad-style problems, students have achieved impressive results. In a class of 13 students, about 11 to 12 were capable of solving all the problems" (T1).

The next popular platform among computer science teachers and students is Snakify (https://snakify.org). Teachers emphasized its effectiveness, particularly its structured approach to problem-solving, which enabled students to progress through different levels, continuously enhancing their skills. The platform was introduced to some teachers through internal professional development courses, where it was recommended as an effective tutorial tool for programming instruction. One teacher shared how they use it in class:

"*We begin by opening the first problem, discussing it, and, if necessary, clarifying what needs to be solved and the steps required. Students then proceed to work on the tasks, and we offer additional support to each of them*" (T15).

Similar to Stepik, Snakify also offers the capability to track students' progress. These resources, which were frequently highlighted by both teachers and students, offer targeted, accessible content that directly aligns with the NIS curriculum and exam preparation needs.

Quizzes and Other Digital Assessment Tools. A variety of digital tools, including interactive quiz platforms, collaborative assessment methods, exam preparation resources, and project-based tasks, have become essential for enhancing both formative and summative assessment in computer science education. These tools not only help measure student progress but also foster deeper engagement, critical thinking, and real-world problem-solving skills.

The integration of quizzes through digital tools such as Kahoot, Quizizz, and Quizlet is widely recognized for enhancing the learning experience at various stages of a lesson. These tools are used both at the beginning of lessons to activate prior knowledge and during the reflection phase to reinforce learning. They also serve as a means to revisit previous topics before introducing new content. Teachers noted their usefulness in quickly assessing student understanding, checking homework, and reviewing content in a dynamic, game-based format—particularly in preparation for summative assessments. Both teachers and students highlighted the effectiveness of these platforms in supporting the memorization of complex terminology and theoretical concepts. By transforming abstract or challenging content into engaging quiz activities, these tools help make learning more accessible, interactive, and enjoyable, ultimately improving comprehension and retention. Students expressed that these tools enhance their learning experience and engagement. One student remarked:

"Competing for the top spots encourages us to work harder, which keeps us motivated. It helps us go over the material again, improving our understanding. It is very beneficial because when we answer correctly, we feel pleased, but if we get it wrong, it pushes us to revisit the topic. It also makes us realize the need to put in more effort" (S3).

To effectively prepare students for external exams, teachers highlighted the benefits of using the ExamPro platform (https://www.exampro.co.uk/). Recognizing its value, teachers from various NIS schools collectively purchased licensed access to this platform, which offers a comprehensive database of exam questions and materials tailored specifically for external assessments. The tasks provided by ExamPro closely align with the format of external annual control assessments, offering a convenient and efficient way to prepare students. The site's features, such as the task constructor, allow teachers to gather tasks by topic, download them, and easily create Word or PDF files. During lessons, teachers incorporated exam practice by selecting relevant questions from past exam papers. These assessments, typically conducted in a written, paper-based format, are timed to simulate real exam conditions. At the end of each session, teachers review the answers with students, facilitating discussions on common mistakes and strategies for improvement.

Students also emphasized the importance of project-based assignments in computer science. They highlighted how practical tasks enable them to apply theoretical knowledge to real-world scenarios. As one student noted:

"We have a lot of practical work where we must complete our project and implement our knowledge. Most of our tasks require us to apply our knowledge to real-life situations. For example, we might be given a scenario involving a radar control system and asked which operating system it should use, why, and how it could handle certain problems" (S12).

Teachers and students agreed that the complexity of these projects increases over time. Early projects focus on basic programming concepts, while more advanced assignments require students to build fully functional applications. One student described this progression:

"Starting in eighth grade, our project was just really simple. It was in C++, just in a terminal. But as years passed, our projects got much more difficult; they got more complex. For example, now we start a project with full documentation, and the project is also itself complex, since we use databases, backend, frontend, and a lot of other technologies to build it" (S1).

Rubrics Generators. While participants did not mention using rubric generators, they highlighted collaborative creation of criteria and descriptors with students for self- and peer-assessment. Teachers explained that students collaboratively set evaluation criteria, used them to assess each other's work in teams, and discussed the results together.

Bilingual and Monolingual Dictionaries and Translation Software. The findings revealed a preference among students for bilingual dictionaries and translation software. The survey results indicated that participants preferred using bilingual dictionaries over monolingual ones (see Table 1). Interview participants also highlighted their reliance on translation software, particularly during their initial transition to English-medium instruction. For instance, one student described her approach to dealing with unfamiliar terms by using translation tools alongside other resources:

"*My screen was split into two parts; on one side, I had GeeksforGeeks, and on the other side, Yandex Translate. Sometimes there were words I did not know. I needed to translate them to understand the text"* (S8).

S3 highlighted the importance of mobile translation apps in learning, noting that using Google Translate to look up unfamiliar words immediately helped reinforce vocabulary over time.

Online Interactive Platforms for Training. Among the online interactive platforms used for instructional purposes, LearningApps was frequently mentioned by teachers as a valuable tool. It was described as effective for integrating directly into lessons through exercises such as text readings, gap-filling tasks, and other interactive activities. T19 noted that, despite the emergence of new apps, "*old apps like LearningApps*" continue to be used because they are useful, offer a variety of activities, and provide ready-made resources that teachers have already created.

WebQuests. In the survey, WebQuest usage received the lowest mean score, indicating that it was rarely used. During the interviews, no participants mentioned using WebQuest in CLIL.

ICT as a Learning Management System in CLIL Computer Science Classes

A Mann-Whitney U test indicated a statistically significant difference between teachers' and students' reported use of learning management systems/tools, U = 1727, Z = -2.900, p = .004, r = .213 (see Table 2). Given that p < .05, the null hypothesis was rejected for this item. The effect size (r = .213) suggests a small to moderate difference in reported usage between the two groups, with teachers reporting higher use (M = 4.29) than students (M = 3.54). This could imply that teachers are either more consistent or obligated to use the LMS/LMT in their teaching, while students' usage is more varied.

Table 2: Descriptive statistics and Mann-Whitney U test results for resources, for learning management system/tool

Item	Mean		SD		U	Z	p	r
	Teachers	Students	Teachers	Students				
Learning Management System/Tool (e.g., Moodle, Canvas, MS Teams)	4.29	3.54	0.860	1.330	1727	-2.900	.004*	0.213

*Note: 1 = Never, 5 = Always, *p < .05.*

Interview participants revealed that while traditional LMSs like Moodle or Canvas are not commonly used, Microsoft Teams has become a central platform for educational activities. Teachers reported using MS Teams to share lesson materials, administer assessments, provide feedback, and maintain communication with students. Within Teams, teachers create dedicated Class spaces where resources are uploaded, assignments are organized, and student progress can be monitored. This functionality allows for detailed tracking of student engagement, including task completion, access times, time spent on assignments, and student responses.

The platform is widely used for both formative and summative purposes. Teachers indicated that uploading daily presentations and classwork helps prevent material loss and supports exam preparation, as all resources remain easily accessible in one place. Students benefit from this organized structure, particularly when revising for assessments.

The utility of MS Teams was especially evident during the COVID-19 pandemic, when it facilitated the continuation of learning during school closures. Its use has persisted post-pandemic, particularly in situations where students are unable to attend in person due to illness or weather-related disruptions. In such cases, teachers provide real-time access to lessons and materials through Teams, ensuring continuity of learning.

Beyond administrative tasks, MS Teams is also used to support pedagogical strategies such as blended learning and flipped classrooms. Teachers leverage the platform to encourage student engagement with learning materials both inside and outside of class, enhancing flexibility and reinforcing content through asynchronous and synchronous methods.

ICT as a Collaboration and Communication Tool in CLIL Computer Science Classes

The quantitative data indicate that, among the collaboration and communication tools listed in the third part of the ICT-related questions, both teachers and students most frequently use computer-mediated communication tools, such as instant messaging. This is followed by cloud-based collaborative editing and

ICT-enabled group projects. Survey results indicated that moderately used tools include those for collaboratively visualizing ideas, wikis, and online discussion boards. Blogs were identified as the least frequently used by both students and teachers, suggesting that they are not a preferred method for collaboration.

Statistically significant differences were found for cloud-based collaborative editing ($U = 1842$, $p = .015$, $r = .181$), group projects ($U = 1595$, $p = .001$, $r = .249$), online discussion boards ($U = 1469$, $p < .001$, $r = .279$), and collaborative tools for visualizing ideas ($U = 1763$, $p = .006$, $r = .202$), with teachers reporting higher usage than students. The null hypothesis was rejected in each case, indicating significant differences in the distribution of responses. The effect sizes ranged from small to moderate ($r = .181$ to $.279$), suggesting meaningful differences in how these tools are used in teaching compared to learning. For computer-mediated communication, wikis, and blogs, no significant differences were found ($p > .05$), so the null hypothesis was retained for these items (see Table 3).

The significant differences in responses between teachers and students could be influenced by response bias, particularly social desirability bias. Teachers may feel an implicit expectation to integrate ICT tools into their teaching practices, leading them to overreport their usage. In contrast, students may provide more neutral or realistic assessments of their actual engagement with these tools, contributing to the observed discrepancy in reported usage.

Table 3: Descriptive statistics and Mann-Whitney U test results for collaboration and communication tools

Item	**Mean**		**SD**		**U**	**Z**	**p**	**r**
	Teachers	Students	Teachers	Students				
Computer-mediated communication (e.g., instant messenger, e-mail, chat)	4.17	3.82	0.857	1.119	2088	-1.539	.124	0.115
Cloud-based collaborative editing (e.g., Google Docs, OneDrive)	3.86	3.26	0.944	1.259	1842	-2.441	.015*	0.181
Group Projects (e.g., creating presentations, websites, videos)	3.74	2.96	0.780	1.196	1595	-3.424	.001*	0.249
Online discussion boards (e.g., Padlet, Jamboard)	3.09	2.28	0.951	1.107	1469	-3.866	<.001*	0.279
Collaborative tools for visualizing ideas (e.g., mind maps, posters)	2.94	2.34	1.187	1.123	1763	-2.746	.006*	0.202
Wikis (e.g., Wikibooks)	2.89	2.62	1.132	1.219	2182	-1.147	.251	0.086
Blogs (e.g., Edublogs)	1.89	1.76	0.963	1.010	2239	-.993	.321	0.074

*Note: 1 = Never, 5 = Always, *p < .05.*

Computer-mediated Communication and Group Projects. Interview participants indicated that communication in the educational setting is primarily facilitated through platforms such as WhatsApp and Microsoft Teams. MS Teams is used extensively not only for teacher-student interaction but also for professional collaboration among teachers across the NIS network. Teachers described using the platform to coordinate with colleagues in other cities, particularly during exam periods and summative assessments. In addition to professional communication, MS Teams supports instructional needs within the classroom. For example, teachers frequently use the platform to share links and materials with students during lessons in real time. From the student perspective, MS Teams was seen as a convenient tool for private communication with teachers, allowing them to ask individual questions without interrupting the flow of the class.

Teachers have particularly highlighted the use of Microsoft Teams for sharing materials among computer science educators across all 21 Nazarbayev Intellectual Schools as one of the platform's most useful aspects. MS Teams has facilitated collaboration among teachers within the NIS network, leading to the creation of a comprehensive database of lesson plans and educational resources. This initiative began during the pandemic when teachers from the 21 NIS schools started uploading materials to Teams in a centralized repository organized by grade level and topic, benefiting all educators. Teachers appreciate that this database not only reduces the time they spend on lesson planning but also provides a valuable bank of resources in MS Teams, enabling them to share experiences and learn from one another.

Cloud-based Collaborative Editing. Participants highlighted the use of cloud-based collaborative tools, particularly Google Docs and Google Slides, for group work and shared assignments. Teachers and students reported that these tools are regularly employed for creating joint documents and developing group presentations. Students typically work in small groups to research a specific aspect of a topic, collaboratively develop a presentation, and then present their findings to the class. This process allows all group members to contribute actively and engage with the content. Teachers follow up by providing feedback and clarifying any misunderstandings, thereby reinforcing the learning objectives. The collaborative nature of these tools supports both student autonomy and peer learning in a structured digital environment.

Collaborative Online Platforms for Idea Sharing. During the interviews, teachers mentioned assigning tasks that involve collaborative poster creation, mind maps, and using online discussion boards such as Padlet. These discussion boards allow students to share ideas, provide feedback, and engage in collective brainstorming, which enhances their understanding of the topics. Teachers can also assess students' prior knowledge and tailor their instruction accordingly. While survey participants indicated that they use wikis, interviews revealed that these wikis, such as Wikibooks, are primarily utilized as resources for accessing content rather than for collaborative creation. Similarly, no participants mentioned engaging in collaborative blog creation.

DISCUSSION AND CONCLUSION

The findings of this study highlight the significant role of ICT in facilitating CLIL instruction in computer science education. In response to the first research question, "Which ICT tools and resources are used in CLIL computer science classes?", the study reveals that teachers and students extensively use multimedia tools such as PowerPoint presentations, videos, and various visualization tools to enhance content delivery and comprehension. This aligns with previous research indicating that multimodal input enhances both conceptual understanding and linguistic competence in CLIL settings (Martínez-Soto & Prendes-Espinosa, 2023) by supporting different learning styles (e.g., visual, auditory) and exposing learners to the same content through various channels (e.g., reading, watching a video, engaging with interactive quizzes).

The findings highlight the central role of visualization tools in enhancing teaching and learning in the CLIL context. The use of tools such as mind maps, tree maps, fishbone diagrams, and graphs reflects a deliberate effort by educators to facilitate the organization of complex concepts and improve students' ability to make connections between different pieces of information. As highlighted by Menyhei (2021), the visual presentation and structuring of thought elements greatly assist in fostering a deeper understanding of connections, improving memory and recall, and enhancing critical thinking, comprehension, and focus skills.

The study reveals that platforms such as BZFAR, W3Schools, Stepik, and Snakify are highly valued for their ability to offer clear, accessible content aligned with the NIS curriculum. Custom-built platforms significantly enhance students' learning experiences by offering curriculum-specific resources. Teachers praise platforms like Stepik for enabling the creation of custom digital courses, where materials can be organized, assignments integrated, and student progress tracked. Although research shows that WebQuests can offer a well-structured, inquiry-based learning experience (Zhu & Chan, 2023), this approach was not widely adopted by NIS teachers and students. WebQuests could be a valuable alternative to traditional group research tasks in NIS, where students typically create a presentation as the outcome. By offering a clearly defined structure – dividing the process into sections such as introduction, task, process, resources, and evaluation – WebQuests provide a more organized framework for inquiry-based learning. Similarly, the study found that rubric generators are generally underused. However, teachers could benefit from utilizing MS Teams' built-in rubric creation feature. Since many teachers already assign tasks through MS Teams, integrating rubrics into these assignments would not only streamline the grading process but also add clarity and consistency by providing clear criteria for both content mastery and language learning.

The study highlights the integration of diverse assessment tools in computer science education. These tools enhance both formative and summative assessments by fostering engagement, reinforcing learning, and developing critical problem-solving skills. Digital quiz platforms such as Kahoot, Quizizz, and Quizlet are valued for their ability to assess understanding, reinforce terminology, and make learning more engaging.

The findings of this study indicate a pronounced preference among students for bilingual dictionaries and translation software, especially during their initial transition to English-medium instruction. This preference aligns with existing literature, which suggests that learners often favor bilingual resources over monolingual ones in the early stages of language acquisition (Tahriri & Ariyan, 2015). One primary reason for this inclination is the immediate clarity that bilingual dictionaries provide. They offer direct translations, enabling learners to quickly grasp the meanings of unfamiliar words without the added complexity of interpreting definitions in the target language. While bilingual dictionaries are indispensable during the initial stages of language learning, educators should encourage a gradual shift towards monolingual resources to support comprehensive language development and proficiency (Tahriri & Ariyan, 2015).

The study also highlights the continued popularity of online interactive platforms such as LearningApps. Teachers emphasized a thoughtful approach to integrating technology in the classroom: they prioritize learning objectives over the novelty of the tools, as discussed by Kolb (2017). This means that technology is employed only when it effectively supports student learning outcomes, rather than being used just for the sake of using it. Teachers do not feel pressured to adopt the latest tools; if an "old" technology like LearningApps successfully meets their learning goals, they continue to use it. This approach exemplifies the philosophy of "learning first, technology second" (Kolb, 2017), ensuring that technological choices are driven by pedagogical purpose rather than trend-chasing.

Digital platforms, including LMS, have become essential for managing and supporting educational processes in modern learning environments. While Microsoft Teams is not a traditional LMS, its extensive use during the COVID-19 pandemic highlighted its value in contexts where formal LMSs were unavailable (Sobaih et al., 2021). In NIS, MS Teams emerged as the primary platform for organizing and managing educational materials.

Similar to the findings of Navarro-Pablo et al. (2019), tools that promote collaborative studying are among the lowest priorities among the digital resources used by teachers in their CLIL classes. The relatively low usage of tools such as blogs and wikis suggests that they are not fully integrated into the collaborative practices of teachers and students. However, these tools offer significant potential for enhancing language development and collaboration. Teachers could explore using blogs and wikis as engaging alternatives to creating traditional presentations. Wikis, for example, offer features like a history page that tracks student contributions, providing insights into collaboration and participation (Gao et al., 2021). Similarly, blogs foster discussion and interaction among participants by allowing comments to be posted, which enhances engagement and collaboration (Onojah et al., 2022).

As for the second research question, “How are these ICT tools integrated into the teaching of computer science within a CLIL framework?”, it is clear that ICT tools are integrated in ways that support not only content delivery but also critical thinking and problem-solving development.

Presentation tools are used to condense complex information, provide coding templates, and link additional resources. Unlike previous studies, such as Griffith (2017), which found that teachers less confident in their target language skills often relied on excessive text in their slides, this study shows that teachers use concise, focused content complemented by visual elements. The study also highlights the extensive use of video resources in CLIL lessons, which teachers carefully select to match students’ competence levels and background knowledge. Videos serve as effective scaffolding tools that support the development of listening and comprehension skills, aligning with the observations of Cinganotto and Cuccurullu (2015). Additionally, teachers create their own video content and engage students as co-creators. This co-creation process empowers students, allowing them to take ownership of their learning and strengthening the collaborative, project-based learning environment. Teachers strategically choose videos and multimedia resources that align with students’ language proficiency levels and subject knowledge, creating a scaffolding environment that supports both content and language learning.

It can also be observed that multimedia input is supported by scaffolding techniques such as pause-and-discuss, along with activities designed to enhance understanding, in accordance with the guidelines set forth by Mahan (2020) and Zaparucha (2019). These multimedia tools and resources not only assist students but also help teachers deliver key content points, boosting their confidence, especially for those who struggle with the English language. This is consistent with the study by Štefková and Danihelová (2023), which highlights that content teachers who do not achieve a B2 level in English require support in integrating the foreign language into their instruction. Where language input from content teachers is limited, the use of English during classes can be encouraged through internet applications, and the application-based teaching activities still help achieve the goals of target language learning.

The integration of ICT into assessment practices highlights the importance of technology in promoting active learning and engagement. Teachers also recognize the potential of project-based tasks and real-world applications, which are often facilitated by ICT, to deepen student understanding and foster critical problem-solving skills. Project-based tasks enhance applied learning and real-world application of theoretical knowledge. However, this study also shows that higher-order thinking skills can be developed not only through hands-on activities, such as programming and software development, but also through teacher-centered technology use. For example, during the presentation of new topics, teachers can foster critical thinking, aligning with Kolb (2017). Teachers' PowerPoint presentations often include thought-provoking questions that require skills such as analysis and evaluation. These practices are a deliberate effort to integrate ICT tools into the classroom in ways that go beyond simple content delivery, reinforcing both cognitive and linguistic development.

The ongoing development and sharing of resources within the NIS network exemplify a collaborative approach to education, which could serve as a model for other institutions. Unlike studies that emphasize the lack of CLIL resources as a major obstacle (McDougald et al., 2023; Mahan & Norheim, 2021), this study demonstrates how NIS has successfully mitigated this challenge by establishing a comprehensive resource bank across twenty-one schools. This initiative not only reduces lesson preparation time but also promotes a culture of knowledge sharing throughout the network. Furthermore, the organization of internal courses and seminars allows teachers to regularly share best practices, including showcasing useful digital tools and instructional resources, thus fostering continuous professional development. Collaborative practices extend to the joint purchase and shared use of licensed products, enhancing both cost efficiency and resource utilization across the network. Additionally, the sharing practices of NIS teachers are evident in how they share resources, such as comprehensive computer science websites created by individual teachers and courses developed on the Stepik platform, which are used across the NIS network.

The common thread among participants' perceptions of using ICT tools and resources is the need for clarity and focus. These tools should distill key concepts and use a variety of visuals to help students grasp abstract concepts more effectively. They should also align with the curriculum and external examinations, serving as valuable resources for exam preparation. The language used should be easily understandable, and tasks should be structured to progress from lower-order to higher-order thinking skills. Additionally, the tools should foster active learning, encouraging pair and group discussions and collaboration. Most importantly, technology should be integrated through pedagogy-driven approaches, rather than allowing technology to dictate the teaching methods. Only by prioritizing educational goals and pedagogical frameworks can technology truly enhance students' learning experiences. In this way, ICT tools not only support but also strengthen the core CLIL components of content, communication, and cognition, ensuring a more effective and meaningful learning process.

Limitations and Future Directions

This study has several limitations, including the use of convenience sampling and reliance on self-reported data, which may introduce bias and limit the generalizability of the findings. Furthermore, the relatively low response rate from teachers in the questionnaire may restrict the depth of insights gained. Despite these limitations, the study provides valuable insights into the integration of ICT tools in CLIL computer science classes. The findings highlight the potential of digital tools to enhance educational delivery, foster collaboration, and facilitate resource sharing within the NIS network, offering guidance for future efforts to improve educational practices and learning outcomes.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS

Gulmira Kussaiynkyzy: Conceptualization, Investigation, Data curation, Original draft preparation, Writing-Original draft preparation. **Ida Dringó-Horváth:** Supervision, Validation, Writing-Review, and Editing.

DECLARATION OF GENERATIVE AI

During the preparation of this work, the authors used ChatGPT to enhance the clarity of the writing. After using ChatGPT, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

DATA AVAILABILITY STATEMENT

Data available on request from the authors.

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