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DIGITAL SCREENING AND MONITORING OF LEARNING DYNAMICS AMONG STUDENTS WITH SPECIAL EDUCATIONAL NEEDS IN NATURAL SCIENCE EDUCATION

This study tackles the need for objective assessment of learning dynamics among students with special educational needs (SEN) in inclusive education in Kazakhstan. Conventional summative and criteria-based assessment mainly records outcomes. They often do not capture individual learning pace, cognitive demand, recurring error patterns, or the degree of independence demonstrated during task completion. These limitations are especially important in natural science subjects, where learners must work with abstract concepts, visual representations, formulas, and causal relationships. The purpose of the study was to develop and empirically test a model of digital screening and continuous pedagogical monitoring in inclusive sixth-grade natural science classes. The study involved 34 students with SEN and was conducted from January to May 2026. Google Classroom and electronic progress logs were used to record digital learning indicators, including task scores, completion time, number of attempts, regularity of participation, and use of learning resources. The data were evaluated using descriptive statistics, a paired-samples Student's t-test, and Pearson correlation analysis. The mean achievement score increased from 61.8% at pre-test to 76.9% at post-test, while variability decreased. The difference was statistically significant, $t(33) = 6.18$, $p < .001$. Digital task scores were strongly associated with final achievement ($r = .74$, $p < .001$), and regular task completion also showed a positive relationship with performance ($r = .66$, $p < .001$). The findings show that digital screening supports early identification of learning difficulties, timely feedback, and more flexible adjustment of individual educational trajectories in inclusive natural science education.

Keywords: inclusive education, special educational needs, digital screening, pedagogical monitoring, learning analytics, natural science education.

Introduction

Today, digital transformation and the development of an inclusive society in Kazakhstan require a new approach to learning: high-quality knowledge needs to be accessible to every child. This task is most difficult to implement when teaching natural science subjects to students with special educational needs (SES). Such subjects require developed abstract and logical thinking, as well as the ability to build causal relationships, which often causes cognitive difficulties in children.

Although the updated content of education and criteria-based assessment (summative assessment for a unit and for a term) are actively applied in the republic's schools, they still record only the final result. The learning process itself falls out of the teacher's field of vision. Traditional control does not allow you to notice in time how fast the child is learning the material, how he copes with the cognitive strain, where exactly he makes mistakes, and how independent he is in his work.

The paradox of the modern school is that the mass introduction of virtual platforms (LMS) has been reduced to formal accounting of academic performance. The powerful analytical potential of IT tools is practically not used for pedagogical diagnostics and flexible configuration of the educational process. As a result, there is an obvious gap between technologic capabilities and real inclusive practices [1].

This conclusion is supported by recent research in Learning Analytics, which indicates that educational platforms collect substantial volumes of digital data. However, this data is rarely used to identify learning difficulties faced by students with disabilities and special educational needs in a

timely manner. Instead of facilitating pedagogical decision-making, the analytical capabilities of learning management systems (LMSs) tend to focus more on administrative monitoring and the recording of learning outcomes [2, 3].

Creating evidence-based digital screening and continuous assessment models helps solve this problem. By tracking the student's "digital footprint", the teacher can quickly interpret the data and instantly adjust the individual educational route [4]. This approach alters evaluation from a statement of fact into a living, formative tool. This is critically important when reviewing complex natural sciences. In this context, the integrative course "Natural Science" in the 6th grade becomes a key propaedeutic basis that prepares students with SEN for further development of isolated disciplines-chemistry, physics, and biology.

Recent research in Educational Data Mining and Learning Analytics has shown that analyzing students' digital footprints allows us to identify consistent patterns of errors, predict academic risks, and effectively adapt the educational process to meet individual students' needs in a timely manner [3].

Research relevance. The contradictions outlined above show that equal access to complex subject knowledge isn't merely a declarative goal and a major challenge for modern schools in Kazakhstan. Natural science subjects are particularly demanding for students with SEN because they involve abstract concepts, formulas, visual models, and complex causal relationships. If the dynamics of a learner's cognitive difficulties are not identified at an early stage, subsequent study of separate disciplines such as chemistry, physics, and biology may become substantially more difficult.

A major hindrance to effective inclusion is the "blind spot" in conventional assessment. Summative assessment for a unit and for a term records whether a learner has achieved the expected result, but it provides limited information about the learning process itself. For students with SEN, teachers need to understand how quickly fatigue develops, how rapidly didactic units are mastered, where reasoning breaks down, when assistance is required, and when a learner can work independently.

This creates an urgent need to move from slow control to adaptive digital technologies. Automated digital screening can continuously record a learner's digital footprint during task performance, permitting teachers not only to identify existing gaps and also to anticipate emerging difficulties and adjust an individual educational trajectory before persistent underachievement or learning stress develops.

Analysis of the level of research of the problem. Issues of inclusive education and the use of digital technologies in pedagogy are in the focus of attention of both domestic and foreign researchers.

The theoretical and methodological foundations of the development of inclusive education in Kazakhstan, as well as issues of personnel training and psychological and pedagogical support for students with SEN, are described in detail in the works of Kazakhstani scientists. In particular, the works of Z. A. Movkebayeva, G. A. Abayeva, and B. A. Dyusenbayeva [5, 6, 7] substantiate the concept of individualization of the educational process, reveal approaches to the decomposition of professional competencies of special teachers, and point out the critical importance of creating an modifiable educational environment.

Monitoring aspects and problems of implementing digital tools in Kazakhstani schools is considered in the research of K. M. Berkimbayev[8], who points out the demand for a comprehensive digital transformation of student knowledge control.

In the near abroad, the problems of special pedagogy and differentiation of training are actively developed by N. M. Nazarova and O. I. Kukushkina [9]. Researchers of the Institute of Correctional Pedagogy substantiate the concept of "scaffolding tools", proving that computer technologies can act as cognitive supports for children with mental and speech disorders.

The next stage in the development of this research area involved the application of Learning Analytics technologies focused on analysing digital data generated during the educational process to personalise learning. In their review, C. Baek and S. J. Aguilar analysed publications on Learning

Analytics from 2011 to 2020 concerning students with disabilities and special educational needs. The authors found that only about one-third of the studies directly focused on this group of learners, whereas most addressed the early identification of learning difficulties, the prediction of educational risks, the accessibility of digital educational technologies, and support for pedagogical decision-making. The researchers emphasise the need to develop specialised Learning Analytics models that account for the specific characteristics and needs of students with special educational needs and facilitate timely pedagogical intervention [10].

In foreign countries, there is an exponential growth in the number of publications devoted to the use of intelligent adaptive systems (Intelligent Tutoring Systems) in inclusion. According to a systematic review by T. A. Mikropoulos and G. Iatraki, digital technologies are an effective means of supporting the learning of students with special educational needs in the study of natural science disciplines. Their use contributes to improving academic results, increasing student motivation and involvement, and creating conditions for objective monitoring of their educational achievements [11].

These findings are further supported by the systematic review and meta-analysis conducted by S. E. Wilson, W. J. Therrien, and colleagues, which examined the effectiveness of Inquiry-Based Science Instruction for students with disabilities and special educational needs in science education. Based on an analysis of 26 empirical studies, the authors found that the use of inquiry-based teaching methods, combined with pedagogical support, content adaptation, and cognitive scaffolding, contributes to statistically significant improvements in students' subject knowledge and inquiry skills. At the same time, the authors emphasize that sustainable educational outcomes can be achieved only through systematic monitoring of learning progress and timely adjustment of pedagogical support. This confirms the relevance of developing digital tools for screening and monitoring the learning progress of students with special educational needs [12].

A systematic review by García Terceño and Greca analyzed 27 studies on science education for students with special educational needs. The authors found that the most effective approaches were learner-centered and combined inquiry-based learning, hands-on activities, content adaptation, and explicit instruction. They further highlighted the limited evidence base and the need for evidence-based models for assessing achievement and monitoring educational progress among students with SEN [13]. Wade et al. presented evidence-based recommendations for digital monitoring of Individualized Education Program (IEP) goals in distance learning. Their model included electronic forms, mobile applications, videoconferencing platforms, and online services for collecting and analyzing achievement data and supporting collaboration between teachers and families [14].

The evidence base on Learning Progress Monitoring (LPM) is further summarized in the meta-analysis by Fuchs, Radkowsch, and Sommerhoff [15]. Their findings are particularly relevant to the present study because they demonstrate that regular collection and analysis of achievement data can support timely pedagogical assistance and alteration of the learning process.

The literature review reveals two central contradictions. At the theoretical and methodological level, the recognized need to individualize the education of students with SEN is not yet supported by clearly validated digital markers capable of measuring learning microdynamics in real time. At the practice-oriented level, the rapid introduction of instructional platforms in Kazakhstan is not matched by a sufficient number of adapted digital screening methods for natural science subjects that take into account individual educational needs.

The identified research gap is that most digital assessment systems are designed for typically developing learners. In contrast, foreign adaptive systems are not sufficiently aligned with Kazakhstan's curricula and criteria-based assessment framework.

The object of the study is the process of teaching natural science subjects to students with special educational needs in inclusive education. The subject of the study is a pedagogical model of digital screening and monitoring of learning dynamics among students with SEN in natural science education.

The study attempts to theoretically substantiate, develop, and experimentally test the effectiveness of the digital screening and persistent monitoring model designed for optimizing the teaching of natural science subjects to school students with SEN.

The objectives were: (1) to identify cognitive barriers experienced by students with SEN when mastering natural science concepts; (2) to determine digital markers reflecting learning dynamics, including completion time, error patterns, attempts, and use of hints; (3) to develop and implement adapted digital tasks; and (4) to assess the effect of continuous digital monitoring on science achievement and learning dynamics.

The scientific novelty of the study lies in the operationalization of learning dynamics utilizing a set of digital markers and in their embedding into a continuous monitoring model adapted to inclusive sixth-grade natural science education. The practical significance lies in the possibility of using this model for early identification of learning difficulties and timely adjustment of individual educational trajectories.

Research materials and methods

The research intends to develop and test a model for digital screening and monitoring the learning dynamics of students with special educational needs (SEN) when studying subjects of the natural science cycle. The methodological basis of the study is competence-based, system-activity, all-encompassing and data-oriented approaches that consider digital educational technologies as a tool for objective assessment and monitoring of individual educational progress of students.

To achieve this goal, a set of complementary theoretical and empirical research methods was used.

Theoretical methods included analysis, synthesis, comparison, generalization, and systematization of domestic and foreign scientific publications indexed in the Scopus and Web of Science databases on digital assessment, learning analytics, Learning Progress Monitoring, digital screening, and training of students with special educational needs. The analysis of scientific literature allowed us to identify current trends in the use of digital technologies for diagnostics and supervision of students' educational achievements.

The empirical part of the study was conducted in general education schools in Pavlodar, with the participation of sixth-grade students who study the natural science "Natural Science", which is a prerequisite for the disciplines of biology, physics, and chemistry. The study involved 34 students with special educational needs who have the results of psychological, medical, and pedagogical consultation (PMPK) (on which our attention was focused). The study was conducted between January and May 2026.

Digital monitoring was implemented through Google Classroom and Kundelik.kz, supplemented by digital diagnostic tasks and electronic progress logs.

The study recorded indicators of students' learning activity, including the results of performing diagnostic tasks, the number of correct answers, the time required to complete tasks, the frequency of access to digital educational resources, the number of attempts to complete tasks, and the dynamics of learning material development.

The data were examined using IBM SPSS Statistics. Mean values (M), standard deviations (SD), and medians (Me) were calculated to describe the sample. The statistical significance of pre-test and post-test differences was assessed using a paired-samples Student's t-test. Pearson correlation analysis was used to examine relationships between digital monitoring indicators and learning results. Statistical significance was set at $p < .05$.

The reliability of the research results was ensured by the integrated use of qualitative and quantitative methods of analysis, comparison of data from various sources, as well as compliance with uniform conditions for digital diagnostics and observation of students' educational achievements.

The study followed a one-group pre-test–post-test design. The intervention consisted of regular digital diagnostic tasks, automated recording of task-performance indicators, and teacher feedback

based on the collected data. The same assessment framework was applied at baseline and at the final stage to ensure comparability of the results.

Results and discussion

The study involved a group of 34 students with special educational needs. The study aimed to determine the dynamics of the development of the knowledge component when using an electronic educational platform in the learning process.

At the first stage, digital screening was conducted to determine the initial level of sixth-grade students' mastery of the subject "Natural Science," identify individual learning difficulties, and establish a baseline for subsequent monitoring. Design of the pedagogical experiment:

Students with SEN (n = 34)



PRE-TEST (baseline assessment)



DIGITAL MONITORING INTERVENTION

Google Classroom, adapted tasks, feedback, and learning analytics



POST-TEST (final assessment)



STATISTICAL ANALYSIS (paired t-test and correlations)

Analysis of the data presented in Table 1 shows a pronounced positive dynamics of students' academic results as a result of the introduction of digital monitoring. At the stage of input diagnostics (pre-test), the average success rate for completing tasks was 61.8 %, which reflects the basic level of mastering the content of the subject "Natural Science".

Table 1 – Dynamics of students' average academic achievement (pre-test/post-test)

Stage	Period	Average score (%)
Pre-test	January 2026	61.8
Post-test	May 2026	76.9

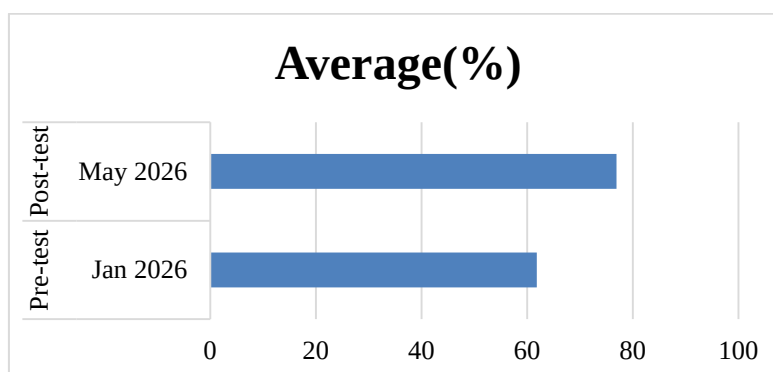


Figure 1 – Dynamics of students' average academic achievement (pre-test/post-test)

The results obtained allow us to conclude that the implemented digital monitoring model has a positive impact on students' academic performance, including in inclusive education, where individualization of the pace and trajectory of learning is especially important.

Within the framework of digital screening and monitoring of educational achievements in the Google Classroom environment, a set of diagnostic tasks on the subject of "Natural Science" was used to assess the subject knowledge, skills, and elements of educational independence of students with special educational needs. The structure of tasks included test tasks with the choice of one correct answer, tasks for establishing correspondences, short open-ended questions, as well as tasks that require analyzing visual information (diagrams, graphs) and solving simple practice-oriented learning situations. This set of tasks allowed us to assess both the reproductive level of knowledge acquisition and the basic elements of their application in academic and life contexts.

The results of the tasks were evaluated on the basis of a point-based criterion system. For test tasks, a dichotomous scale was used (1 point — correct answer, 0 points — incorrect answer). For tasks with a short and detailed answer, partial evaluation criteria were used to take into account the degree of completeness and correctness of the answer. The final result was converted to a percentage expression, which ensured comparability of data between different stages of diagnosis and the possibility of statistical processing.

The meaningful validity of evaluation tools was ensured by its development in accordance with the curriculum for natural science disciplines and the criteria for evaluating the system of summative assessment for a unit and for a term, as well as taking into account the level of cognitive goals corresponding to the Bloom taxonomy. Additionally, the tasks were evaluated by subject teachers and a specialist in special and inclusive education, after which adjustments were made to simplify the wording and reduce the mental effort for students with special educational needs.

The reliability of diagnostic instruments was ensured by preliminary pilot testing on a sample of students of a comparable level of training, which made it possible to clarify the wording of individual tasks and exclude ambiguous elements. The internal consistency of tasks was confirmed by the Cronbach coefficient, which was 0.82, denoting a high degree of reliability of the tools used. Additionally, the stability of the results was confirmed by repeated execution of individual diagnostic tasks, which showed the stability of the obtained indicators over time.

Diagnostic tools included tasks of various levels of complexity aimed at testing the assimilation of basic natural science concepts, understanding cause-and-effect relationships between natural phenomena, interpreting graphic information, and applying knowledge in practice-oriented situations. The use of the digital format provided automated registration of task results, the time of their completion, and the timeliness of sending work, which made it possible to obtain objective quantitative indicators of each student's educational activity.

At the first stage of statistical data processing, descriptive statistics were analyzed, which made it possible to assess the overall level of academic achievement of 6th grade students in the subject "Natural Science" and the degree of variability of results during digital monitoring.

The results of the input diagnostics showed that the average success rate in performing diagnostic tasks was $M = 61.8\%$ with a standard deviation of $SD = 12.4\%$, which indicates a heterogeneous level of students' training. The median value ($Me = 63.0\%$) was close to the arithmetic mean, which indicates that there is no pronounced asymmetry in the distribution of results.

After the introduction of digital monitoring on the Google Classroom system, an increase in the average level of academic achievement was noted to $M = 76.9\%$, while reducing the standard deviation to $SD = 9.1$. A decrease in the variability of results indicates a gradual leveling of students' subject preparation and a decrease in differences between students in the degree of mastering educational material. The median value also increased to $Me = 78.0\%$, which confirms the positive dynamics of the majority of study participants.

The obtained indicators allow us to conclude that the use of digital monitoring not only increased the average level of educational results, but also assisted in a more uniform development of the content of the course "Natural Science". Regular feedback, timely identification of

educational difficulties, and the possibility of prompt adjustment of educational tasks created conditions for improving the effectiveness of the educational process.

Table 2 – Descriptive statistics of the results of digital screening and monitoring of scholastic performance of 6th grade students in the subject "Natural Science" (n = 34)

Table 2 – Descriptive statistics of digital screening and monitoring results (n = 34)

Indicator	n	Min	Max	M	SD	Me
Pre-test	34	35	86	61.8	12.4	63.0
Post-test	34	55	95	76.9	9.1	78.0

Note – M = arithmetic mean; Me = median; SD = standard deviation.

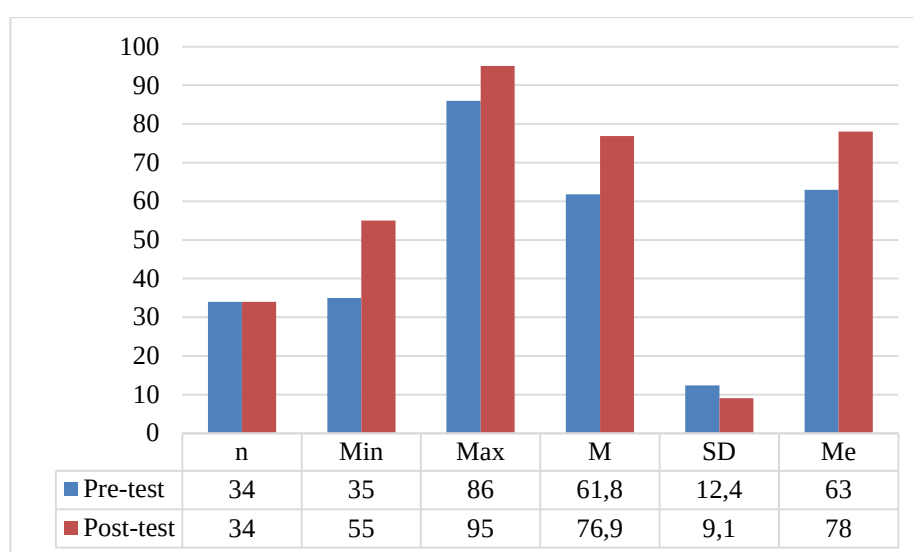


Figure 2 – Descriptive statistics of digital screening and monitoring results (n = 34)

The increase in the minimum score from 35% to 55% suggests that the most noticeable positive changes occurred among students who experienced the greatest difficulties in studying natural science. At the same time, an increase in the maximum result to 95% indicates the preservation of high educational motivation and success among students with an initially high level of training.

To evaluate the effectiveness of digital screening and learning-dynamics monitoring, a paired-samples Student's t-test was used to determine whether the pre-test and post-test results of the same group differed significantly.

The results of the analysis showed a statistically significant increase in the level of educational achievements after the introduction of digital monitoring. The average success rate of diagnostic tasks increased from $61.8 \pm 12.4\%$ to $76.9 \pm 9.1\%$.

The Student's t-test yielded $t(33) = 6.18$, with $p < 0.001$, indicating a high probability that the identified differences are due to the introduction of digital monitoring rather than random factors.

Thus, the null hypothesis about the absence of differences between the results of input and final diagnostics was rejected, and the alternative hypothesis about the positive effect of digital monitoring on learning outcomes was statistically confirmed.

The results obtained indicate that the systematic use of the Google Classroom tool for arranging digital screening, regular diagnostics, and prompt feedback contributes to improving the quality of learning material for 6th grade students. A particularly noticeable positive trend was

observed among students who experienced difficulties in studying the subject "Natural Science", which confirms the effectiveness of using digital technologies to individualize the educational process.

Table 3 - Results of checking the statistical significance of differences (paired Student's t-test)

Table 3 – Paired-samples Student's t-test results

Indicator	Before monitoring (M ± SD)	After monitoring (M ± SD)	t	df	p
Task completion success, %	61.8 ± 12.4	76.9 ± 9.1	6.18	33	< .001

The results of the study showed the presence of statistically significant relationships between the studied variables.

A strong positive correlation was found between the average score on digital diagnostic tasks and students' final academic performance ($r = 0.74$; $p < 0.001$). This indicates that students who perform better in digital tasks tend to have higher final scores in the subject of "Natural Science".

There was also a moderate negative correlation between task completion duration and academic achievement ($r = -0.52$; $p = 0.002$), which indicates that more successful students complete tasks faster and more efficiently.

In addition, a moderate positive correlation was found between the regularity of completing tasks in Google Classroom and overall scholastic performance ($r = 0.66$; $p < 0.001$), which confirms the importance of systematic learning activities for advancing educational outcomes.

Table 4-Results of Pearson correlation analysis

Table 4 – Pearson correlation analysis results

Indicator	r	p	Interpretation
Digital task scores ↔ overall performance	0.74	< .001	Strong positive relationship
Completion time ↔ performance	-0.52	.002	Moderate negative relationship
Regularity of completion ↔ performance	0.66	< .001	Moderate positive relationship

Summarizing the results of the study shows that the introduction of digital screening and systematic monitoring of the learning performance of 6th grade students in the subject "Natural Science" based on the Google Classroom framework has led to continual positive changes regarding educational results.

Descriptive statistics indicate an increase in the average level of academic achievement, a decrease in the variability of results, and a leveling of individual indicators of students, including students with special educational needs. This indicates a more uniform development of educational material and an increase in the overall effectiveness of the educational process.

The paired-samples t-test confirmed statistically significant differences between baseline and final assessment, supporting a positive association between the digital monitoring intervention and students' learning outcomes.

Pearson's correlation analysis demonstrated significant relationships between indicators of students' digital activity (task performance, regularity of learning activities, time of completion) and

their final academic performance. The most pronounced positive relationship was established between the quality of digital tasks and the level of educational achievements, which confirms the diagnostic value of students' digital traces.

Taken together, the findings show that digital screening and monitoring in Google Classroom can be used not only to assess current knowledge but also to track learning dynamics, identify difficulties, and support individualized instruction for students with SEN.

The study examined the possibilities of digital screening and monitoring of learning dynamics among 6th-grade students studying the subject "Natural Science" using the Google Classroom interface, including students with special educational needs.

The relevance of this work is determined by the rapid digitalization of education, the growing requirements for individualization of training, and the need to move from traditional final assessment to persistent monitoring of educational progress. In the context of inclusive education, early detection of learning difficulties and prompt pedagogical support are particularly important, which is impossible without using digital tools for recording and analyzing educational data. In this regard, digital screening technologies and learning analytics are becoming a key resource for improving the quality of education and guaranteeing educational equity.

The study has several limitations. It involved a relatively small sample from schools in one city and did not include a control group. Therefore, the results should be interpreted as evidence of positive change associated with the intervention rather than as definitive proof of causality. Future studies should include larger and more diverse samples, control or comparison groups, longer monitoring periods, and predictive models based on artificial intelligence.

Conclusion

The study examined the possibilities of digital screening and monitoring the dynamics of learning among 6th-grade students studying the subject "Natural Science" using the Google Classroom interface, including students with special educational needs.

The rapid digitalization of education determines the relevance of this work, the growing requirements for individualization of training, and the need to move from traditional final assessment to continuous supervision of educational progress. In the context of inclusive education, early detection of learning difficulties and prompt pedagogical support are of particular importance, which is impossible without the use of digital tools for recording and analyzing educational data. In this regard, digital screening technologies and learning analytics are becoming key resources for improving the quality of education and ensuring educational equity.

The results of the study showed that the systematic use of digital monitoring helps increase students' educational achievement and reduce the spread of individual results, indicating more uniform development of educational material. Particularly significant changes were observed in students with special educational needs, for whom digital feedback provided more stable learning dynamics along with timely correction of learning difficulties.

Statistical analysis using Student's criterion confirmed the presence of statistically significant differences between the results of the input and final diagnostics, which shows a positive impact of digital monitoring on educational results. The data obtained confirm that the transition to the systematic use of digital assessment tools can improve the objectivity of pedagogical decisions and the effectiveness of the educational process.

Pearson's correlation analysis uncovered stable relationships between indicators of students' digital activity and their academic success. The most pronounced relationship was established between the performance of digital tasks and final academic performance, which confirms the importance of digital footprints as indicators of academic success and the potential of their use in predictive analytics.

Thus, digital screening and monitoring of learning in the Google Classroom environment is an effective tool for improving the quality of science education, giving not only an assessment of the

current level of knowledge, but also support for individual educational trajectories of students, including students with special educational needs.

The practical relevance of the study lies in the possibility of introducing the developed approach into the school education system to improve the effectiveness of teaching natural science subjects, early detection of educational deficits, and strengthening targeted pedagogical support.

The prospects for further research are related to expanding the experimental base, including control groups, as well as developing predictive analytics and artificial intelligence models to predict learning dynamics and automate educational monitoring in inclusive education.

For school practice, it is recommended that teachers use a limited set of transparent digital indicators, review them regularly, combine automated data with professional pedagogical judgment, and adapt task wording, pace, and feedback to the needs of students with SEN.

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ЖАРАТЫЛЫСТАНУ-ҒЫЛЫМИ ЦИКЛ ПӘНДЕРІН ОҚУ БАРЫСЫНДА ЕРЕКШЕ БІЛІМ БЕРУ ҚАЖЕТТІЛІКТЕРІ БАР ОҚУШЫЛАРДЫҢ ОҚУ ДИНАМИКАСЫН ЦИФРЛЫҚ СКРИНИНГТЕУ ЖӘНЕ МОНИТОРИНГТЕУ

Мақалада Қазақстандағы инклюзивті білім беру жағдайында ерекше білім беру қажеттіліктері бар (ЕББҚ) оқушылардың оқу динамикасын объективті бағалау мәселесі қарастырылады. Дәстүрлі қорытынды және критериалды бағалау көбіне соңғы нәтижені тіркейді және оқу материалын меңгерудің жеке қарқынын, когнитивтік жүктемені, қайталанатын қателерді және тапсырманы орындаудағы дербестік деңгейін толық көрсете бермейді. Бұл шектеулер абстрактілі ұғымдармен, көрнекі модельдермен, формулалармен және себеп-салдарлық байланыстармен жұмыс істеуді талап ететін жаратылыстану пәндерінде ерекше маңызды. Зерттеудің мақсаты алтыншы сыныптың инклюзивті жаратылыстану сабақтарында цифрлық скрининг пен үздіксіз педагогикалық мониторинг моделін әзірлеу және эмпирикалық тұрғыдан тексеру болды. Зерттеуге ЕББҚ бар 34 оқушы қатысты; зерттеу 2026 жылғы қаңтар-мамыр аралығында жүргізілді. Google Classroom және электрондық үлгерім журналдары арқылы тапсырма нәтижелері, орындау уақыты, әрекет саны, оқу белсенділігінің тұрақтылығы және цифрлық ресурстарды пайдалану көрсеткіштері тіркелді. Деректер сипаттамалық статистика, жұпталған Стьюдент t-критерийі және Пирсон корреляциялық талдауы арқылы өңделді. Орташа үлгерім көрсеткіші бастапқы тестілеудегі 61,8%-дан қорытынды кезеңде 76,9%-ға дейін өсті, ал нәтижелердің шашырауы азайды. Айырмашылық статистикалық тұрғыдан мәнді болды: $t(33) = 6,18$; $p < 0,001$. Цифрлық тапсырма нәтижелері мен қорытынды үлгерім арасында күшті оң байланыс анықталды ($r = 0,74$; $p < 0,001$), ал тапсырмаларды тұрақты орындау да оқу нәтижелерімен оң байланыс көрсетті ($r = 0,66$; $p < 0,001$). Нәтижелер цифрлық скрининг оқу қиындықтарын ерте анықтауға, уақтылы кері байланыс беруге және жеке білім беру траекторияларын икемді түзетуге мүмкіндік беретінін көрсетті.

Түйін сөздер: инклюзивті білім беру, ерекше білім беру қажеттіліктері, цифрлық скрининг, педагогикалық мониторинг, оқу аналитикасы, жаратылыстану-ғылыми білім беру.

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ЦИФРОВОЙ СКРИНИНГ И МОНИТОРИНГ ДИНАМИКИ ОБУЧЕНИЯ УЧАЩИХСЯ С ОСОБЫМИ ОБРАЗОВАТЕЛЬНЫМИ ПОТРЕБНОСТЯМИ ПРИ ИЗУЧЕНИИ ПРЕДМЕТОВ ЕСТЕСТВЕННОНАУЧНОГО ЦИКЛА

В статье рассматривается проблема объективной оценки динамики обучения учащихся с особыми образовательными потребностями (ООП) в условиях инклюзивного образования Казахстана. Традиционное итоговое и критериальное оценивание преимущественно фиксирует конечный результат и не всегда отражает индивидуальный темп усвоения материала, когнитивную нагрузку, повторяющиеся ошибки и степень самостоятельности учащегося. Эти ограничения особенно значимы при изучении естественнонаучных дисциплин, предполагающих работу с абстрактными понятиями, визуальными моделями, формулами и причинно-следственными связями. Цель исследования заключалась в разработке и эмпирической проверке модели цифрового скрининга и непрерывного педагогического мониторинга в инклюзивных классах шестого класса. В исследовании приняли участие 34 учащихся с ООП; работа проводилась с января по май 2026 года. С использованием Google Classroom и электронных журналов фиксировались результаты заданий,

время выполнения, количество попыток, регулярность учебной активности и обращения к цифровым ресурсам. Данные анализировались методами описательной статистики, парного t-критерия Стьюдента и корреляционного анализа Пирсона. Средний показатель успеваемости увеличился с 61,8% на входном тестировании до 76,9% на итоговом этапе, а вариативность результатов снизилась. Различия были статистически значимыми: $t(33) = 6,18$; $p < 0,001$. Между результатами цифровых заданий и итоговой успеваемостью выявлена сильная положительная связь ($r = 0,74$; $p < 0,001$), а регулярность выполнения заданий также положительно коррелировала с результатами обучения ($r = 0,66$; $p < 0,001$). Полученные данные показывают, что цифровой скрининг способствует раннему выявлению трудностей, своевременной обратной связи и гибкой корректировке индивидуальных образовательных траекторий.

Ключевые слова: инклюзивное образование, особые образовательные потребности, цифровой скрининг, педагогический мониторинг, учебная аналитика, естественнонаучное образование.

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