ИНФОРМАЦИОННЫЕ ТЕХНОЛОГИИ В ОБРАЗОВАНИИ

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STUDYING AND ENHANCING THE METHODS FOR DISTANCE TEACHING OF COMPUTER SCIENCE IN KAZAKH SECONDARY SCHOOL STUDENTS DURING THE PANDEMIC

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Abstract. *Introduction.* In 2020, the first two weeks of the enforced transformation of all the levels of school education, which was initiated as one of the measures against the Coronavirus disease (COVID-19), revealed a range of issues hampering the appropriate distance education. The absence of the methodological basis for conducting online classes in the Kazakh pedagogical community defined the need to study and enhance forms and technologies that would be efficient to use to interact with students during the transition of the national education system to distance education.

Aim. The *aim* of this research lies in defining efficient methods for distance teaching of computer science in the Kazakh secondary school students in terms of ensuring the maintenance of the quality of knowledge and the academic progress of students at the sufficient level corresponding to that of the traditional in-person education.

Methodology and research methods. A total of five educators and 320 students of three Kazakh schools took part in the study. At the moment of the experiment, the students were aged 12 to 18 years old. The participants were divided into seven groups according to the educational level (5th–11th forms) in order to make it more convenient to trace qualitative changes in the academic progress depending on the selected method for distance teaching of computer science. The authors conducted three control evaluations of the quality of knowledge in each of the 320 participants. The t-test for unpaired samples for every group was conducted to prove the statistical certainty of the calculated average reference values, which were required to confirm the viability of the conducted research. The analysis of the data obtained at the concluding stage of the experiment allowed to compare them with the reference values calculated at the preliminary stage of the research in question. For the comparison, The authors applied the Mann–Whitney U test for independent samples.

Results. The preliminary analysis of the quality of knowledge related to the discipline of computer science in the participants revealed generally high and average level of both acquisition of theoretical information and development of the subject-related skills, which was registered based of the results of in-person education. The leading experience of the specialists composing the authors' initiative research group allowed developing a structural scheme for an online lesson. The lessons applying this scheme were conducted up to the end of the academic quarter. By conducting the Mann–Whitney U test, we discovered that the obtained average values of the quality of teaching computer science to the participants statistically increased (I group – Uemp = 6.49 ($p \leq 0.05$), II group – Uemp = 7.46 ($p \leq 0.05$), III group – Uemp = 6.05 ($p \leq 0.01$), IV group – Uemp = 6.71 ($p \leq 0.05$), V group – Uemp = 6.91 ($p \leq 0.01$), VI group – Uemp = 6.65 ($p \leq 0.05$), VII group – Uemp = 6.21 ($p \leq 0.05$)). Despite temporary fall in the efficiency of teaching computer science registered during the transition to the distance model, it was managed to achieve the level of academic progress and acquisition of knowledge corresponding to that of in-person education.

Scientific novelty. TThe significance of the collected and analysed data was statistically proved. The data confirmed the efficiency of the use of defined and adapted approaches and teaching techniques, which were able to compensate the absence of traditional in-person lessons, while preventing the fall in the academic progress and the quality of knowledge in students.

Practical significance. The obtained results evidence the success of the arrangements aimed at the enhancement of the methods for distance teaching of computer science in the Kazakh secondary school students during the transition to distance education enforced due to the pandemic.

Keywords: distance learning, computer science, information technologies, technology in education, teaching methods, pedagogics, school education.

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ИССЛЕДОВАНИЕ И ОПТИМИЗАЦИЯ ЭФФЕКТИВНОСТИ МЕТОДОВ ДИСТАНЦИОННОГО ОБУЧЕНИЯ ИНФОРМАТИКЕ КАЗАХСТАНСКИХ ШКОЛЬНИКОВ В ПЕРИОД ПАНДЕМИИ

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Аннотация. *Введение.* В 2020 году вынужденная трансформация всех уровней школьного обучения, инициированная в ходе осуществления комплекса мероприятий по борьбе с пандемией коронавирусной инфекции COVID-19, в первые же недели выявила целый ряд проблем, так или иначе затрудняющих полноценное функционирование дистанционного формата обучения. Отсутствие у казахстанского педагогического сообщества сформированного к этому моменту методологического базиса проведения онлайн-уроков определило необходимость изучения и оптимизации форм и технологий взаимодействия с обучающимися, эффективных для использования при переходе системы национального образования на дистанционную модель.

Цель. Цель настоящего исследования заключается в определении эффективных методов дистанционного обучения информатике казахстанских школьников с точки зрения обеспечения поддержания качества знаний и успеваемости обучающихся на достаточном уровне, соответствующем результатам традиционного очного формата образования.

Методология, методы и методики. В исследовании приняли участие 5 педагогов и 320 обучающихся из 3 казахстанских школ. Возраст учащихся на момент проведения эксперимента – от 12 до 18 лет. Для удобства отслеживания качественных изменений уровня подготовки обучающихся в соответствии с выбранными методами дистанционного обучения информатике испытуемые были разделены на 7 групп согласно уровням образования (5–11 классы). По каждому из 320 испытуемых мы проводили три контрольных измерения качества знаний. Для определения статистической достоверности рассчитанных нами средних эталонных значений, определение которых требовалось для подтверждения результативности дальнейшего хода исследования, был проведен расчет t-критерия Стьюдента для непарных выборок по каждой из семи групп. Анализ данных, полученных на завершающем этапе эксперимента, позволил провести их сравнение с эталонными значениями, рассчитанными нами в ходе предварительного этапа описываемого исследования. Сопоставление проводилось методом определения непараметрического критерия U Манна – Уитни для независимых выборок.

Результаты. Предварительный анализ качества знаний по предмету «Информатика» у испытуемых показал в целом высокий и средний уровень усвоения учебного материала и развития предметно-практических навыков, регистрируемый по итогам обучения в очном формате. Передовой опыт составляющих нашу инициативную исследовательскую группу специалистов позволил разработать структурную схему проведения урока в условиях дистанционного формата. Уроки с использованием данной схемы проходили до окончания учебной четверти. Используя расчет U-критерия Манна – Уитни, мы установили, что полученные усредненные показатели качества обучения испытуемых информатике статистически значимо возросли (I группа: Uэмп = 6,49 ($p \leq 0,05$), II группа: Uэмп = 7,46 ($p \leq 0,05$), III группа: Uэмп = 6,05 ($p \leq 0,01$), IV группа: Uэмп

= 6,71 (p ≤ 0,05), V группа: Uэмп = 6,91 (p ≤ 0,01), VI группа: Uэмп = 6,65 (p ≤ 0,05), VII группа: Uэмп = 6,21 (p ≤ 0,05)). Несмотря на временное падение эффективности обучения информатике, зарегистрированное при переходе на дистанционный формат, к моменту окончания эксперимента удалось добиться уровней успеваемости и усвоения знаний, соответствующих таковым при очном обучении.

Научная новизна. Эффективность использования выявленных и адаптированных нами подходов и методологий преподавания, которые смогли компенсировать отсутствие возможности проведения традиционных уроков в очном формате и в то же время не допустить падения уровня успеваемости и качества знаний учащихся, подтверждена собранным и проанализированным нами массивом эмпирических данных, значимость которых статистически доказана.

Практическая значимость. Полученные результаты свидетельствуют об успешности осуществленных в рамках данного исследования мероприятий, направленных на оптимизацию эффективности методов обучения казахстанских школьников информатике при переходе на режим дистанционного образования, введенный в спешном порядке в связи с пандемией.

Ключевые слова: дистанционное обучение, информатика, информационные технологии, технические средства обучения, методы обучения, педагогика, школьное образование.

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ESTUDIO Y OPTIMIZACIÓN DE LA EFICIENCIA DE LOS MÉTODOS DE ENSEÑANZA A DISTANCIA DE LA INFORMÁTICA PARA LOS ESCOLARES DE KAZAJSTÁN EN TIEMPOS DE LA PANDEMIA

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Abstracto. *Introducción.* En 2020, la transformación forzosa de todos los niveles de la educación escolar, iniciada durante la implementación del conjunto de medidas para combatir la

pandemia a raíz de la infección por coronavirus COVID-19, reveló una serie de problemas en las primeras semanas, que de una forma u otra impedían el pleno funcionamiento del formato de la enseñanza a distancia. La falta de una plataforma metodológica para impartir las clases en línea por parte de la comunidad pedagógica kazaja en ese momento, determinó la necesidad de estudiar y optimizar las formas y tecnologías de interacción con los alumnos a fin de que fueran efectivas para su uso en la transición del sistema educativo nacional a un modelo de enseñanza a distancia.

Objetivo. El propósito de este estudio, es identificar métodos efectivos de la enseñanza a distancia de la informática para los escolares de Kazajstán, cuya finalidad es mantener la calidad del conocimiento y el rendimiento del alumnado en un nivel suficiente y que corresponda a los resultados del formato tradicional de educación a tiempo completo.

Metodología, métodos y procesos de investigación. En el estudio hicieron parte 5 profesores y 320 estudiantes de 3 escuelas kazajas. La edad de los alumnos al momento del experimento era entre 12 y 18 años. Para facilitar el seguimiento de los cambios cualitativos en el nivel de formación de los escolares de acuerdo con los métodos elegidos de enseñanza a distancia en informática, los individuos objeto del estudio se dividieron en 7 grupos según los niveles de educación (grados 5-11). Para cada uno de los 320 individuos, llevamos a cabo tres medidas de control de la calidad del conocimiento. Para determinar la significación estadística de los valores de referencia promedio calculados por nosotros, cuya determinación se requería para confirmar la efectividad del curso posterior del estudio, calculamos la prueba t de Student para muestras no apareadas para cada uno de los siete grupos. El análisis de los datos obtenidos en la etapa final del experimento permitió compararlos con los valores de referencia calculados por nosotros durante la etapa preliminar del estudio descrito. La comparación se realizó por el método de determinación no paramétrica de la prueba U de Mann-Whitney para muestras independientes.

Resultados. Un análisis preliminar de la calidad del conocimiento en el tema "Informática" entre los individuos mostró un nivel generalmente alto y promedio de asimilación del material educativo y el desarrollo de habilidades prácticas basadas en el tema, registrado sobre la base de la formación de tipo presencial. La avanzada experiencia de los especialistas que integran nuestro grupo de investigación de iniciativa hizo posible desarrollar un diagrama de bloques para la realización de una clase en formato a distancia. Las clases se impartieron utilizando este esquema hasta el final del trimestre académico. Utilizando el cálculo del criterio U de Mann-Whitney, encontramos que los indicadores promedio obtenidos de la calidad de la enseñanza de la asignatura de informática ofrecida a los alumnos aumentaron estadísticamente de manera significativa (grupo I: Uemp = 6.49 ($p \leq 0.05$), grupo II: Uemp = 7.46 ($p \leq 0,05$), grupo III: Uemp = 6,05 ($p \leq 0,01$), grupo IV: Uemp = 6,71 ($p \leq 0,05$), grupo V: Uemp = 6,91 ($p \leq 0,01$), grupo VI: Uemp = 6,65 ($p \leq 0,05$), grupo VII: Uemp = 6,21 ($p \leq 0,05$)). A pesar de la caída temporal en la efectividad de la enseñanza de la informática, registrada durante la transición a un formato a distancia, al finalizar el experimento fue posible alcanzar niveles de rendimiento académico y adquisición de conocimientos correspondientes a la educación de estilo presencial.

Novedad científica. La efectividad del uso de los enfoques y metodologías de enseñanza identificados y adaptados por nosotros, que pudieron compensar la falta de posibilidad de impartir las clases tradicionales en formato presencial y al mismo tiempo evitar una caída en el nivel de progreso y calidad del conocimiento de los escolares, fue confirmado por la serie de datos empíricos que recopilamos y analizamos y, cuya importancia fue estadísticamente probada.

Significado práctico. Los resultados obtenidos confirman el éxito de las actividades realizadas en el marco de este estudio, destinadas a optimizar la eficacia de los métodos

de enseñanza de la informática a los escolares kazajos durante la transición al régimen de educación a distancia, introducido apresuradamente por motivos relacionados con la pandemia.

Palabras claves: Enseñanza a distancia, informática, tecnologías de la información, material didáctico, métodos de enseñanza, pedagogía, educación escolar.

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Introduction

At the beginning of 2020, the humankind faced the outbreak of previously unknown Coronavirus of SARS-CoV-2, which caused the unprecedented scale of the struggle against it. As soon as the World Health Organization announced the pandemic, which is an emergency at the international scale, in the Republic of Kazakhstan, from the 16th of March, the Presidential Decree introduced some quarantine and restrictive measures meant to minimise the spread of the Coronavirus pandemic. The lockdown implied almost complete closure of state borders, cessation of shopping, entertaining and other establishments, transfer of the majority of employees to remote mode, prohibition and prevention of crowding both in closed spaces and outdoors [1, 2]. Among the restrictive measure, the urgent transition of the education system to distance model became a separate direction of the national policy against the Coronavirus pandemic. However, this transition became not only a challenge for all the subjects of the educational process, but also a certain driver for the development of both methods for teaching online and those for asynchronous transfer of educational competence from a teacher to a student.

The first two weeks of enforced transformation of all the levels of school education, which was initiated among the measures of the Ministry of Education and Science of the Republic of Kazakhstan against the Coronavirus disease (COVID-19), revealed a range of issues hampering the appropriate distance education [3]. The issues consist in insufficient potential of infrastructure and human resources. The insufficiency of the infrastructure implies obviously scarce computer, multimedia and communicative facilities in the majority of educational institutions as well as a limited channel capacity of local Internet service

providers, which are not ready for a sharply increased traffic load. The problems related to the human resources lie in an extremely small number of efficient and effective methods for distance teaching that are adapted for the Kazakh reality and the absence of practical skills in educators to transpose familiar ways to work into online environment [4]. These facts trigger the objective need for studying the methodological basis compiled by the Kazakh pedagogical society in the period in question, for defining and enhancing the revealed forms and technologies to interact with students, which are used during the transition of the national education system to the distance model.

In this regard, at the premises of the Kokshetau University named after Abay Myrzakhmetov there were formed an initiative group of specialists in organising online courses and developing e-learning services. The group was initiated for interacting with the secondary school educators that faced the necessity to transfer to distance education model. These educators were involved in teaching computer science in 5th-11th forms. The specialists provided permanent methodological support as well as monitored the current quality of student's knowledge and analysed the efficiency of the applied methods in the context of both distance and in-person models.

Thus, the objective of the research is defining the efficiency of the methods applied in distance teaching computer science to the Kazakh secondary school students and analysing the prospects of the enhancement of the methods in question. We believe that, when it is impossible to conduct in-person lessons, the choice of the efficient approaches to organise computer science lessons and the proper mastering of all the necessary theoretical and practical tools are able to ensure a sufficient level of students' acquisition of the subject-related knowledge that can be compared to that in the traditional education model.

Literature Review

The unpredictable development of the Coronavirus outbreak and urgent introduction of preventive measures revealed the extreme deficit of theoretical elaborations on forming the system of pedagogical impact and transfer of knowledge in the situation under consideration. Hence, it sets the priority to consider local cases of the organisation of distance teaching, including computer science, which were described before the pandemic.

Romero and Ventura [5] consider a number of e-learning platforms that are used to this or that extent for teaching various subject disciplines to school students online. It is noted that the material that is presented on those platforms can be used for both students self-studying and as a practice to consolidate the acquired knowledge at the lesson. Moreover, the teaching techniques

using those online courses can be integrated with the in-person education model, since the prospects of massive application is taken into account at the development stage. According to Pardala, such functional potential is present in the Kazakh electronic platform Bilimland, which was also recommended by the Ministry of Education and Science of the Republic of Kazakhstan to the students and educator to be used during the pandemic [6].

Describing the fundamental principles, prerequisites and pedagogical aspects of the online education model, Picciano focuses on a so-called "integrated multimodal environment" [7]. Despite quite a long-time existence of the theoretical and technological basis for distance education, its organisation, in its turn, has been of a temporary or individual character and has not implied any kind of large-scale spread so far. Consequently, practicing educators that normally stay with the class-and-lesson system did not consider distance teaching in depth. Many researchers, for example, Kaderkeyeva, Bekmanova, Sharipbay [8], stress the generally perceived importance of electronic (online) education in the Kazakn education system, but, at the same time, its impromptness to get developed and to obtain any significant status.

The methods for distance teaching that Fayanto [9] described in his research are based on the presence of interactive components in electronic education resources, which not only considerably facilitate the monitoring of the acquisition of knowledge and skills and their practical application but also positively affect students' motivation, their involvement in improving their personal academic progress. Kaya and Ozel noted that it is particularly relevant for computer science lessons, since solving tasks at the computer requires checking their performance promptly and introducing corrections online [10].

The researchers and educators Oyelere, Wajiga et al. [11] noted that the wide opportunities of education mobile applications highlight their accessibility and universality as means of solving applicable learning tasks. Besides, communicative potential of contemporary education mobile devices as such in organising online education can greatly compensate its social aspect as it allows three-party communication among a student, their teacher and their classmates. Hence, in case distance education is enforced, there is no need to replace the methods of group workings, which sometimes appear indispensable, by differentiation.

In general, it can be stressed that the majority of researchers recommend being selective when choosing the methods for distance education, since, for example, the thematic content of the subject discipline of computer science requires the application of rather a wide range of forms of teaching. This means that every separate unit of educative tasks requires the integration of corresponding approaches, technologies and resources. The fragmentation of the web services available for this purpose confirms the absence of the need for total

transition of school education online in the "pre-COVID" era. It is opposed to the results of pedagogical experimental tests published in the early months of the pandemic in 2020.

For example, the German researchers Konig and Glutsch [12] described difficulties of the enforced transition to distance education in Germany. They stated the acute necessity for developing a comprehensive web-assistant for all the participants of education process, which would involve all the necessary materials for acquisition of the academic programme. The researchers confirmed that a set of methods for teaching school students online depends, firstly, on the teacher's competence in information technology and then only, on the availability of technical solutions. Therefore, within distance education model, such groups of software products as messengers and services for video conferences gained an advantage and resulted being a substitute for in-person education [13]. However, such subject discipline as computer science, that is specifically distinct from other school disciplines, requires a certain set of programming solutions whose absence makes studying it ineffective.

In this regard, Fujita [14], a Japanese researcher of the informatisation of education, states that, if an educator has a certain set of online instruments for teaching the majority of computer science subject units, even in distance teaching, they can organise a lesson correctly and lead their students from theory to its practical implementation and preserve the opportunities for their individual work. We believe that his work proved the relevance of such research. Conducting such research is currently a source for theoretical knowledge and solutions to emerging problems in the education system both global and national levels. Therefore, the current lack of scientific analysis of and grounds for the efficiency of the methods for distance teaching of computer science in Kazakh secondary school students during the pandemic determine the novelty of this research.

Methodology, Materials and Methods

The experimental test was conducted from March to December in 2020. A total of five educators and 320 students of three Kazakh schools took part in the study. The schools are, namely, Petropavlovsk Secondary School No.3, Novorybinsk Secondary General School of the North Kazakhstan Region, Regional Boarding School for Hearing-Impaired Children (Petropavlovsk, Republic of Kazakhstan). At the moment of the experiment, the students were aged 12 to 18 years old. The conducted research included three stages:

- preliminary;
- basic;
- additional.

At the first (preliminary) stage, there were determined the experimental test, the number of participants, the plan of empirical part. We concluded the agreements with the administration body of the selected educational institutions on the participation in the research, which allowed us to access the databases of current academic progress and quality of knowledge on computer science in students. Together with the teachers working at these schools and cooperating with our research group we defined the main thematic directions in education corresponding to the Kazakh education programme for computer science and selected the most suitable for distance teaching didactic methods and software products (services) available at the moment. As a result, there was developed a preliminary algorithm of realisation of the basic content of the education programme using online technologies, which is presented in Table 1.

Table 1

The content of the study of the methods for distance teaching computer science in the Kazakh secondary school students

Form	Basic content	Methods applied	Software for education
5	Computer science and information	Explanatory and illustrative, reproductive	Bilimland
	Graphics and animation	Interactive, project method	Logiclike
6	Working with electronic documents	Reproductive, self-learning	Google Docs
	Algorithms and actors	Demonstration, interactive	Scratch Mobile
7	Computer networks and security	Research method, visual	Bilimland
	Algorithms and computer programming	Interactive, reproductive	Moodle
8	Computer simulation	Demonstrational, project method	TinkerCad
	Algorithms and computer programming	Visual, reproductive	Moodle
9	Structured programming	Reproductive	OnlineGD
	Practical computer simulation	Visual, self-learning	Yenka Online
10	Object-oriented programming	Project method	Online GD
11	Web elaboration	Reproductive, project method	Web server Sivinskiy.com
	Information security	Interactive, explanatory and illustrative	Online Mektep

Apart from the mentioned methodological approaches to teaching computer science [9, 15], it was planned to use such services for organising an online lesson and video conferences as Zoom, Google Class and Microsoft Teams as well as mobile applications for rapid interchange of messages and media content (WhatsApp, Telegram, Viber) as means of communication and interchange of study materials.

Due to the impossibility to study the experimental test plan and instruct the participant in person, it was realised via a video conference. During this remote meeting, we obtained the informed consent from all the potential participants. The parents (official representatives) of the students expressed no objections.

The methodological basis for the research is composed of the works by Vajndorf-Sysoeva [16] (the teaching technique for distance education), Romero and Cope (the processing of academic progress data – Big Data) [7, 17]. Besides, we widely used experimental pedagogical elaborations by the employees of the selected education institutions that participated in our experiment and Koval's technologies on analytics and management in school environment through the application of information and communication technologies [18].

The basic stage of the presented experimental test took place from April 1 to May 25 in 2020 during the last academic quarter. Due to the implemented Kundelik's automated online system for calculating and registering current and final academic progress in the Kazakh schools, we could conduct the analyses and determine the quality of knowledge in the participants at the beginning of the experiment (before distance education model was introduced). This platform assumes ten-point-scale evaluation of students at every lesson, which proved to be quite a prospective factor for conducting an analytical and synthetic monitoring, which is an integral part of our research [19].

In order to make it more convenient to follow qualitative changes in the academic progress of the students depending on the selected distance education methods, the participants were separated into seven groups based on their level of education (5th-11th forms). Each group included three subgroups represented by each of the three schools. We conducted three control evaluation of the quality of knowledge for each of the 320 participants. The data was downloaded to the Kundelik's platform for every stage separately:

- before the experiment;
- after the basic stage of the experiment;
- after the additional stage of the experiment.

The data was processed in Excel spreadsheets with the embedded functions. The statistical certainty of the research results was proved with the online service Statpsy.

During the basic stage of the experiment, we conducted time-to-time consultations for the teachers on the choice of the distance education methods to

teach computer science. At the additional stage (from September 2 to December 30, 2020), the implementation of the methods was corrected in order to enhance the education process and online lessons. The main qualitative changes are described in the results section of this work.

Results

The preliminary analysis of the quality of knowledge related to the computer science subject in the participants revealed generally high and average level of both acquisition of theoretical information and development of the subject-related practical skills, which was registered based of the results of in-person education (with the use of traditional methods). The obtained values (Table 2) shall be considered reference ones, which means that a significant deviation from them (decreasing) shall evidence inefficiency of the applied methods teaching techniques of distance education.

Table 2

Average indicators of the quality of knowledge of computer science before the basic stage of the experiment

Group	Form	Subgroup 1		Subgroup 2		Subgroup 3		Overall result	
		Average value	σ	Average value	σ	Average value	σ	Average value	σ
I	5	7.56	1.12	8.23	1.45	7.91	1.39	7.90	1.32
II	6	8.45	2.08	8.72	1.34	8.11	1.71	8.43	1.71
III	7	7.23	1.39	6.49	1.77	6.92	2.05	6.88	1.74
IV	8	8.35	0.78	7.79	1.19	8.03	1.25	8.06	1.07
V	9	7.62	1.03	9.05	1.62	8.07	1.41	8.25	1.35
VI	10	8.11	0.96	7.39	0.99	8.19	1.03	7.90	0.99
VII	11	7.13	1.53	7.34	1.20	7.91	1.58	7.46	1.44

σ – standard deviation

The school form-based groups differed significantly in the number of the participants as a consequence of urgent circumstances of the conducted experience (enforcement of distance education amid the Coronavirus pandemic) and the necessity for reaching the largest number of participants possible (as the introduction of online lessons involved all the education levels). Thus, we decided to conduct a statistical analysis taking this factor into account and, if necessary, to consider separate subgroups combined with the others (within the same form). It should be noted that the first experimental group included 53 students, the second one – 58, the third one – 37, the forth one – 42, the fifth one – 47, the sixth one – 49, the seventh one – 34. Upon the statistical processing of the indicators of the quality of knowledge related to the discipline of computer science

in the participants before the basic stage of the experiment we excluded eight students (three from the first group, two from the second group, two from the fifth group and one from the seventh group) from the overall calculations. This decision was taken when we calculated disperse characteristics and noticed that the qualitative values of their academic progress resulted beyond normal distribution. Nevertheless, they continued their participation in the experiment as a school form is an integral unit, but the data obtained from monitoring them was not included into the overall analysis.

In order to prove the statistical certainty of the calculated average reference values, which are required to confirm the validity of the experiment, we conducted a t-test for unpaired samples for each of the seven groups. It was determined that the parallel presence of the three groups related to different educational institutions justified the totality of their critical values, since the detected differences ($p \leq 0.05$, provided $t1 = 7.87$, $t2 = 7.69$, $t3 = 7.93$) lie within the acceptable range for this kind of research.

Before the basic stage of the experiment, both the content analysis of theoretical and practical body of literature on the organisation and maintenance of distance education [20, 21] and the advanced experience of the specialist in our initiative group [22, 23] allowed us to elaborate a structural scheme for conducting a lesson when an in-person lesson is impossible. The content of this scheme includes the following elements:

1. Stage of organisation (external):

a. Preparing software and devices for teaching (starting applications, authorising, if necessary, announcing the start of the lesson and other related information, for example, links to the video conference, study materials, files containing some tasks, in the chat in the selected messenger or another means of communication).

b. Checking homework and the results of students' self-studying (getting the information on the completion of the tasks and practices from the study portal's server, a system of file exchange or another service, filling in the online gradebook).

c. Monitoring the online activity (checking if the students are ready for the online lesson).

2. Stage of motivation (online):

a. Greeting and setting the objective (communicating with the student in the video conference, applying active teaching methods such as brainstorm, case analyses, business games);

b. Theoretical preparation and instructions (online demonstration of study materials, predominantly in the form of charts and videos, synchronised explication and commenting, use of illustrative teaching methods);

c. Realisation of the social component (organising the student's interaction with the help of standard applications for video conferences, applying discussion and problem-based learning).

3. Stage of practice (asynchronous):

a. Accomplishing study tasks (working with electronic systems for distance education, accomplishing tasks in specialised educational web-portals or proprietary websites offering the practical materials that correspond to the selected topic, traditional task solution in a written or electronic way);

b. Realisation of the health protection component (physical activity break, exercises for the neck, the back and the lower extremities, complex of exercises to relax the eyes)

c. Project and extracurricular activity (student projects as electronic documents or multimedia that reflect their real work, ensuring students interaction within the class through the technological communication means, watching the topic-related video lessons recommended by the teacher).

4. Stage of post-lesson activity

a. Publishing the accomplished tasks (downloading them to the educational web-server or sending them directly to the teacher in any available way: e-mail, social networks, messengers);

b. Reflection and self-studying (analysing and comprehending the lessons results, studying additional literature, watching educational videos, visiting development web-resources).

Figure 1 illustrates the described structural scheme for conducting an online lesson.

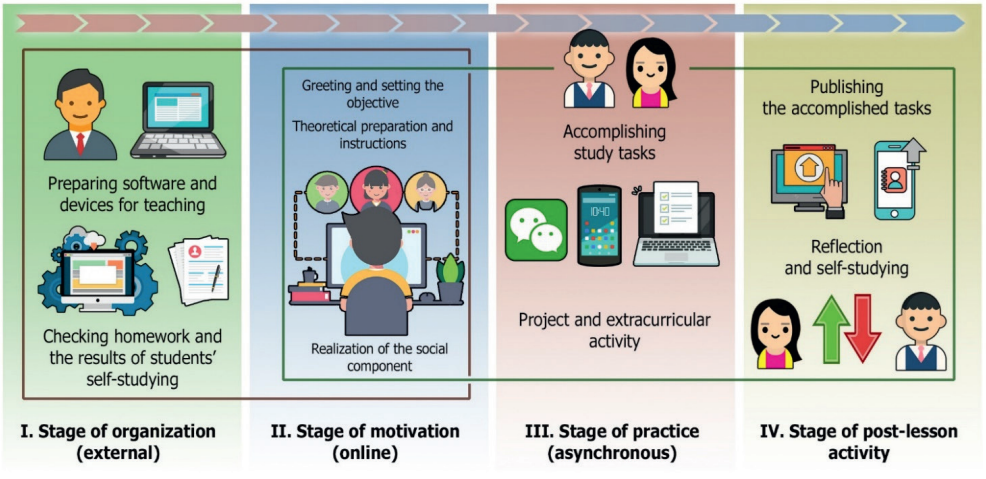

Fig. 1. Structural scheme for conducting an online lesson

Such lessons (based on the scheme presented above) were conducted up to the end of the quarter. Meanwhile, we collected and processed sufficient empirical data, which allowed us to make intermediary conclusions on the experiment. Table 3 shows the calculated values of the quality of knowledge related to the computer science subject in the participants after the second part of the experiment, which evidence a slight decrease. According to the participating teachers, this fact may have a number of objective reasons:

– enforced transition to distance education;

– lack of the necessary period for the school students to adapt to new educational circumstances;

– insufficient facilities for education process at the beginning of distance learning;

– external problems (disruptions, low speed of the internet connection);

– educational servers breakdowns due to a sharp increase in the traffic and user activity.

Besides, the lack of practical experience in using distance education methods in the teachers and current need for their enhancement also affected the decrease in qualitative values.

Table 3

Average indicators of the quality of knowledge of computer science in the participant after the basic stage of the experiment

Group	Form	Subgroup 1		Subgroup 2		Subgroup 3		Overall result	
		Average value	σ	Average value	σ	Average value	σ	Average value	σ
I	5	4.46	0.72	5.64	1.45	5.66	1.61	5.25	1.26
II	6	6.43	1.79	6.47	1.82	6.19	1.53	6.36	1.71
III	7	5.11	0.99	4.41	2.17	5.04	2.47	4.85	1.88
IV	8	5.81	1.01	4.97	1.51	5.06	0.99	5.28	1.17
V	9	4.85	0.89	6.13	1.22	5.96	1.55	5.65	1.22
VI	10	6.39	0.57	4.05	0.93	5.19	1.49	5.21	1.00
VII	11	4.27	1.75	4.72	1.31	5.42	1.53	4.80	1.53

σ – standard deviation

The analysis of the obtained data allowed to compare them to the reference values calculated at the preliminary stage of the experiment. We applied the Mann–Whitney U test for independent samples. We used the standard formula and compiled a consolidated range of paired samples under comparison. Their elements were ranged increasingly. Every element attributed a rank. The desired range was split into a smaller one. For each of them, the sum of the

ranks was calculated separately. The resulted U-value was compared to the table values.

$$U = n_1 \cdot n_2 + \frac{n_x \cdot (n_x + 1)}{2} - T_x$$

According to the obtained empirical values, the detected difference in samples can be considered statistically significant: I group – Uemp = 6.58 ($p \leq 0.05$), II group – Uemp = 7.39 ($p \leq 0.05$), III group – Uemp = 5.86 ($p \leq 0.05$), IV group – Uemp = 6.67 ($p \leq 0.05$), V group – Uemp = 6.94 ($p \leq 0.01$), VI group – Uemp = 6.55 ($p \leq 0.05$), VII group – Uemp = 6.13 ($p \leq 0.01$).

After the basic stage of the experiment was finished, in order to enhance the methods for distance teaching computer science, we elaborate the following recommendations for the teachers:

- organising the online lessons of computer science and teaching this subject in asynchronous mode should be synchronised with other subject disciplines, i.e. one should avoid the multi-lesson activity that has not been coordinated, while, if possible, integrate inter-subject connections;

- creating the subject-based chats (for study materials exchange) and the class-based chats (for organisational issues) when using messengers as the main means of communication among the parties of the education process;

- using available educational mobile applications, in particular, those with graphic interface for the solution of such logical tasks as ”Pereprava”, “Vodolei”, “Chertezhik”, to ensure more comprehensive understanding of the “Algorithms and actors” unit;

- downloading in advance all the task templates studied within the course to the server when teaching programming in the Moodle environment, since it significantly motivates the students to develop the programming skills and solve as many suggested algorithmic problems as possible on their own;

- using such educational platforms as Bilimland and Online Mektep should be combined with the teacher’s explanatory and illustrative activity represented by theoretical and instructive video conferences in Zoom or similar services;

- working with electronic documents through the interaction with Google Docs should be anticipated by registration and authorisation of new users (if they have not had the accounts before);

- the methodologically grounded implementation of the online application TinkerCad (or similar) when teaching basic computer simulation should be accompanied by the corresponding study documents or other materials (video lessons, online guide, slides) that are designed to facilitate the use of this software product;

- certain difficulties concerning the interface of some electronic tools − for example, Yenka Online, a computer simulation system; Online GD, a web-com-

pilation system of the object-oriented programming languages, – which emerge at the initial stage of studying object-oriented programming, should be taken into account when explaining the related topics and demonstration method should be applied (using them on the teacher's device while demonstrating the desktop at the video conference);

-when teaching "Graphics and Animation" and "Algorithms and Actors" at the middle forms (5th–6th forms), taking into account that the game methods used in the applications Logiclike and Scratch Mobile can exceedingly involve the students as they are based on "achievement and encouragement". In this regard, a teacher should control the accomplishments of the tasks with the embedded administrative tools.

The third (additional) stage of our experiment involved the application of the enhanced methods according to the presented recommendations. It took place during two quarters of the following (2020–2021) academic year, since the lockdown and distance education still persisted in Kazakhstan (September-December). Our research group received positive feedback from the computer science teachers, which confirmed the increased efficiency of distance education according to the corrected teaching techniques. The results of monitoring the academic progress and the quality of subject-related knowledge that we conducted upon this stage of the experiment are presented in Table 4.

Table 4

Average indicators of the quality of knowledge of computer science in the participant after the additional stage of the experiment

Group	Form	Subgroup 1		Subgroup 2		Subgroup 3		Overall result	
		Average value	σ	Average value	σ	Average value	σ	Average value	σ
I	5	7.57	1.24	8.15	1.32	7.47	1.28	7.73	1.28
II	6	8.92	2.48	8.9	1.82	7.87	1.72	8.56	2.01
III	7	7.53	1.8	6.94	2.21	7.27	2.23	7.25	2.08
IV	8	8.44	1.04	7.66	1.67	8.36	0.95	8.15	1.22
V	9	7.12	0.69	9.09	1.96	8.36	0.91	8.19	1.19
VI	10	7.89	1.32	7.89	1.49	8.49	1.34	8.09	1.38
VII	11	6.73	1.96	7.78	0.99	8.38	1.1	7.63	1.35

σ – standard deviation

We conducted the Mann–Whitney U test, just like at the previous stage, and determined that the obtained average indicators of the quality of teaching computer science to the participants increased significantly (I group – Uemp = 6.49 ($p \leq 0.05$), II group – Uemp = 7.46 ($p \leq 0.05$), III group – Uemp = 6.05 ($p \leq$

0.01), IV group – Uemp = 6.71 ($p \leq 0.05$), V group – Uemp = 6.91 ($p \leq 0.01$), VI group – Uemp = 6.65 ($p \leq 0.05$), VII group – Uemp = 6.21 ($p \leq 0.05$)). Figure 2 illustrates that, despite a temporary fall in the efficiency of teaching computer science registered during the transition to distance education, it was managed to achieve the level of the academic progress and acquisition of knowledge corresponding to that of in-person (traditional) education.

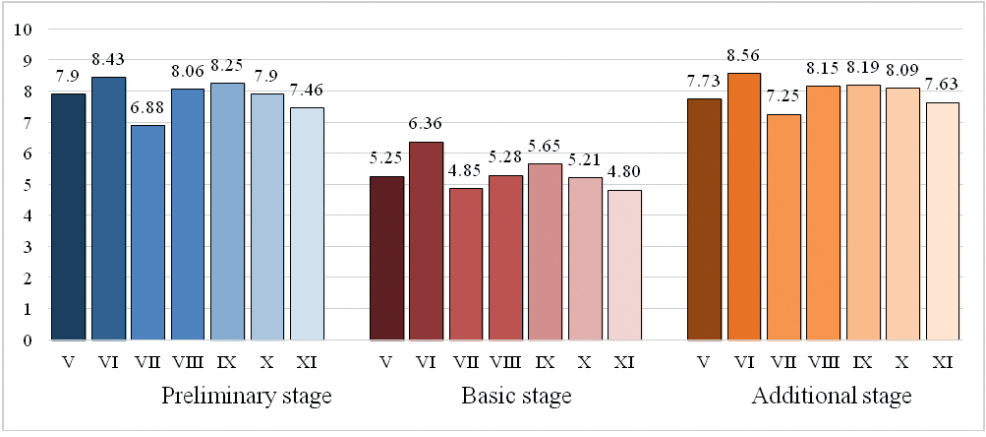

Fig. 2. Dynamics of change in academic progress in the participants during the transition to distance education

The obtained results evidence the success of the arrangements aimed at the enhancement of the methods for distance teaching of computer science in the Kazakh secondary school students during the transition to distance education enforced due to the pandemic.

Discussion

In the course of this research, some similar research papers were published, which allow us to analytically compare, align, specify and conclude on the relevance and validity of the described experiment.

The proved necessity for a synchronised demonstration of study materials and the teacher's comments, which we showed in the elaborated structural scheme, align with the empirical data on the efficiency of distance education during the pandemic that was obtained by Indonesian researcher Nadeak [24]. He also states the limited nature of the traditional teaching methods and the impossibility to apply them beyond in-person education. In this regard, it should be noted that the teaching techniques that we studied and enhanced in the

course of the research make it possible to conduct distance education process at a competence level covering all the units of computer science subject discipline that are compulsory in the Kazakh educational programme.

The relevant problem of maintaining the quality of education in the enforced transition to distance education, which our research is based on, is also considered by Lassoued, Alhendawi, Bashitialshaaer [25]. They described a range of obstacles caused by the necessity to adapt to the drastic change in the pedagogical impact, which impede the maintenance of the academic progress and acquisition of knowledge at the same level. We believe that the problems that they rose and researched are also currently peculiar of the Kazakh education system, in particular, concerning the computer science lessons. We consider that the majority of these problems can be successfully solved if one uses the described methods for distance teaching and technologies for their enhancement, since the differentiation and inhomogeneity of the educational environment universal ways to maintain the quality of knowledge, which are still relevant in any situation.

Our results also correspond to those of Marek, an American research who was the first to describe teachers' experience in the transition to distance education at the beginning of the COVID-19 pandemic [26]. Based on the Kazakh school students, we determined that it is possible and effective to adapt the traditional pedagogical methods to be used in online lessons, although it requires the teachers to be theoretically, practically and technically prepared or an adaptation period for getting accustomed to new circumstances and finding adequate didactic methods. Thus, the nature of the change in academic progress of the participants, which we registered in the course of the presented experimental test, corresponds with the theoretical model suggested by Marek and his Malaysian colleague Chew [26].

Due to the insufficiency of the currently available related empirical research, we consider the most similar experiment conducted by German researchers Klein and Ivanjek. They dealt with the problems of distance teaching physics during the pandemic, the related change in the academic progress, efficiency of online lessons and virtual laboratories [27]. We should note that computer science, which is traditionally one of science and mathematics subject disciplines along with physics, can be considered in the context of their findings. Ivanjek et al. empirically proved positive correlation of academic progress indicators upon the implementation of some arrangements that enhance distance education proves. These suggestions, which enhance the teaching techniques and are designed for online lessons, correspond with the recommendation that we elaborated to enhance distance teaching of computer science in Kazakh secondary school students. The large number of participants (578 in Klein's case

and 320 in our case) ensures the statistical certainty of the conclusions on the successfully conducted research and the enhancement of distance teaching methods. The concordance of the results with those of other related research as well as the practical approbation of previously existing theories confirms the scientific significance of the presented research.

Conclusion

The accelerated changes in the educational system during the pandemic defined the topicality of the problem and the enhancement of the methods for distance teaching of computer science in Kazakh school students. There emerged the urgent need for finding and adapting the most relevant teaching approaches and methodologies, which could compensate currently impossible traditional in-person lessons while, at the same time, preventing the fall in the academic progress and the quality of knowledge in students. We believe that it was achieved in the course of the presented experimental test. Moreover, we believe that the elaborated recommendations and structural schemes may be applied to teach other school subject disciplines. The efficiency of their use is proved by the collected and analysed empirical data that is statistically confirmed.

As a venue for future research, we suggest the elaboration of advanced distance teaching methods, which use implies the extrapolation to the majority of subject disciplines with the account of current circumstance of educational process. Besides, the analysis of pedagogical experience in enhancing the teaching techniques for conducting online lessons during the transition to distance education due to the COVID-19 pandemic is of scientific interest.

The results of the presented research may be of use for teachers when teaching computer science online as well as for researchers dealing with the issues of teaching methods enhancement.

Our close cooperation with the teachers participating in the experiment resulted to be very successful, in particular, in terms of the application of the advanced experience. Such kind of cooperation is always important, especially at such a complicated time as we experience now.

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