

ISSN 2518-1726 (Online),
ISSN 1991-346X (Print)

**ACADEMIC SCIENTIFIC
JOURNAL OF COMPUTER SCIENCE**

**№4
2025**

ISSN 2518-1726 (Online),
ISSN 1991-346X (Print)



CENTRAL ASIAN ACADEMIC
RESEARCH CENTER



**ACADEMIC SCIENTIFIC
JOURNAL OF COMPUTER
SCIENCE**

4 (356)

OCTOBER – DECEMBER 2025

**PUBLISHED SINCE JANUARY 1963
PUBLISHED 4 TIMES A YEAR**

ALMATY, NAS RK

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Academic Scientific Journal of Computer Science

ISSN 2518-1726 (Online),

ISSN 1991-346X (Print)

Owner: «Central Asian Academic Research Center» LLP (Almaty).

Certificate № **KZ77VPY00121154** on the re-registration of the periodical printed and online publication of the information agency, issued on **05.06.2025** by the Republican State Institution «Information Committee» of the Ministry of Culture and Information of the Republic of Kazakhstan

Subject area: *information and communication technologies.*

Currently: *included in the list of journals recommended by the CCSES MSHE RK in the direction of «Information and communication technologies».*

Periodicity: *4 times a year.*

<http://www.physico-mathematical.kz/index.php/en/>

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Academic Scientific Journal of Computer Science

ISSN 2518-1726 (Online),

ISSN 1991-346X (Print)

Меншіктеуші: «Орталық Азия академиялық ғылыми орталығы» ЖШС (Алматы).

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Тақырыптық бағыты: *ақпараттық-коммуникациялық технологиялар*

Қазіргі уақытта: *«ақпараттық-коммуникациялық технологиялар» бағыты бойынша ҚР БҒМ БҒСБК ұсынған журналдар тізіміне енді.*

Мерзімділігі: *жылына 4 рет.*

<http://www.physico-mathematical.kz/index.php/en/>

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Academic Scientific Journal of Computer Science

ISSN 2518-1726 (Online),

ISSN 1991-346X (Print)

Собственник: *ТОО «Центрально-азиатский академический научный центр» (г. Алматы).*

Свидетельство о постановке на учет периодического печатного издания, информационного агентства и сетевого издания № **KZ77VPY00121154**. Дата выдачи **05.06.2025**

Тематическая направленность: *информационно-коммуникационные технологии.*

В настоящее время: *вошел в список журналов, рекомендованных КОКСНВО МНВО РК по направлению «информационно-коммуникационные технологии».*

Периодичность: *4 раза в год.*

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CONTENTS

B. Assanova, Zh. Moldasheva, A.T. Kishubaeva Decision support system structure and blocks for selecting efficient delayed coking modes.....	11
Zh.T. Abildayeva, R.K. Uskenbayeva, G.S. Beketova, N.B. Konyrbaev, S.B. Seydazimov Multi-criterion optimization of advertising budget allocation in the agro-industrial complex based on NSGA-III algorithm.....	26
A.O. Aliyeva, B.S. Omarov, R.B. Abdrakhmanov, D.R. Sultan, A.B. Toktarova Neural network model for automatic detection of Kazakh-language hatespeech.....	40
O. Auyelbekov, E. Bostanov, S. Sapakova, L. Tukenova, A. Kozhagul Modeling and analysis of a generator with permanent and variable magnets.....	55
G. Autova, G. Nurtayeva, E. Zulfukharova, G. Yeleussizova, R. Zhumabekova Theoretical foundations of interdisciplinary integration of physics and computer science.....	73
A.Zh. Akhmetova, M.A. Kantureyeva, A.A. Abisheva, A. Aubakirova, A.A. Shekerbek Analysis of the social network user's environment.....	89
A.Sh. Barakova, K.S. Shadinova, A.S. Orynbaeva, G. Sugurzhanova Design of a model for protecting a website's authentication data and content based on blockchain technology.....	102
A.N. Zhidebayeva, G.U. Madaliyeva, B.O. Tastanbekova, S.S. Karzhaubekova, G.S. Shaimerdenova Deep neural network Conv-LSTM for ECG-based cardiac disorder identification.....	122
N.M. Zhunissov, A.B. Aben, A.B. Amanzholova The fraud detection model in text messages.....	138
A. Issakhov, A. Alzhanov, A. Akhmedov, A. Amanzholov, T. Murat Numerical simulation of thermohydrodynamics during heated water discharge into Lake Balkhash.....	152

Z. Kaderkeyeva, B. Razakhova, G. Bekmanova, A. Nazyrova, M. Zhasuzakova
Q-Bilim: an intelligent system for assessing learning outcomes based on competencies.....171

N. Karymsakova, A. Boltaboyeva, D. Turmakhanbet, M. Maulenbekov, T. Abdirova
Unsupervised learning for the identification of critical conditions in renewable energy production.....184

A.Kulakayeva, E.Daineko, B. Medetov, A. Nurlankyzy
Evaluation of the effectiveness of modern neural network architectures for VAD under low snr ratio conditions.....203

B. Orazbayev, A. Zhumadillayeva, K. Orazbayeva, R. Yessirkessinov, Zh. Tuleuov
Development of models of sulfur production processes based on artificial neural networks and simulation.....216

L. Rzayeva, A. Ryzhova, M. Zhaparkhanova, A. Myrzatay, Zh. Kozhakhmet
A new LSTM-based web application for automated password strength evaluation.....234

D. Sagidoldin, A. Zhetpisbayeva, B. Zhumazhanov, B. Zhumazhanov
Increasing the reliability of data transmission from small spacecraft using SDR equipment.....259

A.N. Seraly, A.D. Mekhtiyev, G.Z. Ziyatbekova, K.B. Begalieva, R.A. Mekhtiyev
Development of hardware for monitoring optical parameters.....274

A.A. Taurbekova, M.V. Markosyan
Development and implementation of a computational model of magmatic processes in the bowls of the Earth and on its surface.....288

K. Chezhimbayeva, A. Mukhamejanova, Y. Garmashova
Fuzzy-logic-based expert system for predicting QoS in 5G networks.....306

МАЗМҰНЫ

Б.У. Асанова, Ж.Ж. Молдашева, А. Кишубаева Баяу кокстеу қондырғысы үшін тиімді жұмыс режимдерін таңдауға шешім қолдау жүйесі құрылымы.....	11
Ж.Т. Әбілдаева, Р.К. Ускенбаева, Г.С. Бекетова, Н.Б. Қоңырбаев, С.Б. Сейдазимов NSGA-III алгоритмі негізінде агроөнеркәсіптік кешендегі жарнамалық бюджетті бөлуді көп критериялы оңтайландыру.....	26
А.О. Әлиева, Б.С. Омаров, Р.Б. Абдрахманов, Д.Р. Султан, А.Б. Тоқтарова Қазақ тіліндегі дискриминацияны автоматты анықтауға арналған нейрондық желілік моделі.....	40
О. Әуелбеков, Е. Бостанов, С. Сапақова, Л. Түкенова, А. Қожағұл Тұрақты және айнымалы магниттері бар генераторды модельдеу және талдау.....	55
Г.М. Аутова, Г.К. Нуртаева, Ә.М. Зильбухарова, Г.С. Елеусизова, Р.Р. Жұмабекова Физика мен информатика пәндерінің пәнаралық интеграциясының теориялық негіздері.....	73
А.Ж. Ахметова, М.А. Кантуреева, А.А. Абишева, А. Аубакирова, А.А. Шекербек Әлеуметтік желі қолданушыларының ортасын талдау.....	89
А.Ш. Баракова, К.С. Шадинова, А.С. Орынбаева, Г. Сугуржанова Блокчейн технологиясы негізінде веб сайттың аутентификациялық деректері мен өнімін қорғау моделін құрастыру.....	102
А.Н. Жидебаева, Г.У. Мадалиева, Б.О. Тастанбекова, С.С. Қаржаубекова, Г.С. Шаймерденова Жүрек ауруларын анықтауда Conv-LSTM архитектурасына негізделген терең нейрондық желі.....	122
Н.М. Жунисов, А.Б. Абен, Ә.Б. Аманжолова Мәтіндік хабарламалардағы алаяқтықты анықтау моделі.....	138
А.А. Исахов, А. Альжанов, А. Ахмедов, А. Аманжолов, Т. Мурат Балқаш көліне жылы су ағызу кезіндегі термогидродинамиканы сандық модельдеу.....	152

З.К. Кадеркеева, Б.Ш. Разахова, Г.Т. Бекманова, А.Е. Назырова, М.Ж. Жасұзақова Q-Bilim: құзыреттерге негізделген оқу нәтижелерін бағалауға арналған интеллектуалды жүйе.....	171
Н. Карымсакова, А. Болтабоева, Д. Тұрмаханбет, М. Мауленбеков, Т. Абдирова Жанартылатын энергия өндірісіндегі критикалық режимдерді анықтауға арналған мұғалімсіз оқыту.....	184
А. Кулакаева, Е. Дайнеко, Б. Медетов, А. Нурланқызы Сигнал/шуыл қатынасы төмен жағдайларда заманауи нейрондық желілік VAD архитектураларының тиімділігін бағалау.....	203
Б. Оразбаев, А. Жумадиллаева, К. Оразбаева, Р. Есиркесинов, Ж. Тулеуов Күкірт өндіру процесстерінің модельдерін жасанды нейрондық желілер негізінде әзірлеу және модельдеу.....	216
Л. Рзаева, А. Рыжова, М. Жапарханова, А. Мырзатай, Ж. Кожамет, Құпиясөздің беріктігін автоматты бағалауға арналған LSTM негізіндегі жаңа веб-қосымша.....	234
Д.Т. Сагидолдин, А.Т. Жетписбаева, Б.Р. Жумажанов, Б.С. Жумажанов SDR жабдықтарын пайдалану арқылы, шағын ғарыш аппараттарынан деректерді берудің сенімділігін арттыру.....	259
А.Н. Сералы, А.Д. Мехтиев, Г.З. Зиятбекова, К.Б. Бегалиева, Р.А. Мехтиев Оптикалық параметрлерді бақылауға арналған аппараттық құрылғыны әзірлеу.....	274
А.А. Таурбекова, М.В. Маркосян Жер көзіндегі және оның бетіндегі магматтық процестердің есептік моделін әзірлеу және енгізу.....	288
К.С. Чежимбаева, А. Мухамеджанова, Ю. Гармашова Айқын емес логика негізінде 5G желілеріндегі QoS болжау expertтік жүйесі.....	306

СОДЕРЖАНИЕ

Б.У. Асанова, Ж.Ж. Молдашева, А. Кишубаева Структура и функциональные блоки системы поддержки решений для выбора режимов замедленного коксования.....	11
Ж.Т. Абилдаева, Р.К. Ускенбаева, Г.С. Бекетова, Н.Б. Конырбаев, С.Б. Сейдазимов Многокритериальная оптимизация распределения рекламного бюджета в апк на основе алгоритма NSGA-III.....	26
А.О. Алиева, Б.С. Омаров, Р.Б. Абдрахманов, Д.Р. Султан, А.Б. Токтарова Нейросетевая модель для автоматического обнаружения дискриминации в казахском языке.....	40
О. Ауельбеков, Е. Бостанов, С. Сапакова, Л. Туkenова, А. Кожугул Моделирование и анализ генератора с постоянными и переменными магнитами.....	55
Г.М. Аутова, Г.К. Нуртаева, Э.М. Зулбухарова, Г.С. Елеусизова, Р.Р. Жумабекова Теоретические основы междисциплинарной интеграции физики и информатики.....	73
А.Ж. Ахметова, М.А. Кантуреева, А.А. Абишева, А. Аубакирова, А.А. Шекербек Анализ окружения ползователей социальной сети.....	89
А.Ш. Баракова, К.С. Шадинова, А.С. Орынбаева, Г. Сугуржанова Разработка модели защиты аутентификационных данных и контента веб-сайта на основе технологии блокчейн.....	102
А.Н. Жидебаева, Г.У. Мадалиева, Б.О. Тастанбекова, С.С. Каржаубекова, Г.С. Шаймерденова Глубокая нейронная сеть на основе архитектуры Conv-LSTM для выявления сердечных заболеваний.....	122
Н.М. Жунисов, А.Б. Абен, А.Б. Аманжолова Модель обнаружения мошенничества в текстовых сообщениях.....	138
А.А. Исахов, А. Альжанов, А. Ахмедов, А. Аманжолов, Т. Мурат Численное моделирование термогидродинамики при сбросе подогретых вод в озеро Балхаш.....	152

З.К. Кадеркеева, Б.Ш. Разахова, Г.Т. Бекманова, А.Е. Назырова, М.Ж. Жасузакова Q-Bilim: интеллектуальная система оценки результатов обучения на основе компетенций.....	171
Н. Карымсакова, А. Болтабоева, Д. Тұрмаханбет, М. Мауленбеков, Т. Абдирова Обучение без учителя для выявления критических режимов в производстве возобновляемой энергии.....	184
А. Кулакаева, Е. Дайнеко, Б. Медетов, А. Нурланкызы Оценка эффективности современных нейросетевых архитектур VAD при низком отношении сигнал/шум.....	203
Б. Оразбаев, А. Жумадиллаева, К. Оразбаева, Р. Есиркесинов, Ж. Тулеуов Разработка моделей процессов производства серы на основе искусственных нейронных сетей и моделирование.....	216
Л. Рзаева, А. Рыжова, М. Жапарханова, А. Мырзатай, Ж. Кожамет Новое веб-приложение на основе LSTM для автоматизированной оценки надежности паролей.....	234
Д.Т. Сагидолдин, А.Т. Жетписбаева, Б.Р. Жумажанов, Б.С. Жумажанов Повышение надёжности передачи данных с малых космических аппаратов с применением SDR оборудования.....	259
А.Н. Сералы, А.Д. Мехтиев, Г.З. Зиятбекова, К.Б. Бегалиева, Р.А. Мехтиев Разработка аппаратного средства для контроля оптических параметров.....	274
А.А. Таурбекова, М.В. Маркосян, Н.Т. Карымсакова Разработка и реализация вычислительной модели магматических процессов в недрах земли и на её поверхности.....	288
К.С. Чежимбаева, А. Мухамеджанова, Ю. Гармашова Экспертная система прогнозирования QoS в 5G-сетях на основе нечеткой логики.....	306

ACADEMIC SCIENTIFIC JOURNAL OF COMPUTER SCIENCE
ISSN 1991-346X
Volume 4. Number 356 (2025). 171–183

<https://doi.org/10.32014/2025.2518-1726.390>

IRSTI 28.17.23
UDC 004.89

© **Z. Kaderkeyeva¹, B. Razakhova^{1,2}, G. Bekmanova^{1,2}, A. Nazyrova^{1,2*},
M. Zhasuzakova³, 2025.**

¹L.N. Gumilyov Eurasian National University, Astana, Kazakhstan;

²Public Association "Kazakhstan Academy of Artificial Intelligence",
Astana, Kazakhstan;

³Almaty Technological University, Almaty, Kazakhstan.

E-mail: nazyrova_aye_1@enu.kz

Q-BILIM: AN INTELLIGENT SYSTEM FOR ASSESSING LEARNING OUTCOMES BASED ON COMPETENCIES

Kaderkeyeva Zulfiya — Master of Technical Sciences, senior lecturer of the Department of Artificial Intelligence, L.N. Gumilyov Eurasian National University, Astana, Kazakhstan,

E-mail: kaderkeyeva_zk@enu.kz, ORCID ID: <https://orcid.org/0000-0001-8237-8549>;

Razakhova Bibigul — Candidate of Technical Sciences, Head of the Department of Artificial Intelligence Technologies, L.N. Gumilyov Eurasian National University, Astana, Kazakhstan; Public Association "Kazakhstan Academy of Artificial Intelligence", Astana, Kazakhstan,

E-mail: razakhova_bsh@enu.kz, ORCID ID: <https://orcid.org/0000-0002-8152-8661>;

Bekmanova Gulmira — Candidate of technical sciences, PhD, associate professor of the Department of Artificial intelligence, L.N. Gumilyov Eurasian National University, Astana, Kazakhstan; Public Association "Kazakhstan Academy of Artificial Intelligence", Astana, Kazakhstan,

E-mail: gulmira-r@yandex.kz, ORCID ID: <https://orcid.org/0000-0001-8554-7627>;

Nazyrova Aizhan — PhD, senior lecturer of the Department of Artificial intelligence, L.N. Gumilyov Eurasian National University, Astana, Kazakhstan; Public Association "Kazakhstan Academy of Artificial Intelligence", Astana, Kazakhstan,

E-mail: nazyrova_aye_1@enu.kz, ORCID ID: <https://orcid.org/0000-0002-9162-6791>;

Zhasuzakova Meiramkul — PhD, Assistant Professor of the Department of Computer Engineering, Almaty Technological University, Almaty, Kazakhstan,

E-mail: zhasuzakova.m@mail.ru, ORCID ID: <https://orcid.org/0000-0001-7510-5948>.

Abstract. Competency-based education (CBE) requires transparent and objective assessment mechanisms to accurately evaluate learning outcomes. However, many institutions still face challenges related to inconsistent assessment tools, subjective grading, and weak alignment between competencies, outcomes, and evaluation criteria. This paper presents Q-Bilim, an intelligent assessment system that structures and automates evaluation processes through a weighted model linking competencies, expected outcomes, and measurement instruments. An empirical study of Q-Bilim was conducted in the “Database Fundamentals”

course from 2021 to 2024 with 170 undergraduate students of varying academic preparation. A unified four-level grading scale ensured consistency, while statistical methods such as ANOVA, Tukey's HSD test, regression analysis, and cluster analysis were used to assess cohort differences, identify learning patterns, and examine how assessment weightings affect overall performance. This approach provided insights into factors shaping competency development. The study's main contribution is the development and validation of a scalable, competency-based assessment framework implemented within Q-Bilim. Findings show a clear relationship between assessment weightings and student achievement, while cluster analysis revealed distinct learner categories from high-performing students to those needing additional support. The practical significance of Q-Bilim lies in its ability to support long-term monitoring, expose weaknesses in curriculum design, and help instructors make timely, data-driven decisions. Future work includes expanding the system to other disciplines and integrating advanced AI methods – such as graph neural networks – to enhance analytical precision, personalization, and usability.

Keywords: competency-based education, learning outcomes, student performance, educational analytics, Q-Bilim, assessment system

This research is funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP19678613).

© З.К. Кадеркеева¹, Б.Ш. Разахова^{1,2}, Г.Т. Бекманова^{1,2},
А.Е. Назырова^{1,2*}, М.Ж. Жасұзақова³, 2025.

¹Л.Н. Гумилев атындағы Еуразия ұлттық университеті,
Астана, Қазақстан;

²«Қазақстан жасанды интеллект академиясы» Қоғамдық Бірлестігі,
Астана, Қазақстан;

³ Алматы технологиялық университеті, Алматы, Қазақстан
E-mail: nazyrova_aye_1@enu.kz

Q-BILIM: ҚҰЗЫРЕТТЕРГЕ НЕГІЗДЕЛГЕН ОҚУ НӘТИЖЕЛЕРІН БАҒАЛАУҒА АРНАЛҒАН ИНТЕЛЛЕКТУАЛДЫ ЖҮЙЕ

Кадеркеева Зульфия — техника ғылымдарының магистрі, Жасанды интеллект кафедрасының аға оқытушысы, Л.Н. Гумилев атындағы Еуразия ұлттық университеті, Астана, Қазақстан,

E-mail: kaderkeyeva_zk@enu.kz, ORCID ID: <https://orcid.org/0000-0001-8237-8549>;

Разахова Бибиғул — техника ғылымдарының кандидаты, Жасанды интеллект технологиялары кафедрасының меңгерушісі, Л.Н. Гумилев атындағы Еуразия ұлттық университеті, Астана, Қазақстан; «Қазақстан жасанды интеллект академиясы» Қоғамдық бірлестігі, Астана, Қазақстан,

E-mail: razakhova_bsh@enu.kz, ORCID ID: <https://orcid.org/0000-0002-8152-8661>; **Бекманова**

Гүлмира — техника ғылымдарының кандидаты, PhD, Жасанды интеллект кафедрасының қауымдастырылған профессор, Л.Н. Гумилев атындағы Еуразия ұлттық университеті, Астана, Қазақстан; «Қазақстан жасанды интеллект академиясы» Қоғамдық

бірлестігі, Астана, Қазақстан,

E-mail: gulmira-r@yandex.kz, ORCID: <https://orcid.org/0000-0001-8554-7627>;

Назырова Айжан — PhD, Жасанды интеллект кафедрасының аға оқытушысы, Л.Н. Гумилев атындағы Еуразия ұлттық университеті, Астана, Қазақстан, «Қазақстан жасанды интеллект академиясы» Қоғамдық бірлестігі, Астана, Қазақстан,

E-mail: nazurova_aye_1@enu.kz, ORCID ID: <https://orcid.org/0000-0002-9162-6791>;

Жасұзақова Мейрамкүл — PhD, Компьютерлік инженерия кафедрасының ассистент-профессоры, Алматы технологиялық университеті, Алматы, Қазақстан,

E-mail: zhasuzakova.m@mail.ru, ORCID ID: <https://orcid.org/0000-0001-7510-5948>.

Аннотация. Құзыреттілікке негізделген білім беру (СВЕ) оқу нәтижелерін дәл бағалау үшін ашық және объективті бағалау механизмдерін талап етеді. Алайда көптеген оқу орындары бағалау құралдарының жүйесіздігіне, балл қоюдағы субъективтілікке және құзыреттер, күтілетін нәтижелер мен бағалау критерийлері арасындағы әлсіз үйлесімге байланысты қиындықтарға әлі де тап болып отыр. Бұл мақалада құзыреттерді, күтілетін нәтижелерді және өлшеу құралдарын өзара байланыстыратын өлшемдік модель арқылы бағалау үдерісін құрылымдап, автоматтандыратын Q-Bilim интеллектуалды бағалау жүйесі таныстырылады. Q-Bilim жүйесіне жүргізілген эмпирикалық зерттеу 2021–2024 жылдары «Деректер базасының негіздері» курсына әртүрлі дайындық деңгейіндегі 170 бакалавр студентінің қатысуымен өткізілді. Бірыңғай төрт деңгейлі бағалау шкаласы бірізділікті қамтамасыз етті. ANOVA, Tukey HSD, регрессиялық және кластерлік талдау сияқты статистикалық әдістер топтар арасындағы айырмашылықтарды анықтау, оқу үлгілерін сипаттау және бағалау салмақтарының жалпы жетістікке әсерін зерттеу үшін қолданылды. Бұл тәсіл құзыреттіліктің қалыптасуына ықпал ететін факторлар жөнінде маңызды түсініктер берді. Зерттеудің негізгі нәтижесі – Q-Bilim жүйесінде іске асырылған ауқымды, құзыреттілікке бағытталған бағалау моделін әзірлеу және оны дәлелдеу. Нәтижелер бағалау құралдарының салмағы мен студент жетістіктері арасында айқын байланыс бар екенін көрсетті, ал кластерлік талдау жоғары жетістікке жететіндерден бастап қосымша қолдауды қажет ететіндерге дейін әртүрлі студент топтарын анықтады. Q-Bilim жүйесінің практикалық маңызы – ұзақ мерзімді мониторинг жүргізу, оқу бағдарламаларындағы әлсіз тұстарды анықтау және оқытушыларға деректерге негізделген жедел шешімдер қабылдауға көмектесу. Болашақта жүйені басқа пәндерге кеңейту және аналитикалық дәлдікті, жекелендіруді және қолайлылықты арттыру үшін графтық нейрондық желілер сияқты озық жасанды интеллект әдістерін интеграциялау жоспарлануда.

Түйін сөздер: құзыреттілікке негізделген білім беру, оқу нәтижелері, студенттердің үлгерімі, білім беру аналитикасы, Q-Bilim, бағалау жүйесі

© **З.К. Кадеркеева¹, Б.Ш. Разахова^{1,2}, Г.Т. Бекманова^{1,2},
А.Е. Назырова^{1,2*}, М.Ж. Жасузакова³, 2025.**

¹Евразийский национальный университет им. Л.Н. Гумилёва,
Астана, Казахстан;

²Общественное объединение «Казахстанская академия искусственного
интеллекта», Астана, Казахстан;

³ Алматинский технологический университет, Алматы, Казахстан.
E-mail: nazyrova_aye_1@enu.kz

Q-BİLİM: ИНТЕЛЛЕКТУАЛЬНАЯ СИСТЕМА ОЦЕНКИ РЕЗУЛЬТАТОВ ОБУЧЕНИЯ НА ОСНОВЕ КОМПЕТЕНЦИЙ

Кадеркеева Зульфия — магистр технических наук, старший преподаватель кафедры Искусственного интеллекта, Л.Н. Евразийский национальный университет им. Л.Н. Гумилева, Астана, Казахстан,

E-mail: kaderkeyeva_zk@enu.kz, ORCID ID: <https://orcid.org/0000-0001-8237-8549>;

Разахова Бибигул — к.т.н., заведующий кафедрой Технологий Искусственного интеллекта, Евразийский национальный университет им. Л.Н. Гумилева, Астана, Казахстан; Общественное объединение «Казахстанская академия искусственного интеллекта», Астана, Казахстан,

E-mail: razakhova_bsh@enu.kz, <https://orcid.org/0000-0002-8152-8661>;

Бекманова Гүлмира — PhD, доцент кафедры Искусственного интеллекта, Евразийский национальный университет им. Л.Н. Гумилева, Астана, Казахстан; Общественное объединение «Казахстанская академия искусственного интеллекта», Астана, Казахстан,

E-mail: gulmira-r@yandex.kz, ORCID ID: <https://orcid.org/0000-0001-8554-7627>;

Назырова Айжан — PhD, старший преподаватель кафедры Искусственного интеллекта, Евразийский национальный университет им. Л.Н. Гумилева, Астана, Казахстан; Общественное объединение «Казахстанская академия искусственного интеллекта», Астана, Казахстан,

E-mail: nazyrova_aye_1@enu.kz, ORCID ID: <https://orcid.org/0000-0002-9162-6791>;

Жасузакова Мейрамкул — PhD, ассистент-профессора кафедры Компьютерной инженерии, Алматинский технологический университет, Алматы, Казахстан,

E-mail: zhasuzakova.m@mail.ru, ORCID ID: <https://orcid.org/0000-0001-7510-5948>.

Аннотация. Компетентностное обучение (СВЕ) требует прозрачных и объективных механизмов оценивания для точного измерения результатов обучения. Однако многие учебные заведения по-прежнему сталкиваются с проблемами, связанными с несогласованными инструментами оценивания, субъективностью выставления баллов и слабой связью между компетенциями, ожидаемыми результатами и критериями оценивания. В данной работе представлен Q-Bilim – интеллектуальная система оценивания, которая структурирует и автоматизирует процесс оценки с помощью взвешенной модели, связывающей компетенции, ожидаемые результаты и инструменты измерения. Эмпирическое исследование Q-Bilim проводилось на курсе «Основы баз данных» в 2021–2024 годах с участием 170 студентов бакалавриата с разным уровнем подготовки. Единая четырехуровневая шкала обеспечила согласованность, а такие статистические методы, как ANOVA, критерий Тьюки (HSD), регрессионный и кластерный анализ,

были использованы для оценки различий между группами, выявления учебных паттернов и изучения влияния весовых коэффициентов на итоговые результаты. Такой подход позволил получить представление о факторах, влияющих на формирование компетенций. Основным вкладом исследования является разработка и валидации масштабируемой компетентностно-ориентированной модели оценивания, реализованной в системе Q-Bilim. Результаты показали чёткую связь между весами оценочных инструментов и академическими достижениями студентов, а кластерный анализ позволил выделить различные группы обучающихся – от высокоуспевающих до нуждающихся в поддержке. Практическая значимость Q-Bilim проявляется в возможностях долгосрочного мониторинга, выявления слабых мест в образовательных программах и помощи преподавателям в своевременном принятии решений на основе данных. В дальнейшем планируется расширение системы на другие дисциплины и интеграция методов ИИ – таких как графовые нейронные сети – для повышения аналитической точности, персонализации и удобства использования.

Ключевые слова: компетентностно-ориентированное образование, результаты обучения, академическая успеваемость, образовательная аналитика, Q-Bilim, система оценивания

Introduction. One of the major developments in contemporary educational systems is competency-based education, or CBE. This method emphasizes students' academic knowledge as well as their practical abilities, professional competencies, and capacity to apply knowledge in real-world scenarios. The CBE model is widely used in the United States, Kazakhstan, a number of Latin American nations, and Western European nations (as part of the Bologna Process).

Throughout the educational process, learning outcomes must be methodically planned, tracked, and evaluated in order for CBE to be implemented successfully. However, it frequently becomes challenging to effectively measure the quality of courses because of the irregularities in these procedures and the dearth of efficient assessment instruments in many educational institutions. Furthermore, two major factors that lower the overall efficacy of the teaching process are the instructors' use of a variety of evaluation techniques and the lack of well-defined connections between learning outcomes and competences.

We suggest Q-Bilim, a novel information system, as a solution to these issues. The purpose of this system is to automatically evaluate student performance and track the caliber of competency-based education. The following are the main goals that the Q-Bilim system seeks to accomplish: Osygan Baylanysty, without Q-Bilim dep atalatyn zhana akparattyk zhuyeni usynamyz. Bul zhuye kuzyrettilikke negizdelgen kurstard studentzhetistigin avtomatty turde bagalauqa zhane kurstyn sapasyn monitoringteuge arnalgan.

The following primary goals are intended to be addressed by the Q-Bilim system:

- formalization of the competency model for the course, which involves

describing how competencies, learning goals, and assessment instruments relate to one another;

- evaluation of each component's corresponding student achievement levels;
- examination of the dynamics of course development throughout a number of academic years;
- assessment of the effectiveness of educational decisions, such as modifications to the curriculum or teaching methods;
- graphical reports that give teachers and students clear, understandable feedback.

The Q-Bilim system's architecture, working principles, and results from years of use in a particular course (such as Introduction to Programming) are presented in this article. Statistical techniques like Tukey's post-hoc tests and analysis of variance (ANOVA) have validated the strategy's efficacy.

Literature review. The development of the concepts of learning outcomes and competencies in higher education has been the focus of growing scholarly attention since the late 20th century. Mulder, Weigel, and Collins highlighted the role of competence in vocational education across EU member states, emphasizing its importance for curriculum design and policy implementation Mulder M. et al. (2007). In a similar direction, Harden examined the distinction between instructional objectives and learning outcomes, thereby grounding the paradigm of student-centered learning Harden R.M. (2002).

From the perspective of personalization and adaptability, Brusilovsky and Millán provided a seminal contribution by introducing user models for adaptive hypermedia, offering theoretical and practical foundations for individualized learning pathways Brusilovsky P. et al. (2007). These ideas paved the way for modern applications of artificial intelligence in educational systems.

Digital learning environments have increasingly been analyzed through the lens of AI-based learning analytics. Aldahwan and Alsaeed highlighted the potential of artificial intelligence to enhance the functionality of Learning Management Systems, demonstrating how AI-driven techniques can improve learner monitoring, support, and overall analysis within LMS platforms (Aldahwan & Alsaeed, 2020). Complementing this, Zawacki-Richter and colleagues conducted a systematic review of AI applications in higher education, identifying not only the opportunities but also ethical and methodological limitations of AI integration Zawacki-Richter O. et al. (2019).

A related line of inquiry focuses on the ontological modeling of learning processes. Capuano, Gaeta, Salerno, and Mangione proposed an ontology-based approach for context-aware e-learning, demonstrating how semantic structures can enhance the organization and adaptation of educational content (Capuano et al., 2011). This was expanded by Nazyrova et al., who investigated the consistency between prerequisites and learning outcomes across educational programs using an ontological approach Nazyrova A. et al. (2023). Together, these works suggest the value of ontology for the automated analysis and improvement of curricula.

Recent years have also seen a surge of interest in assessing and enhancing learning outcomes more broadly. Goss reviewed the literature on outcomes assessment in higher education and academic libraries, pointing to the need for systematic practices Harrold Goss. (2022). Doo and Kim conducted a meta-analysis demonstrating a significant relationship between learning engagement and learning outcomes in online higher education environments (Doo & Kim, 2024). Similarly, Akpen and colleagues provided a systematic review of online learning's impact on students' performance and engagement Akpen C.N. et al. (2024).

Within innovative instructional contexts, Alizadeh explored learner engagement and perceived learning outcomes in immersive flipped learning Alizadeh M. (2024). Alyasin and colleagues further stressed the importance of moving from fragmented practices toward systematized learning outcomes assessment Alyasin A. et al. (2023). Finally, López-Nuñez et al. carried out a systematic review of digital competence evaluation in higher education, underscoring its significance for quality assurance and sustainable educational development López-Nuñez J. et al. (2024).

Research methods. The methodological basis of the study is based on the principles of competency-based education (CBE) and constructive identification. A multi-level methodological approach was used to assess the effectiveness of the Q-Bilim system. It includes formal modeling, empirical data collection, quantitative and qualitative analysis, as well as statistical methods.

Formal modeling. The hierarchical relationships between course competencies, learning outcomes, and assessment tools were described using weighting coefficients. This structure clearly demonstrates the relationship of each learning outcome to a specific competency and allows for objective monitoring over several academic years.

Data and sampling. The empirical study was conducted in the course "Fundamentals of Databases" from 2021 to 2024. A total of 170 students were included. Three cohorts were formed and distributed approximately equally according to the three academic years. The levels of preparation of the students were different: some had basic programming skills, while others started the subject from scratch. This situation ensured the representativeness of the study, however, stratified analysis is considered as a direction for future research.

Unified rating scale. To avoid differences in interpretation, all numerical ratings (0–100) were converted into qualitative levels on a single four-point scale (Table 1). This scale was used throughout the analysis.

Table 1. Unified four-point rating scale

Score range	Quality level
90–100	Excellent
70–89	Good
50–69	Satisfactory
0–49	Needs improvement

Quantitative and qualitative analysis. Student results were presented in both quantitative and qualitative terms. Color-coded tables and charts were used to illustrate the level of mastery of competencies and learning outcomes. This approach made data easier for teachers and students to understand.

Results. Traditional analysis of variance (ANOVA) and Tukey HSD test were used to identify differences in each academic year ($p < 0.05$). In addition, regression analysis was conducted to determine the relationship between the weighting coefficients of assessment tools and the overall performance of students. In addition, cluster analysis was conducted to group students' learning trajectories, resulting in three main categories: "high achievers", "average" and "risk group".

This comprehensive methodological approach allowed, in addition to assessing the effectiveness of the system, to delve deeper into the factors influencing students' academic achievements.

General review of the Q-Bilim system. The Q-Bilim system aims to improve the assessment and monitoring process in competency-based courses. The system is built on a modular architecture and allows teachers to monitor the quality of the course over several academic years, analyze student achievement, and formally model the relationship between learning outcomes and competencies (figure 1).

Architecture of the Q-Bilim System

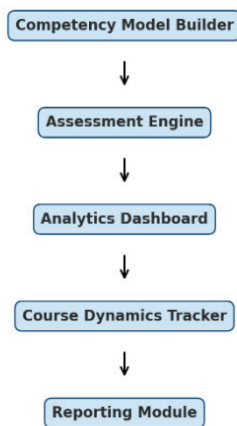


Figure 1. Architecture of the Q-Bilim System

The main feature of this structure is that it presents assessment results in both quantitative and qualitative formats. Student performance is not only presented in terms of average scores, but also in terms of qualitative levels such as "high", "average" or "insufficient". This approach makes the results understandable and easy to interpret for all stakeholders.

Regression analysis. The data collected through the system allowed us to analyze the impact of assessment weightings on student performance. As shown in Figure

2, it was observed that as the weighting ratio increased, the average performance of students also increased. This result proves that instead of distributing the importance of assessment tools equally, it is necessary to consider their contribution to the development of specific course competencies.

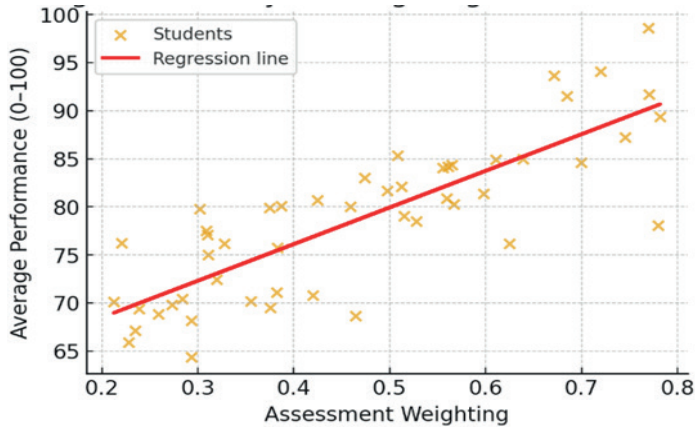


Figure 2. Regression analysis showing the relationship between assessment weightings and student performance

Cluster analysis. A cluster analysis was used to analyze individual student learning trajectories. Figure 3 identifies three main groups of students based on the results obtained for competencies C1 and C2:

- high achievers (green);
- average achievers (blue);
- at-risk (red).

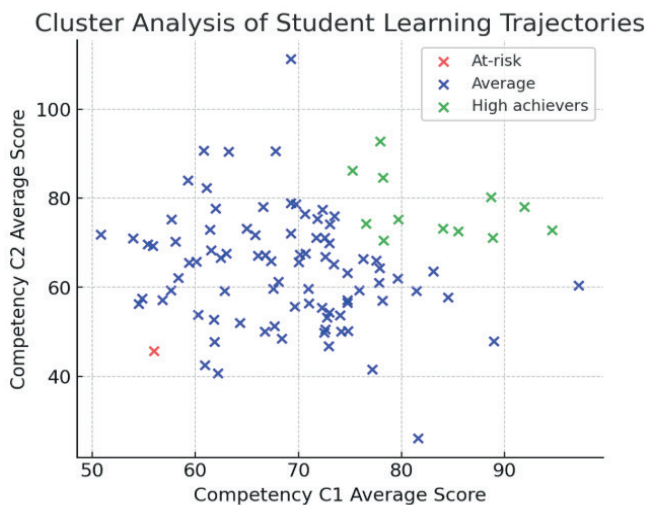


Figure 3. Cluster analysis of student learning trajectories by competencies (C1 vs. C2)

This classification allows teachers to identify students who need additional support in a timely manner. In addition, analyzing differences within groups allows for the adaptation of teaching strategies.

As shown in Figure 4, average scores for all three competencies increased steadily from 2021 to 2024. This trend suggests that curriculum adjustments and assessment changes have had a positive impact on student learning outcomes.

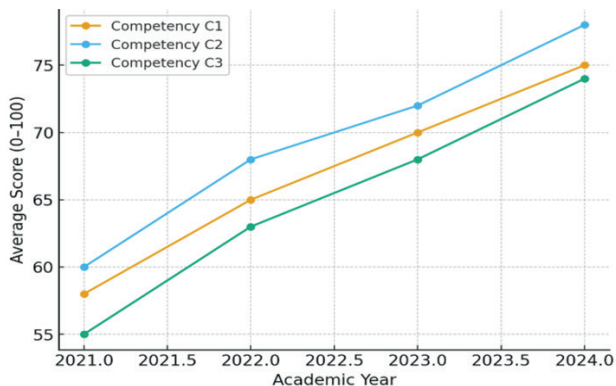


Figure 4. Dynamics of competency mastery across academic years (2021–2024)

This graph shows the change in students’ level of mastery of key competencies over time. From 2021 to 2024, there is a gradual increase in the average indicators for all competencies. Such dynamics prove the positive impact of changes introduced into the curriculum and improvements in the assessment system.

As shown in Figure 5, the distribution of student achievement across grade levels demonstrates a consistent upward trend. Box plots show a clear increase in median values and a decrease in variability, indicating greater stability in learning outcomes. Analysis of variance (ANOVA) results confirm the statistical significance of these differences ($p < 0.05$).

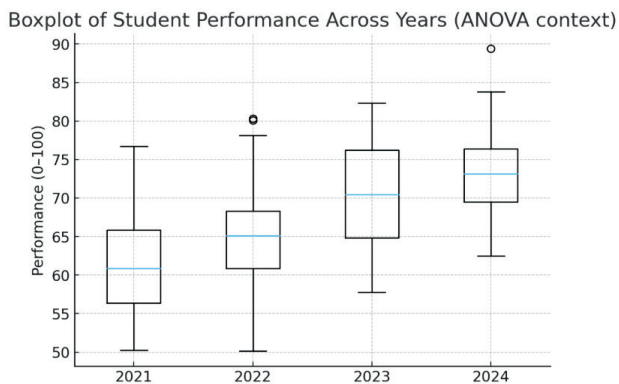


Figure 5. Boxplot of student performance distribution across years, confirming statistically significant differences (ANOVA)

This chart shows the distribution of student performance across each academic year. The boxplot format clearly shows the median, interquartile range, and outliers in student performance. The ANOVA results revealed that there were statistically significant differences ($p < 0.05$) in performance levels between 2021 and 2024. These changes confirm that academic performance has been improving over the years.

Discussion. The findings of this study demonstrate that the Q-Bilim system provides an effective framework for monitoring and assessing competency-based education (CBE). The integration of formalized competency modeling, automated data processing, and analytical visualization significantly enhances the objectivity and consistency of evaluation compared to traditional methods.

The system's ability to visualize longitudinal data enabled instructors to identify weaknesses in the curriculum and apply targeted improvements, aligning with the insights of Ifenthaler, Mah, and Yau, who emphasized the role of learning analytics in supporting study success and informing data-driven educational decisions (Ifenthaler et al., 2019).

The regression analysis further revealed that assessment weighting has a direct correlation with learning outcomes. This aligns with the insights of Romero and Ventura, who emphasized that educational data mining techniques enable the identification of key performance patterns and factors influencing student achievement (Romero & Ventura, 2020). Such findings support the idea that differentiated weighting of assessment tools—depending on their contribution to particular competencies—can lead to more balanced and fair evaluation models. Similarly, the cluster analysis offered valuable insights into individual learning trajectories, facilitating the detection of at-risk students and enabling timely, data-driven pedagogical interventions.

These outcomes align with findings from previous studies emphasizing the importance of data-driven and adaptive approaches in higher education (Zawacki-Richter et al., 2019; Capuano et al., 2011). The use of artificial intelligence and ontological modeling in Q-Bilim reflects a broader trend toward digital transformation in educational analytics and supports the concept of personalized learning pathways, as discussed by Brusilovsky and Millán (2007).

However, several limitations must be noted. The current study was limited to a single discipline (“Fundamentals of Databases”) and relied on a relatively homogeneous student population. The model could benefit from a larger and more diverse dataset to test its generalizability across different academic programs. Additionally, while Q-Bilim incorporates basic statistical analyses, further integration of advanced AI methods – such as predictive modeling and graph-based learning—could enhance its diagnostic capabilities.

Future work will focus on expanding the system's analytical modules, improving the user interface for accessibility, and integrating adaptive feedback mechanisms. The inclusion of machine learning techniques like graph neural networks (GNNs) may enable real-time recommendations for personalized learning support.

In summary, Q-Bilim demonstrates that intelligent, data-driven systems can transform the assessment of learning outcomes in competency-based education. Its implementation supports evidence-based decision-making, contributes to quality assurance in higher education, and fosters a culture of continuous improvement among both instructors and learners.

Conclusion. The study presented the architecture, core components, and implementation results of the Q-Bilim intelligent system, designed for assessing and supervising competency-based education. The system enables the structured analysis of multi-year academic data, allowing for both objective evaluation of student achievements and the monitoring of instructional quality over time. By linking competencies, learning outcomes, and assessment tools through a unified model, Q-Bilim ensures consistency, transparency, and data reliability in the evaluation process.

Key advantages of the system include its ability to align assessment criteria with defined competencies, determine achievement levels with weighted evaluation tools, and automatically translate quantitative indicators into qualitative performance categories. Furthermore, Q-Bilim provides educators and administrators with statistical and visual analytics that facilitate data-informed decision-making.

The application of Q-Bilim in the “Fundamentals of Databases” course demonstrated measurable improvement in student performance, confirmed through statistical methods such as ANOVA and Tukey’s HSD tests. This validates the system’s effectiveness in enhancing both assessment accuracy and learning outcomes.

Future research and development will focus on scaling the system to multiple disciplines and integrating advanced artificial intelligence techniques, including graph neural networks (GNNs), to enable personalized learning recommendations. Ultimately, Q-Bilim stands as a scientifically grounded, data-driven tool that contributes to the modernization and quality assurance of competency-based education.

References

- Akpen C.N., Asaolu S., Atobatele S., Okagbue H., Sampson S. (2024) Impact of online learning on student's performance and engagement: a systematic review. *Discover Education*, 3(1), 205. DOI: <https://doi.org/10.1007/s44217-024-00253-0> (in English)
- Aldahwan N., Alsaed N. (2020) Use of artificial intelligent in Learning Management System (LMS): a systematic literature review. *International Journal of Computer Applications*, 175(13). — P. 16-26. DOI: <https://doi.org/10.5120/ijca2020920611> (in English)
- Alizadeh M. (2024) Exploring engagement and perceived learning outcomes in an immersive flipped learning context. arXiv preprint arXiv:2409.12674. DOI: <https://doi.org/10.32664/ijitgeb.v6i2.155> (in English)
- Alyasin A., Nasser R., El Hajj M., Harb H. (2023). Assessing Learning Outcomes in Higher Education: From Practice to Systematization. *TEM Journal*, 12(3). DOI: <https://doi.org/10.18421/TEM123-41> (in English)
- Brusilovsky P., Millán E. (2007) User models for adaptive hypermedia and adaptive educational systems. In *The adaptive web: methods and strategies of web personalization.* — P. 3-53. Berlin,

Heidelberg: Springer Berlin Heidelberg. DOI: https://doi.org/10.1007/978-3-540-72079-9_1 (in English)

Capuano N., Gaeta M., Salerno S., Mangione G.R. (2011, November) An ontology-based approach for context-aware e-learning. In 2011 Third International Conference on Intelligent Networking and Collaborative Systems. — P. 789-794. IEEE, DOI: <https://doi.org/10.1109/INCoS.2011.53> (in English)

Doo M.Y., Kim J. (2024) The relationship between learning engagement and learning outcomes in online learning in higher education: A meta-analysis study. *Distance Education*, 45(1). — P. 60-82. DOI: <https://doi.org/10.1080/01587919.2024.2303484> (in English)

Harden R.M. (2002) Learning outcomes and instructional objectives: is there a difference?. *Medical teacher*, 24(2). — P. 151-155. DOI: <https://doi.org/10.1080/0142159022020687> (in English)

Goss H. (2022). Student learning outcomes assessment in higher education and in academic libraries: A review of the literature. *The Journal of Academic Librarianship*, 48(2). — 102485 p. DOI: <https://doi.org/10.1016/j.acalib.2021.102485> (in English)

Ifenthaler D., Mah D.K., Yau J.Y.K. (2019) Utilising learning analytics for study success: Reflections on current empirical findings. In *Utilizing learning analytics to support study success*. — P. 27-36). Cham: Springer International Publishing. DOI: https://doi.org/10.1007/978-3-319-64792-0_2 (in English)

López-Nuñez J.A., Alonso-García S., Berral-Ortiz, B., Victoria-Maldonado, J.J. (2024) A systematic review of digital competence evaluation in higher education. *Education Sciences*, 14(11), 1181. DOI: <https://doi.org/10.3390/educsci14111181> (in English)

Mulder M., Weigel T., Collins K. (2007) The concept of competence in the development of vocational education and training in selected EU member states: a critical analysis. *Journal of Vocational Education and Training*, 59(1). — P. 67-88. DOI: <https://doi.org/10.1080/13636820601145630> (in English)

Nazyrova A., Milosz M., Bekmanova G., Omarbekova A., Mukanova A., Aimicheva G. (2023) Analysis of the consistency of prerequisites and learning outcomes of educational programme courses by using the ontological approach. *Applied Sciences*, 13(4), 2661. DOI: <https://doi.org/10.3390/app13042661> (in English)

Romero C., Ventura S. (2020) Educational data mining and learning analytics: An updated survey. *Wiley interdisciplinary reviews: Data mining and knowledge discovery*, 10(3), e1355. DOI: <https://doi.org/10.1002/widm.1355> (in English)

Zawacki-Richter O., Marín, V.I., Bond M., Gouverneur F. (2019) Systematic review of research on artificial intelligence applications in higher education—where are the educators?. *International journal of educational technology in higher education*, 16(1). — P. 1-27. DOI: <https://doi.org/10.1186/s41239-019-0171-0> (in English)

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ISSN2518-1726 (Online),

ISSN 1991-346X (Print)

Ответственный редактор *А. Ботанқызы*

Редакторы: *Д.С. Аленов, Т. Апендиев*

Верстка на компьютере: *Г.Д. Жадырановой*

Подписано в печать 22.12.2025.

Формат 60x881/8. Бумага офсетная.

Печать –ризограф. 20,0 п.л. Заказ 4.