A specialized Ukrainian-Polish computer science translator for primary education: Design and implementation

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Abstract

As a result of the full-scale Russian invasion of Ukraine that began on February 24, 2022, a large number of Ukrainians were forced to leave their homes and seek refuge in other countries, particularly in Poland. Many Ukrainian children found themselves in a difficult situation, continuing their education in Ukrainian schools remotely while also attending Polish schools offline. This parallel education in two school systems and languages creates challenges for students, especially in understanding and using the specialised terminology of school subjects like computer science. To address this issue, we propose creating a specialised Ukrainian-Polish dictionary of computer science terms for primary school students. This study aims to design and implement a Ukrainian-Polish online dictionary of computer science terms to support the bilingual education of Ukrainian primary school students in Poland, helping overcome language barriers and terminological challenges and aiding adaptation to the new educational environment.

Keywords

Ukrainian-Polish computer science translator, primary education, bilingual education, computer science terminology, refugee education, language barrier, educational technology, online translator

1. Introduction

As a result of the full-scale Russian invasion of Ukraine that began on February 24, 2022, a large number of Ukrainians were forced to leave their homes and seek refuge in other countries (as of 16.05.2024 - 6,483,500 people [1]). In particular, a significant number of Ukrainian women (43.75% of all who left) with school-age children (31.93% aged 5 to 17 years), including primary school students, migrated to Poland.

These children found themselves in a difficult situation, continuing their education in Ukrainian schools remotely while also attending Polish schools offline [2]. Such parallel education in two school systems and languages creates challenges for students [3], especially in understanding and using the specialised terminology of school subjects.

In particular, this applies to computer science – a subject filled with a large number of specific terms. In Ukrainian schools, computer science is studied as a separate subject from the 3rd grade [4], while in Poland – from the 1st grade [5].

All this leads to problems with understanding and communication in computer science lessons, complicates students' learning of the material and creates psychological discomfort from uncertainty in their own knowledge. This problem is especially acute for primary school students who are just beginning to become familiar with computer science.

To solve this problem, a specialised Ukrainian-Polish dictionary of computer science terms for primary school students is proposed. Such a dictionary will help students systematise and compare the terminology of the two languages, improve their understanding of the subject, and facilitate communication in computer science lessons in Polish schools.

Moreover, to facilitate the use of the dictionary, an online translator based on it is planned, which will be a useful tool for both students and teachers. The interactivity and accessibility of the online translator will allow quick finding of the necessary terms and viewing options for their translation and interpretation.

The purpose of the study – design and implementation of a Ukrainian-Polish online translator of computer science terms for primary school students.

According to the purpose, the main **objectives of the study** are defined as follows:

1. To extract computer science terminology from computer science textbooks for primary school students in Poland and Ukraine for compiling a dictionary.
2. To design and implement an online translator based on the created dictionary.

Research methods:

- *search* for computer science textbooks for primary school students in Polish and Ukrainian;
- *analysis* of textbook content to find terms or terminological dictionaries;
- *synthesis* of dictionaries: a) terms in Ukrainian and Polish with full correspondence (for translation); b) terms in Ukrainian that do not have a complete equivalent in Polish (for interpretation); c) terms in Polish that do not have a complete equivalent in Ukrainian (for interpretation);
- *software engineering methods* for designing and implementing an online translator.

2. Extraction of Ukrainian and Polish computer science terminology from primary school computer science textbooks

2.1. Analysis of educational programmes and textbooks on computer science for primary schools in Ukraine

The article [6] discusses the importance of information technology in modern society, which leads to an increase in the number of countries introducing information technology even in primary schools. In particular, it emphasises that the content of curricula often includes digital literacy and computer science, confirming the importance of these aspects in primary education.

According to the State Standard of Primary Education, the aim of the informatics educational field is the formation of information and communication competence and other key competencies, the ability to solve problems using digital devices, information and communication technologies and critical thinking for development, creative self-expression, own and social well-being, skills of safe and ethical activity in the information society [4].

The purpose of computer science education in grades 1-2 is the diverse development of the child's personality and his/her worldview orientations, the formation of information and other key competencies necessary for life and further education [7].

Computer science educational programmes for grades 2-4 are developed in accordance with the State Standard of Primary Education and approved by the Ministry of Education and Science of Ukraine.

A request to Claude 3 regarding the comparison of typical educational programmes on computer science for grades 1-2, developed under the guidance of O. Ya. Savchenko [7] and R. B. Shyian [8], provided an opportunity to summarise their common features:

- the goal is to form information competence and develop logical, algorithmic, and creative thinking in students;
- attention is paid to the formation of skills to find, process, store and present information;
- they include topics about digital devices, their safety, and ethics in the information space;
- they provide for the acquisition of practical skills in working with graphic and text editors.

Table 1 shows the differences and features of the programmes [7] and [8].

Table 1
Differences and features of programmes for grades 1-2 [7] and [8].

Programme [7]	Programme [8]
Built linearly-concentrically with horizontal deepening	Built on 5 content lines
Study of computer science from 2nd grade	Study of computer science from 1st grade
Includes approximate objects and teaching aids	Contains more detailed proposed content and expected results
Provides for the study of a programming environment from 3-4 grades	Does not include a programming environment

A request to Claude 3 regarding the comparison of typical educational programmes on computer science for grades 3-4, developed under the guidance of O. Ya. Savchenko [9] and R. B. Shyian [10], provided an opportunity to summarise their common features:

- the goal is to form information and communication competence, skills to work with information, use digital devices and programs;
- they provide for the formation of algorithmic thinking, creation of simple programs and understanding of the principles of functioning of digital devices;
- they lay the foundations for safe and ethical behaviour in the information environment.

Table 2 shows the differences and features of the programmes developed under the guidance of O. Ya. Savchenko and R. B. Shyian.

Table 2
Differences and features of programmes for grades 3-4 [9] and [10].

Programme [9]	Programme [10]
The content is presented along the following content lines: "Information. Actions with Information", "Computer Devices for Performing Actions with Information", "Object. Object Properties", "Creation of Information Models. Changing Ready-Made Ones. Use", "Algorithms".	The content is presented along the following content lines: "Me in the World of Information (Data. Information. Models)", "My Digital Creativity", "Communication and Collaboration", "Me and Digital Devices", "Responsibility and Safety in the Information Society".
Emphasis on forming skills for creating and editing information objects	Greater emphasis on developing critical thinking and evaluating information
Robotics is not mentioned	A review of robotics designers is mentioned
The use of digital devices for orientation in space and time is not mentioned	The use of digital devices for orientation in space and time is provided

To find out the common and different computer science terminology used in the programmes [7, 8, 9, 10], all computer science terms used in them were extracted. The analysis of the extracted terms provided the opportunity to distinguish computer science terminology:

- for grades 3-4, unique to the program under the guidance of R. B. Shyian: web resource, information properties, hypertext, information resource, information processes, combined tasks, network culture, logical sequence, network community, network navigation, table operations, Internet connection, plagiarism, simple algorithms, element structuring, fake, digital reputation, digital trace;

- for grades 3-4, unique to the programme under the guidance of O. Ya. Savchenko: animation effects, website, virtual library, directory, text bookmarks, information interaction, editing commands, critical evaluation of information, mathematical model, message carriers, organisation of digital device operation, computer memory, message, programme, project, algorithm execution environment, text reading environment, decoding symbols, encoding symbols, object components, dictionary;
- for grades 3-4, common to the programme under the guidance of O. Ya. Savchenko and R. B. Shyian: browser, information object, command, computer presentations, linear algorithm, Internet, information search, search engines, presentation editing, branched algorithm, programming environment, logical sequence system, complex algorithm, information distortion, judgement, text object;
- for grades 1-2, unique to the programme under the guidance of R. B. Shyian: object properties, encyclopaedia, information signs, password, PIN code, software environment;
- cross-cutting for grades 1-4, unique to the programme under the guidance of R. B. Shyian: information security, computer systems, modern information carriers, fact;
- cross-cutting for grades 1-4 according to the programme under the guidance of R. B. Shyian, used in grades 3-4 according to the programme under the guidance of O. Ya. Savchenko: design, sequence of events, sequence ordering;
- for grades 1-2, unique to the programme under the guidance of O. Ya. Savchenko: graphic information, graphic algorithm, computer programme menu;
- cross-cutting for grades 1-4, unique to the programme under the guidance of O. Ya. Savchenko: copyright, geometric model, geometric tasks, information networks, tabular model form;
- cross-cutting for grades 1-4 according to the programme under the guidance of O. Ya. Savchenko, used in grades 3-4 according to the programme under the guidance of R. B. Shyian: hyperlink;
- for grades 1-2, common to the programme under the guidance of O. Ya. Savchenko and R. B. Shyian: information sources, information and communication technologies, computer devices, data carriers, event, text information;
- cross-cutting for grades 1-4 according to the programme under the guidance of O. Ya. Savchenko, used in grades 1-2 according to the programme under the guidance of R. B. Shyian: graphic object;
- cross-cutting for grades 1-4 according to the programmes under the guidance of O. Ya. Savchenko and R. B. Shyian: algorithm, Internet safety, graphic editor, information storage, computer science, information, information model, computer programmes, model, object model, object, table, text, text editor.

No computer science terminology was found for:

- for grades 1-2 according to the programme under the guidance of R. B. Shyian, used in grades 3-4 according to the programme under the guidance of O. Ya. Savchenko;
- for grades 1-2 according to the programme under the guidance of O. Ya. Savchenko, used in grades 3-4 according to the programme under the guidance of R. B. Shyian;
- cross-cutting for grades 1-4 according to the programme under the guidance of R. B. Shyian, used in grades 1-2 according to the programme under the guidance of O. Ya. Savchenko.

A review of the current textbooks [11] showed that computer science education in grades 1-3 is carried out using the textbooks "I Explore the World", and in grade 4 – using the textbooks "Computer Science".

In the 2023-2024 academic year, the Ministry of Education and Science of Ukraine recommended the following computer science textbooks for grade 4:

- according to the programme under the guidance of O. Ya. Savchenko [9]: Morze and Barna [12], Hilberg et al. [13], Korshunova [14], Vorontsova et al. [15], Kornienko et al. [16], Vdovenko [17].
- according to the programme under the guidance of R. B. Shyian [10]: Andrusych and Stetsenko [18], Kozak [19], Lomakovska and Protsenko [20].

Analysis of the table contains all the computer science terms used in the specified textbooks and programmes provided an opportunity to determine potential problems for each pair of the form "textbook – programme", namely mandatory terms present in the programmes but absent in the textbook, and optional terms absent in the programme but present in the textbook:

- – terms provided by the programme [9] but missing in the textbook by Morze and Barna [12]: algorithm, animation effects, Internet safety, browser, website, hyperlink, graphic editor, directory, text bookmarks, information storage, computer science, information interaction, information model, information objects, information, command, editing command, computer presentation, computer programme, design, critical evaluation of information, linear algorithm, mathematical model, Internet, model (25);
  - – terms not provided by the programme [9] but present in the textbook by Morze and Barna [12]: copyright, input information, hypertext, game, graphic object, data, space, software, project, processor, robot, site, script, slide, smartphone, scene in "Scratch", condition, loop, digital devices, artificial intelligence (20);
- – terms provided by the programme [8] but missing in the textbook by Kozak [19]: algorithm, web resource, graphic editor, computer science, computer presentation, computer programme, Internet, information search, branched algorithm, programming environment, logical sequence system, information distortion, text editor, sequence ordering, fake (15);
  - – terms not provided by the programme [8] but present in the textbook by Kozak [19]: URL address, account, browser window, game, graphic object, information sources, experience, emoticons, keywords, integrity criteria for information, integrity criteria for messages, nickname, office software package, portable storage device, plagiarism, message, mail server, file transfer protocol, processor, robot, sprite, scene in "Scratch", file, text formatting, cyclic algorithm, digital reputation, digital data, digital devices (28);
- – terms provided by the programme [9] but missing in the textbook by Kornienko et al. [16]: animation effects, virtual library, directory, text bookmarks, information interaction, information objects, information, editing command, computer programme, linear algorithm, mathematical model, Internet, model, object model, information search, presentation editor, branched algorithm, programming environment, logical sequence system, information distortion, table, text, text editor, sequence ordering (24);
  - – terms not provided by the programme [9] but present in the textbook by Kornienko et al. [16]: loop algorithm, branch algorithm, antivirus programme, web page, executor, algorithm executor, command executor, input information, information sources, designer, modern user experience, collage, integrity criteria for software elements, message, error, portfolio, presentation, receiver, software, programming, abstracting, branched structure, slide, condition, file, fact (26);
- – terms provided by the programme [9] but missing in the textbook by Vdovenko [17]: animation effects, Internet safety, virtual library, hyperlink, directory, text bookmarks, information storage, information interaction, information, command, computer presentation, design, critical evaluation of information, mathematical model, Internet, object model, object, sequence of events, information search, logical sequence system, complex algorithm, information distortion, table, text editor, sequence ordering (25);
  - – terms not provided by the programme [9] but present in the textbook by Vdovenko [17]: paragraph, copyright, academic integrity, branch algorithm, audio file, web page, executor, video file, internal memory, geoboard, hypertext, graphic model, graphic object, software uninstallation, information processes, encoding, computer animation, computer model, integrity criteria for animation, integrity criteria for data, integrity criteria for objects, logical sequence, positioning, project, text editing, text positioning, style, navigation page, storytelling, tester (30);
- – terms provided by the programme [8] but missing in the textbook by Lomakovska and Protsenko [20]: algorithm, Internet safety, browser, web resource, graphic editor, informa-

tion storage, information model, information objects, computer programme, design, linear algorithm, Internet, model, object model, object, sequence of events, information search, search engine, presentation editor, branched algorithm, logical sequence system, text, fact, fake, legal responsibility (25);

- terms not provided by the programme [8] but present in the textbook by Lomakovska and Protsenko [20]: paragraph, web page, executor, graphic object, chart, modern programme user experience, information gathering, information systems, service information, keywords, plagiarism, connector, file extension, system unit, scanner, slide, verbal model, ways of presenting messages, flash drive, flash storage device (20);

- — terms provided by the programme [9] but missing in the textbook by Vorontsova et al. [15]: animation effects, Internet safety, browser, virtual library, directory, text bookmarks, information storage, computer science, information interaction, information model, information objects, information, command, editing command, computer presentation, critical evaluation of information, mathematical model, Internet, object model, sequence of events, information search, search engine, presentation editor, branched algorithm, logical sequence system, complex algorithm, table, text (28);
  - terms not provided by the programme [9] but present in the textbook by Vorontsova et al. [15]: RGB model, auto shape, branch algorithm, animation, clipboard, data input, data output, video editor, properties, object properties, input information, hypertext, software uninstallation, information sources, range, domain, user experience, hard magnetic disk, variable, computer virus, nickname, folder, portable storage device, personal data, confirmation, event, presentation, input devices, output devices, programmer, software, programming, site, text model, word processor, slide theme, title slide, improved experience of programme users, inference, fact, fake, paragraph formatting, false message, loop, font(45);

- — terms provided by the programme [9] but missing in the textbook by Korshunova [14]: animation effects, website, hyperlink, graphic editor, directory, text bookmarks, information storage, information interaction, information model, information objects, information, command, editing command, computer presentation, computer programme, design, critical evaluation of information, linear algorithm, mathematical model, Internet, model, object model, information search, search engine, presentation editor, branched algorithm, programming environment, logical sequence system, complex algorithm, information distortion, table, text, text editor (33);
  - terms not provided by the programme [9] but present in the textbook by Korshunova [14]: animation, byte, bit, flowchart, built-in programmes, web page, winning strategy, statement, video information, measurement, information properties, object properties, geolocation, graphic information, data, sensor, binary encoding, domain, modern programme user experience, personal information, integrity criteria for statements, integrity criteria for facts, nickname, operator, folder, personal data, icon, project, robot, fact (30);

- terms provided by the programme [9] but missing in the textbook Hilberg et al. [13]: animation effects, website, virtual library, graphic editor, directory, computer science, information interaction, information model, information objects, command, editing command, computer presentation, computer programme, design, critical evaluation of information, linear algorithm, mathematical model, Internet, object model, object, sequence of events, information search, search engine, presentation editor, branched algorithm, programming environment, logical sequence system, complex algorithm, information distortion, judgement, table, text, text editor, sequence ordering (34);
- terms not provided by the programme [9] but present in the textbook Hilberg et al. [13]: input information, data, software uninstallation, electronic document, electronic textbook, general personal data, information storage, gathering, audio information, message, information presentation, event, resource, file, cloud environment, digital society, digital devices (17);

- terms provided by the programme [8] but missing in the textbook by Andrusych and Stetsenko [18]: algorithm, browser, web resource, hyperlink, information storage, computer science, information model, information objects, information, command, computer presentation, design, linear algorithm, Internet, model, object model, object, information search, search engine, presentation editor, programming environment, logical sequence system, complex algorithm, text, text editor, sequence ordering, fact, fake, legal responsibility (29);
- terms not provided by the programme [8] but present in the textbook by Andrusych and Stetsenko [18]: Morse code, branch algorithm, algorithmic structures, nested branching, gadget, data, sensor, culture, Internet connection, message, event, presentation, LED, pie chart, touch screen, symbol and text information, instant messaging systems, social network, community, observation (20);

Additionally, mandatory terms missing from all considered textbooks were identified:

- according to the programme under the guidance of O. Ya. Savchenko [9]: animation effects, directory, information interaction, mathematical model, Internet, object model, information search, logical sequence system, table;
- according to the programme under the guidance of R. B. Shyian [10]: algorithm, web resource, Internet, information search, logical sequence system, fake.

A quantitative summary of the obtained results is presented in table 3. Textbooks with the minimum number of missing and redundant terms are marked in yellow, and those with the next minimum number are marked in silver.

Table 3
Evaluation of computer science textbooks for grade 4 by terminological completeness and redundancy.

Textbook	Number of terms present in the programme but missing in the textbook	Number of terms missing in the programme but present in the textbook	Total number
Morze and Barna [12]	25	20	45
Kozak [19]	28	24	52
Kornienko et al. [16]	24	26	50
Vdovenko [17]	25	30	55
Lomakovska and Protsenko [20]	25	20	45
Vorontsova et al. [15]	28	45	73
Korshunova [14]	33	30	63
Hilberg et al. [13]	34	17	51
Andrusych and Stetsenko [18]	29	20	49

Table 3 clearly shows that according to the programme [9], the most terminologically complete textbook is the textbook by the author team led by Kornienko et al. [16], and the least redundant is the textbook by Hilberg et al. [13]. However, on average, the textbook by the author team led by Morze and Barna [12] is ahead in terms of completeness and redundancy of terms. According to the programme [8], the most terminologically complete textbook is the textbook by the author team led by Lomakovska and Protsenko [20], and the least redundant are the textbooks by Hilberg et al. [13] and Andrusych and Stetsenko [18]. However, on average, the textbook by the author team led by Lomakovska and Protsenko [20] is ahead in terms of completeness and redundancy of terms.

The expert evaluation method was used to determine textbook ratings based on terminological completeness and redundancy. Two experts were asked to evaluate them on a Likert scale from -2 (not at all important) to +2 (extremely important).

The experts' answers to the questionnaire are given in table 4.

Table 4
Experts' ratings based on the questionnaire results.

Question	Expert 1	Expert 2	Average
Rate the importance of the terminological completeness of the textbook (how important is it that all terms present in the programme are in the textbook?)	+2	+2	2
Rate the importance of the terminological redundancy of the textbook (how important is it that the textbook has as few additional terms as possible that are absent in the programme?)	0	-1	-0.5

Accordingly, to determine the rating score of textbooks, it is necessary to subtract half the number of terms absent in the programme but present in the textbook from twice the number of terms present in the programme but absent in the textbook. The ranking results are presented in table 5.

Table 5
Evaluation of computer science textbooks for grade 4 by terminological completeness and redundancy.

Place	Textbook	Number of terms present in the programme but missing in the textbook	Number of terms missing in the programme but present in the textbook	Rating score
1	Vorontsova et al. [15]	28	45	33.5
2	Kornienko et al. [16]	24	26	35
2	Vdovenko [17]	25	30	35
3	Morze and Barna [12]	25	20	40
3	Lomakovska and Protsenko [20]	25	20	40
4	Kozak [19]	28	24	44
5	Andrusych and Stetsenko [18]	29	20	48
6	Korshunova [14]	33	30	51
7	Hilberg et al. [13]	34	17	59.5

2.2. Analysis of computer science curricula and textbooks in Poland

Primary education in Poland is compulsory and lasts 8 years. The obligation to attend school begins at the beginning of the school year in the calendar year in which the child turns 7 years old. Primary education is divided into two stages [21]:

- initial stage (grades 1-3) – duration of 3 years;
- second stage (grades 4-8) – duration of 5 years.

For each stage of primary education, there is a core curriculum that defines the compulsory subjects and expected learning outcomes [21]:

- for grades 1-3, the core subjects are Polish language, mathematics, natural science, music, art, technology, computer science, physical education, and ethics.
- for grades 4-8, the following subjects are added: history, social studies, biology, geography, physics, chemistry, second foreign language.

The early education curriculum is focused on [22]:

- the child-student together with his/her needs, interests and abilities;
- individual and group learning in cooperation and interaction;
- reflection, research, creativity, activity, acquisition of new skills;

- understanding of acquired knowledge, formation and improvement of skills.

The core curriculum of primary school defines the following tasks of general education for grades 1-3 [23]:

1) students gain basic knowledge about facts, principles, theory and practice, mainly related to topics and phenomena closely related to students' experience;
2) students acquire skills to use their knowledge in performing tasks and solving problems;
3) students form attitudes that determine effective and responsible existence in the modern world.

The curriculum for grades 4-8 [24] defines the main objectives of teaching computer science to students as:

- development of logical, algorithmic and abstract thinking;
- mastering programming skills and solving problems using computers and digital devices;
- acquiring skills to effectively use computers, digital devices and computer networks;
- development of competencies of cooperation, communication and project management, including in virtual environments;
- adherence to security principles, ethical norms, data protection, intellectual property and responsible attitude to the use of technologies;
- application of computer science and ICT to solve problems from various fields of knowledge;
- preparation for future professional activities related to the use of information technologies;
- mastering the skills of creating various digital content: texts, presentations, multimedia, web pages;
- development of skills in searching, analysing, and critically evaluating information and its sources;
- familiarisation with the historical development of computer science and information technologies.

To extract computer science terms from Polish computer science textbooks, textbooks for 4th grade (Jochemczyk et al. [25], Koba et al. [26]), 5th grade (Kęska [27]), 6th grade (Jochemczyk et al. [28]), 7th grade (Jochemczyk et al.) and 8th grade (Koba [29]) were analysed.

2.3. Extraction and systematisation of computer science terms in Ukrainian and Polish

For institutions of general secondary education in Ukraine with Polish as the language of instruction, the Ministry of Education and Science of Ukraine recommends a Ukrainian-Polish and Polish-Ukrainian dictionary [30]. The main task of the dictionary is to help students correlate terms in their native language with terms in the Ukrainian language and vice versa, which is especially important in the current conditions [30, p. 3].

Analysis of the Ukrainian computer science terminology presented in the programmes and textbooks, the Polish computer science terminology of textbooks and the Ukrainian-Polish dictionary of computer science terminology provided an opportunity to:

a) extract 48 terms present in Ukrainian computer science programmes and textbooks but absent in the dictionary proposed by the Ministry of Education and Science (table 6);
b) extract 60 terms present in Polish computer science textbooks but absent in the dictionary proposed by the Ministry of Education and Science (table 7).

Table 6: Ukrainian terms missing in the dictionary [30] and their proposed Polish translations.

No.	Ukrainian / English term	Proposed Polish translation
1	Анімаційні ефекти / Animation effects	Efekty animacyjne
2	Віртуальна бібліотека / Virtual library	Wirtualna biblioteka

No.	Ukrainian / English term	Proposed Polish translation
3	Геолокація / Geolocation	Geolokalizacja
4	Геоборд / Geoboard	Geoboard
5	Графічна інформація / Graphic information	Informacja graficzna
6	Графічна модель / Graphic model	Model graficzny
7	Джерела інформації / Information sources	Źródła informacji
8	Діапазон / Range	Zakres
9	Довідник / Directory	Podręcznik
10	Досвід користувача / User experience	Doświadczenie użytkownika
11	Досвід сучасних користувачів / Modern user experience	Doświadczenie współczesnych użytkowników
12	Досвід сучасних користувачів програм / Modern program user experience	Doświadczenie współczesnych użytkowników programów
13	Загальні дані про особу / General personal data	Ogólne dane osobowe
14	Звукова інформація / Audio information	Informacja dźwiękowa
15	Збирання інформації / Information gathering	Gromadzenie informacji
16	Збирання / Gathering	Zbieranie
17	Змінна / Variable	Zmienna
18	Інформаційна взаємодія / Information interaction	Interakcja informacyjna
19	Інформація про особу / Personal information	Informacje o osobie
20	Інформація про послуги / Service information	Informacje o usługach
21	Інформаційні процеси / Information processes	Procesy informacyjne
22	Кодування / Encoding	Kodowanie
23	Комбіновані задачі / Combined tasks	Zadania kombinowane
24	Логічне слідування / Logical sequence	Następstwo logiczne
25	Математична модель / Mathematical model	Model matematyczny
26	Мережева спільнота / Network community	Społeczność sieciowa
27	Носії повідомлень / Message carriers	Nośniki komunikatów
28	Операції з таблицями / Table operations	Operacje na tabelach
29	Організація роботи цифрового пристрою / Organization of digital device operation	Organizacja pracy urządzenia cyfrowego
30	Підключення до Інтернету / Internet connection	Połączenie z internetem
31	Подання інформації / Information presentation	Prezentowanie informacji
32	Помилка / Error	Błąd
33	Прості алгоритми / Simple algorithms	Proste algorytmy
34	Проєкт / Project	Projekt
35	Символи декодування / Decoding symbols	Symbole dekodowania
36	Символи кодування / Encoding symbols	Symbole kodowania
37	Складові частини об'єктів / Object components	Składowe obiektu
38	Словник / Dictionary	Słownik
39	Структурування елементів / Structuring of elements	Strukturyzacja elementów
40	Сучасні носії інформації / Modern information carriers	Współczesne nośniki informacji
41	Тестувальник / Tester	Tester
42	Удосконалений досвід користувачів програм / Improved user experience of programs	Ulepszone doświadczenie użytkownika programów
43	Фейк / Fake	Fake news

No.	Ukrainian / English term	Proposed Polish translation
44	Цифрова репутація / Digital reputation	Reputacja cyfrowa
45	Цифрове суспільство / Digital society	Społeczeństwo cyfrowe
46	Цифрові дані / Digital data	Dane cyfrowe
47	Цифрові пристрої / Digital devices	Urządzenia cyfrowe
48	Цифровий слід / Digital trace	Ślad cyfrowy

Table 7: Polish terms missing in the dictionary [30] and their proposed Ukrainian translations.

No.	Polish term	Proposed Ukrainian / English translation
1	Adres komórki	Адреса комірки / Cell address
2	Algorytm porżadkowania	Алгоритм упорядкування / Sorting algorithm
3	Algorytm wyszukiwania	Алгоритм пошуку / Search algorithm
4	Analizowanie danych	Аналіз даних / Data analysis
5	Animacja Duszka	Анімація Спрайта / Sprite animation
6	Animacja obiektu slajdu	Анімація об'єкта слайда / Slide object animation
7	ASCII	ASCII / ASCII
8	Bajt	Байт / Byte
9	Biezpieczna praca w komputerze	Безпечна робота на комп'ютері / Safe computer work
10	BIOS	BIOS / BIOS
11	Binarny system	Двійкова система / Binary system
12	Blok	Блок / Block
13	Blu-Ray dysk	Blu-Ray диск / Blu-Ray disc
14	Chmura internetowa	Інтернет-хмара / Internet cloud
15	Chronometraż	Хронометраж / Timing
16	Częstotliwość procesora	Частота процесора / Processor frequency
17	Decymalny system	Десяткова система / Decimal system
18	Dokumenty Google	Документи Google / Google Docs
19	Dysk twardy	Жорсткий диск / Hard drive
20	Edycja Tekstu	Редагування тексту / Text editing
21	Edytor grafiki	Редактор графіки / Graphics editor
22	Edytor obrazów	Редактор зображень / Image editor
23	Edytor wideo	Відеоредактор / Video editor
24	Efect 3D	3D-ефект / 3D effect
25	Efect przejścia	Ефект переходу / Transition effect
26	Emoticon	Емотикон / Emoticon
27	Filtrowanie danych	Фільтрування даних / Data filtering
28	Flooding	Флудинг / Flooding
29	Formularz konta	Форма облікового запису / Account form
30	Formatowanie Tabeli	Форматування таблиці / Table formatting
31	GNU	GNU / GNU
32	Grupowanie obiektów	Групування об'єктів / Object grouping
33	Hiperłacze	Гіперпосилання / Hyperlink
34	Historia informatyki	Історія інформатики / History of informatics
35	Importowanie obrazu	Імпортування зображення / Image importing
36	Infografika	Інфографіка / Infographics

No.	Polish term	Proposed Ukrainian / English translation
37	Instalator	Інсталятор / Installer
38	Jasność obrazu	Яскравість зображення / Image brightness
40	Kalkulator systemowy	Системний калькулятор / System calculator
41	Kolumna tekstu	Колонка тексту / Text column
42	Krzyżówki	Кросворди / Crosswords
43	Ksztalty 3D	3D-фігури / 3D shapes
44	Łancuszek internetowy	Інтернет-ланцюжок / Internet chain
45	Logogryfy	Логогрифи / Logogriphs
46	Netykieta	Мережевий етикет / Netiquette
47	Oprogramowanie demonstracyjne	Демонстраційне програмне забезпечення / Demo software
48	Oprogramowanie licencjonowane	Ліцензійне програмне забезпечення / Licensed software
49	Pamięć trwala	Постійна пам'ять / Permanent memory
50	Pisak duszka	Олівець спрайта / Sprite pen
51	Przeglądarka internetowa	Інтернет-переглядач / Internet browser
52	Scena	Сцена / Scene
53	Scratch	Скретч / Scratch
54	Seria danych	Серія даних / Data series
55	Skrypt zielonej flagi	Скрипт зеленого прапора / Green flag script
56	Sortowanie danych	Сортування даних / Data sorting
57	Sterowanie obiektem	Керування об'єктом / Object control
58	Tło sceny	Тло сцени / Scene background
59	Tło scenyykres słupkowy	Стовпчикова діаграма / Bar chart
60	Writer	Writer / Writer

3. Design and implementation of a Ukrainian-Polish online dictionary of computer science terms for primary school students

3.1. Requirements for the online translator

The target audience of the online translator users is Ukrainian primary school students who are temporarily staying in Poland due to the military actions in Ukraine.

Usage scenarios of the translator:

1. A student enters a Ukrainian computer science term, and the translator provides a Polish translation to facilitate communication and learning in the new environment.
2. A student enters a Polish computer science term, and the translator provides a Ukrainian translation to understand the learning material.

Functional requirements for the translator:

1. The translator should have a field for entering terms.
2. The translator should support translation from both Ukrainian to Polish and Polish to Ukrainian.
3. The translator should display the translation in a separate field.

Non-functional requirements for the translator:

1. The translator interface should be intuitive and easy to use for students.

2. The translator should be free and available online.
3. The translator should provide a fast and accurate translation.
4. The translator should contain adapted vocabulary, taking into account the level of primary school.

3.2. Design of the online translator

Three main web development technologies were used to create the Ukrainian-Polish online translator of computer science terms: HTML, CSS, and JavaScript.

HTML was used to structure and present the content of the index.html file, which contains the HTML markup of the main page of the online translator, including the header, fields for entering a term and displaying the translation, translation buttons, and a selection of the translation direction (figure 1).
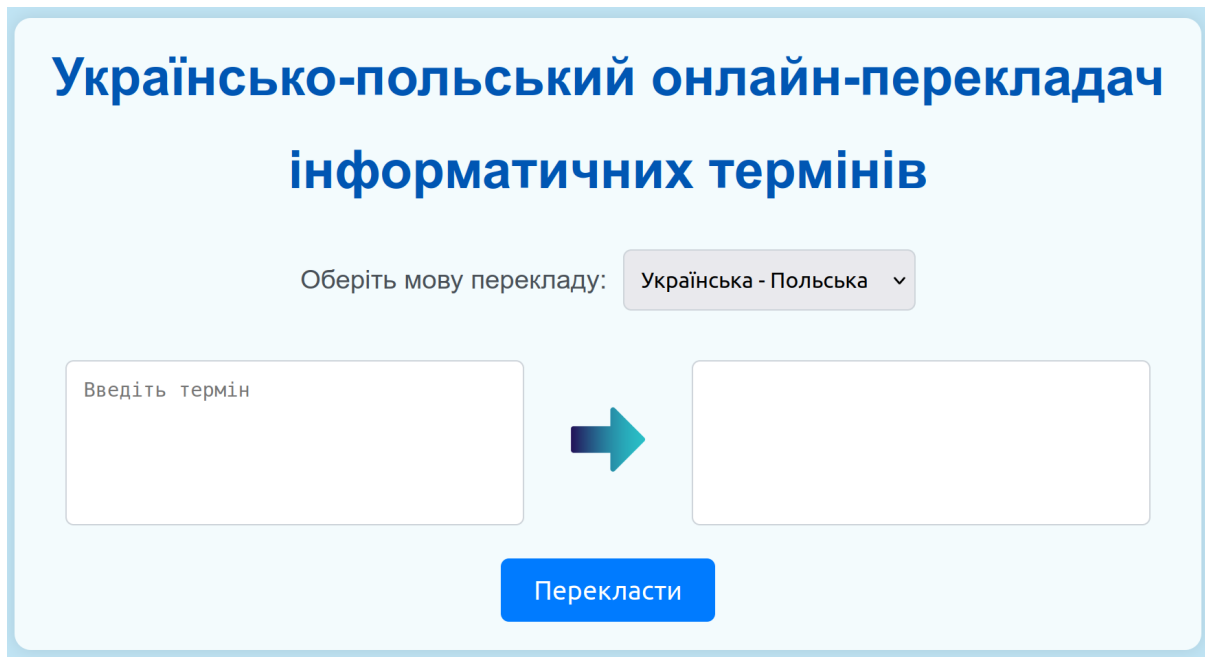

Figure 1: Interface of the online translator.

The styles.css file is responsible for styling and formatting the page elements, such as colours, fonts, placement, and layout.

To ensure the convenience and clarity of the interface for the target audience of primary school students, the following aspects were considered:

- *simplicity and minimalism* – the interface has only the necessary elements to perform the main function of translating terms, without extra details and distractions.
- *clear names and hints* – all interface elements have clear and understandable names, and text fields contain hints to facilitate understanding of their purpose;
- *contrasting colours and readable fonts* – to ensure readability and highlight important elements, contrasting colours and clear fonts with appropriate sizes were chosen;
- *responsive design* – the interface adapts to different screen sizes and devices (computers, tablets, smartphones), ensuring convenient use in any environment.

The script.js file implements the functionality of term translation and interaction with the dictionary.json database, in which Ukrainian terms are used as keys and their Polish translations as corresponding values.

3.3. Implementation of the online translator

Visual Studio Code was used for development, and the Google Chrome web browser was used for testing and debugging.

Since the online translator is a client-side web application, developing a server part and API was not necessary.

The translation logic is implemented in the script.js file (https://github.com/Oleksandra121/kwalifikacyjna). The key function is translateTerm(), which is called when the "Translate" button is clicked. This function performs the following steps:

1. Retrieves the entered term and translation direction from the corresponding fields.
2. Loads the term dictionary dictionary.json using an asynchronous fetch request.
3. Check the availability of a translation for the entered term in the dictionary (figure 2).
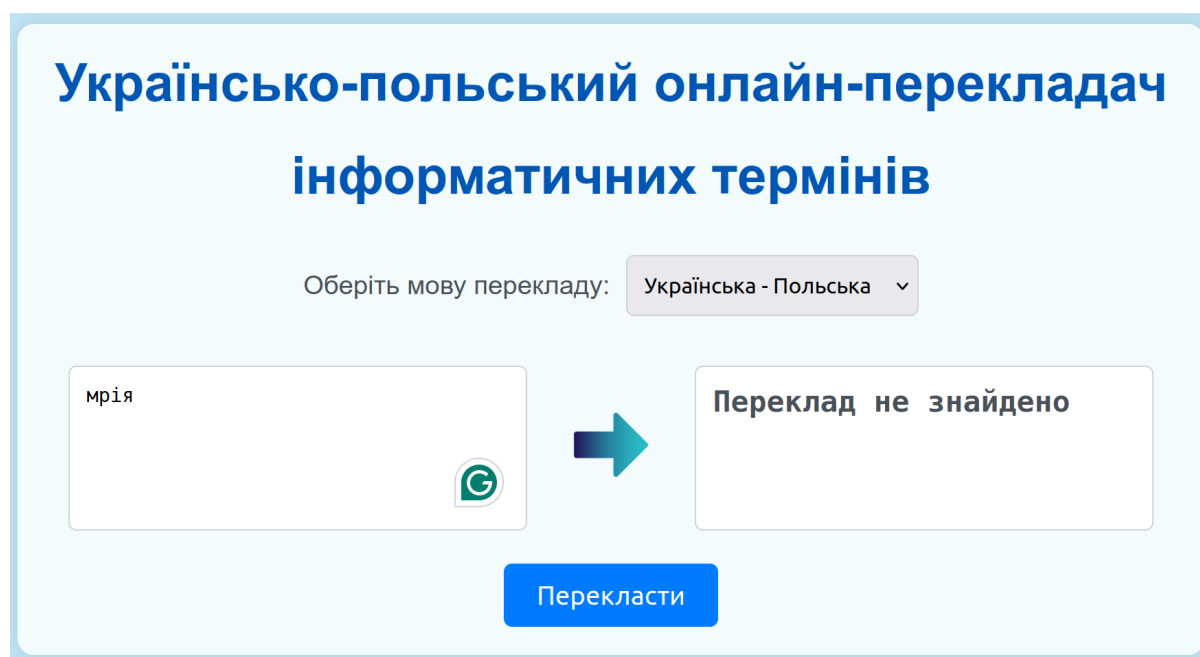4. Displays the translation or a message about the absence of a translation in the text field.

Figure 2: Operation of the online translator.

3.4. Testing the online translator

For testing, the online translator was deployed on GitHub Pages at the URL: https://oleksandra121.github.io/kwalifikacyjna/.

After completing the development, the online translator was tested to ensure correct operation and compliance with the requirements. Testing was conducted in different web browsers (Chrome, Firefox) and on different devices (computers, tablets, smartphones).

The following aspects were checked:

- correct display of the interface on different devices and screen sizes (figure 3);
- correct functioning of the translation direction selection;
- correct translation of terms in both directions (Ukrainian-Polish and Polish-Ukrainian);
- display of appropriate messages in case of the absence of a translation.

The developed Ukrainian-Polish online translator of computer science terms was compared with Google Translate [31] (table 8).
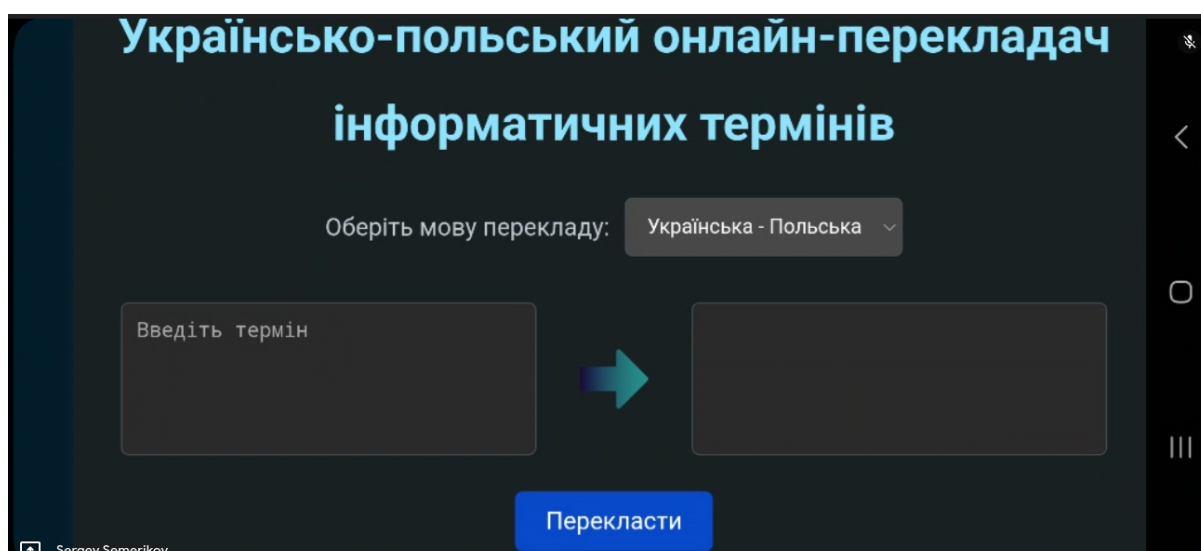
Figure 3: Testing the online translator on a mobile device.

Table 8
Comparison of the functionality of the created online translator and Google Translate.

Function	Ukrainian-Polish online translator of computer science terms	Google Translate
Specialization in IT terminology	+	−
Translation Ukr. ⇌ Pol.	+	+
Term visualization	−	+
Pronunciation playback	−	+
Voice recognition	−	+
Offline mode	−	−
Adding custom terms	+	−

4. Conclusion

As a result of the research, a study of computer science terminology in computer science textbooks and curricula for primary schools in Ukraine and Poland was conducted. Based on this, a Ukrainian-Polish online translator of computer science terms for primary school students was designed and implemented.

The analysis of computer science curricula and textbooks for primary schools in Ukraine and Poland provided an opportunity to identify common and distinctive features in teaching the subject and investigate the terminological completeness and redundancy of Ukrainian textbooks relative to the curricula.

Extracting computer science terms from textbooks and comparing them with the Ukrainian-Polish dictionary recommended by the Ministry of Education and Science identified 48 Ukrainian and 60 Polish terms as missing in the dictionary. Their translation into Polish and Ukrainian, respectively, was proposed.

Based on the conducted research, an online translator of computer science terms in Ukrainian and Polish was designed and implemented. The application interface was developed taking into account the needs of the target audience – Ukrainian primary school students in Poland. The translator is free, available online, provides fast and accurate translation, and contains adapted vocabulary.

Testing the online translator confirmed its correct operation on different devices and browsers, and comparing it with Google Translator showed its competitive advantages in specializing in computer science terminology and the ability to expand the dictionary.

The obtained results can be used to further improve educational and methodological support for

computer science and the development of Ukrainian-Polish educational cooperation. The online translator can become a useful tool for Ukrainian students in Poland, helping them overcome language barriers and adapt to the new educational environment.

Declaration on Generative AI

The authors have not employed any generative AI tools.

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