# Development of a multilingual online course with the language support for teaching physics in English

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**ABSTRACT**

Distance education offers an alternative to traditional teaching methods, particularly online courses. During the pandemic, the role of information and communication technologies in the field of education has increased and is used to organize both synchronous and asynchronous learning. However, not all information and communication technology (ICT) tools and platforms provide the necessary functionality for developing online courses in the direction of language integration. This article discusses the issues of creating a multilingual online course of physics in English with the necessary language support and additional functions for the development of students' academic language. The study used such methods as a survey, focus groups, analytical and descriptive methods, and empirical research. The key features of the developed course are the use of various types of content and methods for assessing both subject and language knowledge and skills. The presented survey results, data on summative assessment (SE), and trial testing show the effectiveness of the developed course modules. The conclusions and results described in the article will be useful to teachers of natural sciences in general education and private schools, especially those using international programs, deputy directors, as well as teachers who teach their subjects in a second or third language.



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## 1. INTRODUCTION

In the context of globalization and intercultural learning worldwide, learning English and subjects in this language is the main topic in the education system. Thus, knowledge of several languages and studying disciplines in a foreign language increases the competitiveness of university graduates and presents many opportunities for school graduates. Also, teaching in English language helps schools pass international accreditation and become a member of global communities of schools, which increases the school's rating on a regional and national scale. Learning entirely in English or partly at some subjects where this language is not the main one (second or third) mainly takes place in private, international, or autonomous schools in the country.

In particular, Kazakhstan took a course towards multilingual education in 2008 and now teaching in English is carried out in such educational organizations as Autonomous Education Organizations (AEO) "Nazarbayev Intellectual Schools (NIS)", "Bilim-Innovation Lyceum (BIL)", Quantum STEM International school. It is worth noting that teaching in English in these and other schools has its own characteristics: the transition to English in senior grades, teaching only some subjects or having an entire educational program in

English using the Content and Language Integrated Learning (CLIL) methods as an elective course. For example, at NIS schools, when students enter 11th grade, they choose two subjects from the natural sciences to pass an external summative (control) exam, which will be passed by them entirely in English. The situation is worsened by the fact that students in Kazakhstan are taught simultaneously in three languages: their mother tongue–Kazakh or Russian (L1); second official language–for Kazakh students it is Russian and for Russian ones is the opposite (L2), so English here comes as the third language to study. Accordingly, the transition from the mother tongue of instruction (L1) to a second one (L2) and to a third language (English) is challenging for learners both linguistically and academically.

Developing methods that will help school students transit to such education both efficiently and with necessary support is a primary task for both international schools and the state's education system. Consequently, the development of such a method is the main objective of this research. We will use information and communication technology (ICT) tools to achieve this goal, namely online courses.

Multilingual or bilingual education has become a popular and frequent object of study for researchers in the field of education for various reasons. The main one is tripling the number of international migrants over the past four decades [1]. As a result, the main principles and characteristics of multilingual education were created in the European Union. In 1995, the European Commission published an official report outlining the basic principles that define multilingual education in European countries [2].

According to Aubakirova *et al.* [3], successful experience in multilingual education was achieved by those European countries that provided educational institutions with sufficient time and focused on training teachers in a multilingual environment. After holding a systematic review of articles, Kirss *et al.* [4] found that research in the field of multilingual education is mainly aimed at identifying factors for improving the effectiveness of education at the school level and only a tiny number at the level of the education system or public policy. At the same time, they identified several levels of influence of multilingual education (macro, meso, and micro).

The researchers will consider one of the factors influencing the effectiveness of a multilingual environment–the use of ICT at the class level (micro level) [5]. So, ICT tools and web services have been used to study subjects in a foreign language in different cases: gamification for the development of competencies [6], elaboration of materials for the lesson [7], use in the blended and flipped learning methods [8], [9], teaching rare languages [10], assessment [11], creation of virtual spaces for the professional development of teachers [12].

During the pandemic, many general education schools switched very rapidly to distance learning [13]. One of the main actions for teachers teaching subjects in a second (third) language was creating a favorable learning environment in a distance (online) format for multilingual education, which in its turn influenced the growth of ICT integration and CLIL methods. One example of such integration has become the creation of online courses for multilingual education [14]. As one of the alternatives to the traditional teaching method, online courses are actively used by universities for blended learning or organizing distance education. A popular type of this tool is massive open online courses (MOOCs) [15], hosted on various educational platforms, such as "Edx", "Coursera", "Udacity", "Open Education", or their own websites [16]–[18]. However, it is worth noting that not all sites and courses are designed for a multilingual learning environment; there are specialized online platforms (e.g., "Lingualeo") with the necessary functions, but they are intended to study grammar and increase the vocabulary of spoken English only [19], [20].

Online physics courses in English are presented on various websites and educational platforms. However, the multilingual environment on these sites is limited to providing subtitles for video lectures or translating the course content into other languages so there is still a need for full support and language integration. In addition, when creating online courses unprofessionally, only a few systems for learning management provide the function of presenting course content in several languages [21]. One such a system as "MathBridge" has been used to organize mathematics online learning for non-English-speaking students during academic mobility [22].

Integrating multilingual content and an online educational environment can significantly increase learning effectiveness in both synchronous and asynchronous formats, improve the visibility and interactivity of the course's primary content, and provide open access to educational resources. Therefore, the main purpose of this study is development a multilingual online course with language integration for physics subject. For our purposes, namely content-language integration, after analyzing the available content management and learning management systems, we have chosen CMS WordPress (does not require high programming skills) and a plugin for this system named by TutorLMS (provides functionality for changing the course content according to various parameters based on the language HTML 5 layout). On these systems, the course "Physics in English" with content-language integration of three languages (Kazakh, Russian, and English) has been created.

## 2. RESEARCH METHOD

This study was carried out at the AEO "Nazarbayev Intellectual Schools" of Pavlodar's chemical and biological direction (NIS ChB Pavlodar) from September 2022 to January 2023 among students of grade 12. In grade 12, an external summative assessment (SE) in physics in English is required to receive a Certificate of Secondary Education. In this regard, it was necessary to create an online course to prepare students and organize "flipped" learning for this exam. The study includes two academic terms and two groups of students. In one of these terms, students used the online course "Physics in English". The study used observation, student interview, empirical research, focus group, and descriptive and analytical methods.

The research allowed us to identify the needs of our target audience. A series of interviews and surveys were conducted with 23 students of NIS ChB Pavlodar to determine their expectations from the online course preparation for external SE (NIS program based on Cambridge AS-A level Physics). Analytical and descriptive methods contributed to establishing a connection between existing online courses in Physics in English and analysis of the target audience and its needs. In addition, focus groups were used to test some of the modules in the developed course.

To compile the structure and content of the course, the ADDIE model was used, which includes: analysis of the needs of the target audience, learning systems and learning objectives (analysis); designing educational and educational online space (design); development course content (development); implementation of course developments in the educational process of students (implementation); and evaluation of the effectiveness of the developed content (evaluation) [23]. The ADDIE method is excellent for creating online courses, as its steps promote a new course and activate students' cognitive activity [24].

## 3. RESULTS AND DISCUSSION

### 3.1. Outcome 1: comparative analysis of online physics courses in English

Many educational platforms for comprehensive schools offer physics courses in English. For example, the "Class Central" online course search resource provides more than 70 courses of the school Physics course. When conducting a comparative analysis of course data from different platforms, the study showed that the courses are divided into the following areas: i) examination area or educational program (GCSE, AS-A level, AP, IB, JEE/NET)–53 courses; ii) subdisciplines of Physics–39 courses; iii) improving skills or competencies (problem-solving, research skills) – 17 courses.

However, only a few courses hosted on platforms, such as "Khan Academy", "Bilimland", and "Twig-bilim" are provided in two or more languages. But even the presented platforms do not offer additional functionality for a better understanding and assimilation of material in English. Accordingly, the course we need to develop should: i) be aimed at students taking the external SE (AS-A level Physics); ii) cover as many subdisciplines of Physics as possible; iii) have differentiation both academically and linguistically; iv) be available to students with different levels of English; and v) be adaptive for use with different teaching methods.

### 3.2. Outcome 2: analysis of the target audience

Target audience analysis typically includes such factors as demographic information, student motivation and knowledge. Regarding demographics, a survey of 23 students showed that our target audience is primarily male students with the same cultural background (all students were born and grew up in Kazakhstan). Since the average age of our students is 17-18 years old, according to the Strauss-Howe theory of generations, they belong to Generation Z (also called homelands). To create a practical course, we need to consider this generation's habits: they mainly choose the online learning format and prefer to select a digital source of information. One of our surveys showed that 44% of learners choose videos to understand a lesson, and 38% prefer an interactive web-based learning environment (simulations, interactive activities, and concept maps). Thus, most students have high digital skills and literacy.

The target audience is highly motivated since the exam of Physics is one of the main ones for including its assessment in the certificate of complete secondary education and considered by universities when entering the specialty of Science and Engineering. Students took physics in English for one academic year. As a result, many students noted the complexity of the academic language in physics. Most students needed the course to: i) memorize terminology and definitions of physical laws in English (63%); ii) review the material covered before the exam (50%); iii) study the features of SE (28%); and iv) improve the quality of responses on structured tasks (14%).

### 3.3. Outcome 3: needs' analysis

The course "Physics in English" has been developed for graduate students of the NIS ChB Pavlodar, who are taking exams in Physics in English according to the educational program "NIS Program" (CIE AS-A level physics). Students have a good level of English, as their average IELTS score is 6.5, which corresponds to the B2 level of the CEFR English proficiency system. However, most students have problems with physics course content in English and difficulty with open-ended assignments.

As a result, the presented course should include all subdisciplines and tasks for skills improvement in the educational program and have additional tools for the development and support of the academic language of students. In addition, this course should be mobile and modular. For example, students can use the course online and consolidate and evaluate their knowledge at extra or elective classes. The course structure will help students navigate through the curriculum sections and show all the necessary learning objectives and assessment criteria to assess their knowledge and skills (competencies).

### 3.4. Outcome 4: course design

#### 3.4.1. Course learning objectives

When developing an online course, it is necessary to consider what learning objectives will be included as they are restricted by the educational program and school curricula [25]. These goals develop students' cognitive and learning skills according to Bloom’s taxonomy [26], from the skills of “knowledge and understanding” to such skills as “creation”. In addition, during the exam, students’ three skills are assessed: AO1-knowledge and understanding; AO2-analysis, synthesis, and evaluation of information; and AO3-practical skills and skills of conducting an experiment [27], [28].

All learning goals have been considered while developing the course and added the following subdisciplines of physics, namely: i) Module 1: physical quantities and units, uncertainties and errors, kinematics, properties of materials, dynamics, conservation laws; ii) Module 2: molecular physics, thermodynamics, oscillations, geometrical optics, wave optics; iii) Module 3: communication systems, alternating current; and iv) Module 4: charged particles, quantum mechanics, nuclear physics. It is necessary to pay attention to the language learning objectives: terminology, phrases, definitions, and academic language functions. Language objectives have been integrated into the course content and will not be evaluated as separate learning objectives.

#### 3.4.2. Course content and structure

When preparing for a course development, the author of the course must decide on the content of the course and its sections. While holding an interview within the students themselves on a Likert scale to the question “Select the type of information that you consider important while studying the topic (1–not important to 4–very important),” the following data were obtained as presented in Table 1. We divided the skills into three parts, which contain both subject content and supportive language components for better assimilation of information in English (Table 2). For these reasons, there are blocks with the necessary grammar rules on the lesson page and the translation of complex terms.

Table 1. A survey of students on the preferred type of information

| Information type | Average value |
|---|---|
| Formula | 3.61 |
| Video (how to solve problems) | 3.50 |
| Presentation | 3.47 |
| Illustrations | 3.44 |
| Answers to tasks | 3.42 |
| Tests | 3.36 |
| Video | 3.33 |
| Open questions | 3.33 |
| Keywords | 3.14 |
| Theoretical information in pdf | 3.14 |
| Learning objectives | 2.92 |
| Assessment criteria | 2.86 |
| Virtual simulators | 2.81 |
| Animations | 2.75 |
| Text | 2.61 |
| Additional information | 1.92 |

**a. Assessment and expected outcomes of the course**

Once the learning objectives and skills for assessment have been selected and the structure and content of the course has been developed, special attention must be paid to assessing students’ knowledge and skills. The assessment types should be considered when organizing an assessment: formative (FA) and internal summing assessment (ISA). Since the main objective of our course is to prepare students for passing the SA and understanding physics in general, we will use FA at every lesson so that students pay attention to their progress and weaknesses in studying the topic presented. In addition, it will allow the teacher to monitor student's progress during the online course. However, it is worth paying attention to the fact that online tools limit testing of some students' skills. For example, we will not be able to check the progress of the solution of the problem or the text written by the student when testing the skills of analysis and synthesis. For this purpose, a prepared mark-scheme for structured tasks will be used, and students will conduct self-assessment themselves. Table 2 lists the parts of the online lesson page we developed regarding skills and distribution of content types and tasks.

Table 2. The structure of the integrated lesson in the developed course "Physics in English" for students

| Function/part | Part 1 | Part 2 | Part 3 |
|---|---|---|---|
| Content | Theoretical material for learning | Practical material for revising | Laboratory work |
| Content type | Video, audio, text, presentation, illustrations. HTML 5 inserts | Text, illustrations, formulas, answers to tasks, video on how to solve problems. HTML 5 inserts | Interactive simulator with the worksheet |
| Task types | Primary consolidating: Multiple choice questions | Multiple choice questions; tasks with multiple correct answers. Structured assignments | Assessment sheet Portfolio of students' findings, achievements, and challenges |
| Language Component | Flashcards, hints, definitions, glossary, audio components | | |

### 3.4.3. Evaluation of course effectiveness

According to Cadapan *et al.* [29], "school management should regularly evaluate the effectiveness of online learning to determine whether this kind of learning modality is effective." To track academic progress and evaluate it during the academic term, students take summative assessment for the unit (SAU) and summative assessment for the term (SAT) [30]. In addition, students pass trial testing in the chosen subject during the entire academic year. At the stage of assessing the effectiveness of the course, we need to check whether the multilingual online course was more effective in preparing students than traditional teaching methods. Pearson's correlation coefficient (Pearson's r) was used for these purposes. Table 3 shows the average score of the experimental group of students on a 100-point scale when passing the SAU who studied Module 1 of the developed course. Students who did the module are marked with code 2 (10 students), and those who did not study with code 1 (13 students).

Table 3. The results of the summing assessment for the section

| Assessment by sections of module 1 | Students' group | |
|---|---|---|
| | 1 | 2 |
| Physical quantities and units | 61 | 73 |
| Uncertainties and errors | 65 | 70 |
| Kinematics | 79 | 75 |
| Properties of materials | 75 | 81 |
| Dynamics | 75 | 85 |
| Conservation laws | 88 | 93 |
| Average value (max. 100) | 73.8 | 79.5 |

Based on Table 3, the correlation coefficient is r=0.82 which means the relationship between student learning outcomes and their participation in the online course. But we would also like to note the limitation of the study in assessing only one module of the developed course. Table 4 shows that students who participated in online courses scored higher than others on practice tests in both AO1 and AO2 skills.

Table 4. Results of trial testing for the exam

| Students | Percentage of completion (%) | | | |
|---|---|---|---|---|
| | AO1 | AO2 | AO3 | Average value |
| 1 | 56.7 | 36.7 | 61.2 | 51.6 |
| 2 | 58.5 | 46.6 | 57 | 54.0 |

## 4. CONCLUSION

The presentation of educational content with the language support while teaching physics in English is essential in the multilingual education. Only a few online platforms with such learning management system have such capabilities and functions. The online educational environment created by integrating CMS

WordPress and LMS Tutor provides the ability to show content not only in several languages but also adds the functions of subject-language integrated learning, which makes combination of these tools unique when creating multilingual online courses.

This study proves that the use of multilingual online courses contributed to the improvement of student's academic performance, as well as their cognitive skills and abilities, and increased their motivation. The most important practical result of the course "Physics in English" is its effective application both in synchronous and asynchronous form of learning, in self-study or with such pedagogical technologies as blended and flipped learning. A survey among graduate students at school showed that students are interested in the subject content of the discipline as well as in academic English. Also, with the help of the survey, prioritized types of information for students (formulas, videos, and presentations) were identified. This contributed to creating an integrated course with balanced language features and subject content.

The structure of the course "Physics in English" was developed. The module course's content helps students choose the Physics subdiscipline they need for primary or additional learning. Regarding course content, the online course was targeted at learners' different skills and abilities across all necessary topics for external SE. Using one of the online course modules on the experimental group showed the effectiveness of the course even being time-consuming for students at a time. However, there were several limitations in the research process: there was no comparison made between the results of the assessment on the course and the final exam of the students (because it will be at the end of the academic year); the cognitive abilities of the experimental group and other students were not taken into account which could affect the final results of the assessment.

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