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ORALBEKOVA ALIYA[1], ARZYMBETOVA SHOLPAN[1], ABDULLAYEVA ZHAZIRA[1], ZHAPBAROVA GULMIRA[1], KASYMBEKOVA GULZEYNEP[2]*

[1]Tashenev University (Shymkent, Kazakhstan)
[2]General Secondary School N146 (Shymkent, Kazakhstan)

*Address of correspondence: Sholpan Arzymbetova, corresponding author, Director of the Institute of Pedagogical and Natural Sciences, Tashenev University, Shymkent City, Kunaeva 21, Republic of Kazakhstan, ORCID ID: https://orcid.org/0000-0002-5484-5936; e-mail address: science@tashenev.edu.kz

Digital Tools to Support Children with Special Educational Needs in Inclusive Education: A Mixed-Methods Study

Abstract

Introduction. Digital transformation in education creates new opportunities to support children with special educational needs (SEN/SEND) in inclusive classrooms, but the effectiveness of digital tools depends on purposeful pedagogical integration, accessibility, and collaboration with families. *Methodology and Methods.* A mixed-methods study (sequential explanatory design) with a quasi-experimental pretest–posttest non-equivalent groups design was conducted in inclusive primary school settings. Participants included 84 children with SEN, 24 educators, and 52 parents. The 12-week intervention implemented a structured toolset. Qualitative data were gathered via interviews and thematic analysis. *Results.* Compared with the comparison group, the experimental group demonstrated higher posttest outcomes, engagement, task completion, and independence. Teacher re-instruction time decreased more substantially. Subgroup gains were notable for AAC users and learners with reading/writing difficulties. Implementation fidelity was high; interviews highlighted improved accessibility and independence alongside infrastructure constraints. *Scientific novelty.* The study provides an evidence-based, school-embedded evaluation of a function-oriented digital support toolkit for SEN learners, combining effectiveness outcomes with implementation fidelity, teacher workload indicators, and home-independence data. *Practical significance.* Findings justify a scalable model for selecting and integrating digital tools by functional needs, embedding them into lesson structure and remedial support, and organizing teacher-specialist-parent collaboration to enhance participation, accessibility, and independence in inclusive education.

Keywords: inclusive education; special educational needs (SEN); assistive technology; digital tools; augmentative and alternative communication (AAC); Universal Design for Learning (UDL); primary school; learning engagement.

Introduction. In the context of the digital transformation of education, identifying effective tools to support children with special educational needs (SEN; also referred to as special educational needs and disabilities, SEND) has become increasingly important. Contemporary educational environments are progressively oriented toward inclusion, personalized learning, and equitable access to high-quality educational resources. However, in practice, children with SEN continue to face a range of barriers, including limited access to learning materials, insufficient adaptation of content and instructional approaches, a shortage of specialized pedagogical resources, and the limited readiness of educational organizations to systematically use digital technologies in remedial-developmental and instructional activities. Children with SEN include learners with diverse developmental and learning characteristics, such as hearing, vision, and speech impairments; musculoskeletal limitations; autism spectrum disorders; developmental delays; intellectual disabilities; learning difficulties; and emotional or behavioral challenges, among others. For this group of learners, flexible formats of information presentation, alternative means of communication, visual support, step-by-step task organization, an adaptive learning pace, and continuous feedback are particularly important. When guided by sound pedagogical design, digital tools can provide these conditions.

Digital technologies in inclusive education encompass a broad range of solutions, including interactive learning platforms; augmentative and alternative communication (AAC) applications; software to develop speech and cognitive skills; screen-access and speech-synthesis tools; digital trainers and game-based learning environments; distance and blended learning platforms; progress monitoring tools; and artificial intelligence (AI)-enabled systems that adapt content to a child's individual capabilities. Their potential is not limited to improving the accessibility of learning materials; they can also enhance motivation, foster independence, expand communicative opportunities, and increase family involvement in the educational process. At the same time, integrating digital tools into the support of children with SEN is not automatically effective. The impact of digital tools depends on multiple factors, including the match between a tool and a learner's specific educational needs, teachers' methodological preparedness, the quality of digital content, parents' digital competence, the availability of technical infrastructure, and adherence to pedagogical ethics, data protection, and age-appropriate use. In some cases, digital means are used formally without considering a child's individual profile, which may reduce educational benefits and even increase cognitive overload.

Therefore, the scholarly significance of this topic lies in the need for a systematic analysis of which digital tools genuinely support the educational, remedial, and social development of children with SEN; under what conditions they are most effective; and which pedagogical models for their use are most productive in inclusive practice. The practical significance of the study is associated with developing recommendations for teachers, support specialists, and parents on the informed selection and use of digital solutions in education. At the policy level, the European Agency for Special Needs and Inclusive Education (2022) frames inclusive digital education as a system-wide agenda that requires accessible infrastructure, teacher capacity building, cross-sector coordination, and learner-centered design. The relevance of the topic is determined by: (a) the increasing number of children with SEN included in mainstream and inclusive education, which requires updated pedagogical approaches and support tools; (b) the digitalization of educational environments, which opens new opportunities for personalized learning but also reveals inequalities in access to high-quality digital resources; (c) the need for evidence-based practices for digital tools in inclusive education based not only on technological novelty but also on pedagogical effectiveness; (d) the need for an interdisciplinary approach that integrates pedagogy, special education, psychology, speech and language therapy, IT solutions, and accessible learning design; and (e) teachers' and parents' demand for concrete, methodologically grounded tools that can be applied in real-world practice.

This study aims to provide a theoretical rationale and analyse the potential of digital tools to support children with special educational needs, and to identify pedagogical conditions that ensure their effective use in the educational process. To achieve this aim, the following objectives were addressed: (1) to refine the concept and functional groups of digital tools used in work with children with SEN; (2) to identify pedagogical, psychological, and organizational foundations for their use; (3) to analyses the influence of digital tools on learning motivation, cognitive engagement, communication, and independence of learners with SEN; (4) to identify risks and limitations of digital support (technical, methodological, cognitive, and ethical); (5) to justify conditions for the effective integration of digital solutions in inclusive practice; and (6) to propose directions for improving digital support for children with SEN in schools and within psychological-pedagogical support systems.

Research question. Which digital tools, and under which pedagogical conditions, most effectively support learning, communication, and development of children with special educational needs in an inclusive educational environment?

Hypothesis. The use of digital tools to support children with SEN will be pedagogically effective (reflected in increased engagement, improved accessibility of learning materials, higher-quality communication, and greater individualization of learning) provided that: (a) digital tools are selected about the child's functional profile and individual educational needs; (b) their use is integrated into lesson structure and remedial-developmental work rather than applied episodically; (c) teachers and support specialists possess methods for adapting digital content; (d) collaboration among teacher, specialist, and parent is ensured; and (e) principles of accessibility, appropriate dosing, safety, and pedagogical appropriateness are followed.

Materials and Methods. The study followed a mixed-methods approach with a predominantly quantitative component and subsequent qualitative clarification of findings (sequential explanatory design). This approach was selected because evaluating the effectiveness of digital tools for supporting children with special educational needs requires both the measurement of learning and behavioral indicators and the analysis of implementation conditions, barriers, and teachers' practices. Recent reviews in inclusive and digital education also emphasize the need to combine outcome data with implementation-process data (teacher training, infrastructure, accessibility, and organizational support) (Melo-López et al., 2025; Mukhtarkyzy et al., 2025). In addition, studies on learning analytics and intellectual/ developmental disabilities underline the importance of addressing data-related barriers, accessibility of monitoring tools, and the ethical use of analytics when digital progress tracking is applied in inclusive settings (Conde & Rodríguez-Sedano, 2024).

The empirical design was quasi-experimental, including an experimental and a comparison group, with measurements before and after the intervention (pretest–posttest non-equivalent groups design). The intervention lasted 12 weeks and was implemented in inclusive primary school classrooms, consistent with international recommendations to evaluate digital solutions in natural educational environments rather than only in laboratory settings (UNESCO, 2023; OECD, 2025).

Participants. Participants included 84 children with SEN (aged 7–11 years; M = 8.9, SD = 1.2) enrolled in inclusive classrooms; 24 educators (primary teachers, special educators/ defect ologists, and teacher assistants); and 52 parents (to provide additional assessments of home-based digital practices and the child's independence). The 24 educators were distributed equally between the study conditions: 12 educators supported the experimental classes and 12 educators supported the comparison classes. Each educator provided one aggregated teacher-level record for re-instruction time at pretest and posttest.

Children were allocated to two comparable groups: the experimental group (n = 42) received instruction with a structured set of digital support tools; the comparison group (n = 42) received standard support practices without systematic implementation of the digital toolset. Group formation was non-random and was carried out at the level of intact inclusive classroom clusters. Individual randomization of children was not applied because existing class composition, school timetables, parental consent procedures, and individual support plans did not allow reassignment of learners between classes. Experimental and comparison classes were matched before the intervention by age range, SEN profile distribution, baseline engagement, task completion, and availability of standard support; therefore, the design should be interpreted as a matched non-randomized quasi-experiment with non-equivalent groups.

The sample included children with a range of educational needs (including speech and language difficulties, autism spectrum disorders, reading/writing difficulties, ADHD, mild intellectual disabilities, and sensory limitations when appropriate accommodations were available). This decision was intentional: contemporary research suggests that digital support in inclusive settings is most effectively analyzed through the lens of variability in needs and customization to the learner's profile rather than solely by diagnostic category (CAST, 2024; UNESCO, 2023). The intervention was based on the principles of accessibility, individualization, Universal Design for Learning (UDL), and pedagogical augmentation rather than technological replacement of the teacher. This aligns with the international agenda on digital inclusion, which emphasizes that technologies strengthen pedagogical practices rather than serve as stand-alone solutions for inclusion (UNESCO, 2023; WHO, 2024).

The following categories of tools were used:

1) augmentative and alternative communication (AAC): pictographic communicators; applications for symbol selection and speech output;

2) reading and writing support: text-to-speech; speech-to-text; apps with adaptive difficulty levels; visual highlighting; font and contrast adjustments;

3) organization and self-regulation: visual schedules; timers; step-by-step checklists; digital reminders and prompts;

4) interactive learning materials: multimodal tasks (text + audio + image); short interactive exercises with immediate feedback;

5) teacher tools: templates for adapting materials; digital monitoring of task completion; observation and progress logs.

The toolset was selected based on each child's functional needs and was agreed upon with the teacher and parent. This approach is consistent with evidence showing that assistive technologies are effective when individually configured and pedagogically integrated (Alsolami, 2022; Erdem, 2024; Pang et al., 2025). For learners on the autism spectrum, prior meta-analytic evidence on iPads/tablets has also shown positive academic effects, which supports the inclusion of structured tablet-mediated tasks when they are linked to individual learning goals (Aspiranti et al., 2020).

Data collection procedure. Data were collected in three stages:

Stage 1. Preparatory (2 weeks): obtaining informed parental consent; teacher briefing; initial assessment of the school's digital environment accessibility; individual tool configuration; pilot testing of observation protocols.

Stage 2. Main (12 weeks): regular use of digital tools during lessons (at least 3 times per week); weekly observation of learning activity and participation; data recording by teachers and the researcher; intermediate meetings with teachers (every 2 weeks) to check implementation fidelity (adherence to the intervention protocol).

Stage 3. Final (1 week): repeated measurements for all quantitative indicators; semi-structured interviews with teachers (n = 24); focus interviews with a subsample of parents (n = 16); collection of qualitative descriptions of successful and challenging cases. The 16 parents invited to the qualitative component were selected through purposive maximum-variation sampling from the total parent sample: 8 parents from the experimental group and 8 from the comparison group. Selection criteria included the child's age, type of SEN, baseline home-learning independence, and level of home digital-tool use. Interviewed and non-interviewed parents were compared by group membership, child age, SEN profile, and baseline parent-rated independence; no statistically significant differences were found (Fisher's exact test or Mann-Whitney U test, $p > .05$).

Data analysis technique. Measures included: learning engagement index (0–100), computed from an observational scale (attention to task, initiation of actions, completion of steps, response to feedback). The index consisted of four observable components scored from 0 to 25 points each; the total score ranged from 0 to 100. Internal consistency in the present sample was acceptable (Cronbach's alpha = .84), and inter-rater reliability for 25% of independently double-coded observations was ICC (2,1) = .81.

Task completion rate: proportion of learning tasks completed within the allocated time.

Independence index: number of steps completed without direct adult prompting during a standardized task. The indicator was based on a standardized eight-step learning task; 25% of sessions were independently coded by a second observer, and inter-rater reliability was ICC (2,1) = .83. Communication participation: number of communicative initiatives per session (for children using AAC and/or requiring communication support). Teacher re-instruction time: minutes per lesson, based on teachers' time logs. Teacher logs were verified against weekly observation protocols; 20% of lessons were double-checked by the researcher, with inter-rater agreement of ICC (2,1) = .86 for logged re-instruction time. Parent-rated home learning independence: a five-item parent questionnaire rated on a 1-5 scale (1 = requires constant adult support; 5 = completes home-learning tasks independently); the mean item score was used in the analysis. Internal consistency was acceptable (Cronbach's alpha = .80), and parents were encouraged to add brief explanatory comments. Qualitative data: semi-structured teacher interviews; parent interviews; researcher field notes; observation protocols for cases of successful/difficult integration. Statistical analysis included descriptive statistics (M, SD, median, IQR); distribution normality checks (Shapiro–Wilk); baseline group comparisons (t-test/Mann–Whitney U); within-group pre–post comparisons (paired t-test/Wilcoxon); between-group comparisons controlling for baseline (ANCOVA); and effect size estimates (Cohen's d, r, partial η^2). The significance level was set at $p < .05$. Child outcomes were analyzed at the child level (n = 84), parent ratings at the parent-child dyad level (n = 52), and teacher re-instruction time at the educator level (n = 24; 12 educators per condition). For the teacher-level ANCOVA, baseline re-instruction time was entered as a covariate, which produced F (1, 21) degrees of freedom.

Qualitative data were analyzed using thematic analysis with iterative coding (open coding, grouping into categories, and theme development), and themes were checked for agreement between two coders. To enhance trustworthiness, expert code reconciliation and triangulation of qualitative themes with quantitative results were used, reflecting contemporary approaches to research on digital inclusion where both outcomes and implementation conditions matter (OECD, 2024; OECD, 2025). Inter-coder agreement for the initial coding matrix was satisfactory (Cohen's kappa = .78), after which discrepancies were discussed and resolved by consensus. The study was conducted in accordance with the principles of confidentiality, voluntary participation, and risk minimization. Personal data were anonymized. When using digital tools, accessibility of interfaces, acceptable screen-time duration, digital safety, and data protection were considered. The importance of these measures is supported by international guidance on technological inclusion and digital ethics in education (UNESCO, 2023; WHO & UNICEF, 2022).

Results. 1. Baseline comparability of the groups. At the pretest stage, no statistically significant differences were found between the experimental and comparison groups on key indicators ($p > .05$): learning engagement index, task completion rate, independence index, communication participation, and parent-rated home learning independence. This allowed for subsequent analyses of pre–post dynamics and between-group differences in posttest outcomes while controlling for baseline levels.

2. Change in learning engagement. In the experimental group, the mean learning engagement index increased from 54.8 (SD = 10.9) to 68.7 (SD = 11.6). In the comparison group, the index changed from 55.6 (SD = 11.2) to 59.8 (SD = 11.5). ANCOVA controlling for pretest scores indicated a statistically significant between-group difference in favor of the experimental group: $F(1, 81) = 18.42$, $p < .001$, partial $\eta^2 = .19$.

3. Task completion rate. In the experimental group, the proportion of tasks completed within the allocated time increased from 61.3% (SD = 14.5) to 78.9% (SD = 13.7). In the comparison group, the rate increased from 62.1% (SD = 15.1) to 67.2% (SD = 14.8). The between-group difference in posttest outcomes (controlling for pretest) was statistically significant: $F(1, 81) = 16.03$, $p < .001$, partial $\eta^2 = .17$.

4. Independence in task performance. The mean independence index (number of steps completed without direct adult prompting during a standardized task) increased from 4.1

(SD = 1.6) to 6.7 (SD = 1.8) in the experimental group, and from 4.3 (SD = 1.7) to 5.1 (SD = 1.9) in the comparison group. The between-group difference in posttest outcomes was statistically significant: $F(1, 81) = 14.27$, $p < .001$, partial $\eta^2 = .15$.

5. Subgroup analysis: communication support (AAC). For the subgroup of children using AAC tools (n = 18), the number of communicative initiatives per session was analyzed. In the experimental subgroup, the median increased from 2.0 to 6.0 initiatives; in the comparison subgroup, from 2.0 to 3.0 initiatives. The difference in gain between subgroups was statistically significant (Mann–Whitney U): $U = 23.5$, $p = .018$, $r = .48$.

6. Subgroup analysis: reading and writing support. For the subgroup of children with pronounced reading/writing difficulties (n = 24), reading speed (words per minute) and the percentage of correctly completed written tasks with digital support were assessed. Reading speed increased by +14.2 words/min in the experimental subgroup and by +5.1 words/min in the comparison subgroup ($p = .012$, $d = .72$). Accuracy of written tasks increased by +16.8 percentage points in the experimental subgroup and by +7.4 percentage points in the comparison subgroup ($p = .021$, $d = .64$).

7. Teacher re-instruction time. The mean time teachers spent on repeating instructions during a lesson decreased from 31.4 min (SD = 7.8) to 22.6 min (SD = 6.9) in the experimental group. In the comparison group, it changed from 30.8 min (SD = 8.1) to 28.9 min (SD = 7.7). The between-group difference in change over time was statistically significant: $F(1, 21) = 8.91$, $p = .007$, partial $\eta^2 = .29$. The unit of analysis for this indicator was the educator (12 in the experimental condition and 12 in the comparison condition), not the individual child; therefore, the analysis used teacher-level aggregated pre/post values.

8. Parent ratings of home learning independence. On the 1–5 scale, parent-rated independence in completing home learning tasks changed as follows: experimental group: 2.6 (SD = 0.7) -> 3.5 (SD = 0.8); comparison group: 2.7 (SD = 0.8) -> 3.0 (SD = 0.8). The between-group difference in posttest outcomes (controlling for pretest) was statistically significant: $F(1, 50) = 6.34$, $p = .015$, partial $\eta^2 = .11$.

Table 1

Main quantitative outcomes (pre/post) and between-group differences

Outcome	Exp pre M (SD)	Exp post M (SD)	Δ	Comp pre M (SD)	Comp post M (SD)	Δ	ANCOVA (F, p, partial η²)
Learning engagement index (0–100)	54.8 (10.9)	68.7 (11.6)	+13.9	55.6 (11.2)	59.8 (11.5)	+4.2	$F(1,81) = 18.42$, $p < .001$, partial $\eta^2 = .19$
Task completion (%)	61.3 (14.5)	78.9 (13.7)	+17.6	62.1 (15.1)	67.2 (14.8)	+5.1	$F(1,81) = 16.03$, $p < .001$, partial $\eta^2 = .17$
Independence index (steps)	4.1 (1.6)	6.7 (1.8)	+2.6	4.3 (1.7)	5.1 (1.9)	+0.8	$F(1,81) = 14.27$, $p < .001$, partial $\eta^2 = .15$
Teacher re-instruction time (min/lesson)	31.4 (7.8)	22.6 (6.9)	-8.8	30.8 (8.1)	28.9 (7.7)	-1.9	$F(1,21) = 8.91$, $p = .007$, partial $\eta^2 = .29$
Parent-rated home learning independence (1–5)	2.6 (0.7)	3.5 (0.8)	+0.9	2.7 (0.8)	3.0 (0.8)	+0.3	$F(1,50) = 6.34$, $p = .015$, partial $\eta^2 = .11$

Table 2
Subgroup results

Subgroup/outcome	Experimental	Comparison	Statistics
AAC (n = 18): communicative initiatives per session (median)	2.0 -> 6.0	2.0 -> 3.0	U = 23.5, p = .018, r = .48
Reading/writing difficulties (n = 24): increase in reading speed (words/min)	+14.2	+5.1	p = .012, d = .72
Reading/writing difficulties (n = 24): increase in accuracy of written tasks (percentage points)	+16.8	+7.4	p = .021, d = .64

Table 3
Qualitative findings (theme frequencies) and protocol adherence

Theme (interviews)	Teacher mentions	Parent mentions
Improved accessibility of learning materials	31	18
Reduction in behavioral outbursts during transitions	22	-
Increased independence (visual prompts, timers)	27	21
Challenges sustaining tool use at home	-	19
Technical and organizational constraints	29	-

Note. Δ = change (post-test - pre-test). ANCOVA was performed, controlling for baseline (pre-test) scores. For teacher re-instruction time, ANCOVA was conducted at the educator level (n = 24; 12 per condition) with baseline teacher time as a covariate, resulting in F(1,21).

9. Qualitative findings. Thematic analysis of teacher and parent interviews identified recurring themes: improved accessibility of learning materials (mentioned 31 times by teachers and 18 times by parents); fewer behavioral outbursts during transitions between tasks (22 teacher mentions); increased child independence when using visual prompts and timers (27 teacher mentions; 21 parent mentions); challenges in sustaining tool use at home (19 parent mentions); and technical and organizational constraints (device shortages, unstable internet, limited preparation time) (29 teacher mentions).

10. Intervention fidelity. The mean implementation fidelity in the experimental group was 82% (range across classes: 71-91%). Fidelity was measured with a 12-item implementation checklist completed weekly by the researcher using classroom observations and teacher logs. The checklist covered frequency of digital tool use, match between selected tool and child's functional need, use of visual schedules/timers, AAC support where relevant, multimodal presentation of tasks, teacher monitoring, and adherence to the agreed lesson structure. Each item was scored as 0 = not implemented or 1 = implemented; the fidelity percentage was calculated as the proportion of planned protocol components completed across observed sessions. A second observer independently coded 25% of sessions, and inter-rater reliability was ICC (2,1) = .86. Most deviations were associated with device shortages on certain days, temporary teacher replacement, and unstable internet connectivity.

Discussion. The findings indicate that systematic use of digital tools in inclusive classrooms is associated with improved learning engagement, task completion, independence, and communication participation among children with SEN. The most pronounced effects were observed in subgroups where digital tools directly compensated for functional barriers: AAC for communication and text-to-speech/speech-to-text plus adaptive tasks for reading and writing. These results align with recent reviews and meta-analyses highlighting the potential of assistive technologies and multimodal digital solutions to increase participation, accessibility, and subjective well-being of learners with disabilities and SEN (Mukhtarkyzy et al., 2025; Pang & Datu, 2025). From a practical standpoint, the results are important for several reasons. First, gains in engagement and task completion reflect not merely a 'technical effect' of device use, but the pedagogical value of a structured, visually supported, and adapted learning environment. This is consistent with UDL principles, which emphasize that effective learning environments should provide multiple means of representation, engagement, and expression (CAST, 2024). Second, the reduction in teacher re-instruction time suggests a potential redistribution of pedagogical resources: the digital environment (visual prompts, step-by-step instructions, timers) takes on part of routine explanations, allowing teachers to devote more time to targeted support. In contemporary discussions of AI and digital technologies in inclusion, this scenario is considered productive: technologies reduce routine workload without replacing pedagogical interaction (OECD, 2024; OECD, 2025; Melo-López et al., 2025). Third, qualitative data suggest that the sustainability of effects depends on implementation context: device availability, teachers' digital competence, family support, and organizational readiness of schools. This conclusion is consistent with studies indicating that, even when teachers view assistive technology positively, implementation is often constrained by insufficient training, limited time, and infrastructure gaps (Alsolami, 2022; Erdem, 2024).

Interpretation in the context of international approaches. The results can be situated within a broader international agenda where digital inclusion is understood not as merely providing hardware, but as a system of solutions including accessibility of interfaces and content, pedagogical strategies, organizational regulations, workforce development, ethics, and data security. UNESCO (2023) emphasizes that educational technologies should be evaluated in terms of relevance, equity, scalability, and sustainability, rather than solely by their availability, and points to a shortage of independent evidence for the effectiveness of many EdTech solutions, making studies in real school settings particularly important. Comparative OECD evidence further shows that digital equity and inclusion depend on a coordinated policy mix that combines access to devices and connectivity with accessibility standards, teacher preparation, data governance, and targeted support for vulnerable learner groups (Gottschalk & Weise, 2023). For children with SEN, these considerations are even more salient. WHO and UNICEF report persistent global inequalities in access to assistive technology, with barriers including cost, shortages of specialists, low awareness, and fragmented support systems. Therefore, even positive local school-based intervention results should be considered together with issues of accessibility and sustainable scaling (WHO & UNICEF, 2022; WHO, 2024). The field-level significance of the Global Report on Assistive Technology has also been emphasized by Smith (2022), who presents it as an important milestone for a new era of assistive technology provision.

Limitations. Despite statistically significant results, several limitations should be noted. (1) Quasi-experimental design: lack of randomization limits causal inference; external factors cannot be fully ruled out. (2) Relatively small sample: adequate for a pilot study, but restricts fine-grained analysis by SEN category and by tool type. (3) Heterogeneity of SEN profiles: reflects real inclusive practice but complicates identification of specific mechanisms of effect. (4) Limited intervention duration (12 weeks): allows assessment of short-term dynamics but not long-term sustainability. (5) Context dependence: findings were obtained in schools with a certain level of organizational readiness and may not generalize to other contexts. (6) Partial reliance on teacher and parent ratings: despite observation protocols and triangulation, some indicators (e.g., home independence) include subjective components. More specifically, groups were formed from intact classroom clusters rather than by individual random allocation; although baseline matching reduced initial group differences, this procedure does not eliminate all selection-related threats to internal validity.

Directions for future research. Promising directions include: longitudinal studies (6–12 months or longer) to assess sustainability of academic, behavioral, and socio-communicative effects; more rigorous experimental designs in school settings (cluster randomization; stepped-wedge designs); differentiated analysis by need profiles (e.g., ASD, dyslexia, speech disorders, sensory limitations) to match tools to profiles; research on implementation fidelity and cost-effectiveness to understand the best effect-to-cost models; assessment of digital accessibility and universal design of content as independent outcome factors; and studies involving AI tools focusing on transparency, teacher control, data protection, and prevention of digital inequality (OECD, 2024; OECD, 2025; Melo-López et al., 2025). Future design iterations should also include participatory design and living-lab models, particularly when developing educational technologies for autistic learners in mainstream primary schools (Ranzato et al., 2025).

Conclusion. This study showed that systematic implementation of digital tools in inclusive educational settings can be associated with improvements in key indicators of participation of children with SEN in the learning process, including higher engagement, greater independence, increased task completion, and expanded communicative activity. The most substantial results were observed when digital tools were selected according to the child's functional needs and integrated into pedagogical practice rather than used episodically. The findings confirm that the effectiveness of digital support depends not only on the type of tool but also on the quality of pedagogical guidance, teacher preparation, organizational readiness of the school, and family participation. This supports viewing digital tools as an important component of an inclusive ecosystem rather than an autonomous solution. The practical value of the study lies in proposing an empirically grounded model for school-based implementation of digital support tools for children with SEN, aligned with principles of accessibility, individualization, and UDL. At the same time, scaling such solutions requires further research and institutional support at the level of policy, infrastructure, and workforce development.

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Information about authors:

Oralbekova Aliya, Acting Associate Professor, PhD, Director of the Department of Science and Innovation, Tashenev University, https://orcid.org/0000-0001-7724-1345, E-mail address: science@tashenev.edu.kz

Arzymbetova Sholpan, Acting Professor, Vice-Rector for Strategic Development and Science, Tashenev University, ORCID ID: https://orcid.org/0000-0001-9829-8762, Email: sh.zh73@mail.ru

Abdullayeva Zhazira, Acting Associate Professor, PhD, Head of the Center for postgraduate education, Tashenev University, ORCID ID: https://orcid.org/0000-0003-4074-4269, E-mail: jazok082@mail.ru

Zhapbarova Gulmira, candidate of pedagogical sciences, Tashenev University, Kunaeva 21 ORCID ID: https://orcid.org/0009-0002-9258-0913, email: Gulmira-71-71@mail.ru

Kasymbekova Gulzeynep, Teacher of General Secondary School No., 146, https://orcid.org/0009-0008-1372-9331, 146_jaily_mektep@mail.ru

