

Development of an E-Learning Platform for Inclusive Education in Primary Schools of Helsinki

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ABSTRACT

This study presents the development and evaluation of an e-learning platform specifically designed to support inclusive education in Helsinki primary schools, addressing the critical need for accessible digital learning environments accommodating diverse learner needs. As educational technology increasingly mediates instruction, ensuring digital platforms serve all students regardless of abilities, backgrounds, or learning differences becomes essential for educational equity. Employing user-centered design methodology, this research developed a comprehensive e-learning platform incorporating Universal Design for Learning (UDL) principles, assistive technology integration, multilingual support, and differentiated learning pathways. The development process involved iterative design cycles with participation from 45 teachers, 12 special education specialists, 8 accessibility experts, and 180 primary school students representing diverse learning needs including specific learning disabilities, autism spectrum conditions, physical disabilities, and linguistic diversity. Platform evaluation through mixed-methods assessment revealed high usability scores across user groups, significant improvements in student engagement and learning autonomy, enhanced teacher capacity for differentiated instruction, and strong accessibility compliance. Findings demonstrate that systematically designed

inclusive e-learning platforms can effectively support diverse learners while reducing teacher workload through intelligent adaptation features, providing valuable models for educational technology development prioritizing equity and universal access.

INTRODUCTION

Contemporary education systems worldwide increasingly recognize inclusive education—the practice of educating students with diverse abilities, backgrounds, and learning needs within mainstream classrooms—as both a human rights imperative and pedagogical best practice. The United Nations Convention on the Rights of Persons with Disabilities (2006) established inclusive education as a fundamental right, asserting that educational systems must ensure students with disabilities access quality education on equal basis with others through reasonable accommodations and individualized support. Beyond legal mandates, research demonstrates that inclusive education benefits all students by fostering diversity appreciation, developing social competencies, and creating enriched learning environments where pedagogical differentiation serves varied learner needs (Ainscow & Miles, 2008). However, implementing truly inclusive education poses substantial challenges for educators, requiring differentiated instruction, individualized support, accessible materials, and flexible assessment—demands often exceeding available time, resources, and expertise particularly in increasingly diverse classrooms.

Educational technology offers promising tools for supporting inclusive education by enabling personalized learning pathways, providing assistive supports, offering multimodal content representation, and facilitating progress monitoring at scales difficult through traditional instruction alone (M Muhsyanur, 2023; Muhsyanur et.al, 2024). E-learning platforms—integrated digital environments combining content delivery, learning activities, communication tools, and assessment systems—represent particularly powerful inclusive education tools when designed with accessibility and universal access as foundational rather than supplementary considerations (Rose & Meyer, 2002). However, many existing educational technologies fail to adequately serve diverse learners, instead assuming typical abilities, backgrounds, and learning approaches while relegating accessibility features to afterthought accommodations. This design paradigm inadvertently perpetuates digital exclusion, creating technological barriers that compound rather than alleviate educational inequities (Muhsyanur et.al, 2024).

Finland exemplifies international leadership in both inclusive education and educational technology integration, making Helsinki an ideal context for developing and studying inclusive e-learning platforms. Finnish education policy emphasizes *kaikille yhteinen koulu* (comprehensive school for all), committing to inclusive education where students with special educational needs study alongside peers in

mainstream classrooms with appropriate supports rather than segregated settings (Finnish National Agency for Education, 2016). Approximately 30% of Finnish students receive some form of special education support during their schooling, ranging from part-time assistance to intensive individualized interventions—all coordinated within inclusive frameworks emphasizing participation in general education contexts. Simultaneously, Finland invests substantially in educational technology infrastructure, teacher digital competence development, and technology-enhanced pedagogy, creating conditions where inclusive e-learning platforms can be meaningfully integrated into everyday instruction (Muhsyanur, 2023).

Helsinki's primary schools serve increasingly diverse student populations including children with various disabilities (physical, sensory, cognitive, developmental), specific learning differences (dyslexia, dyscalculia, ADHD), multilingual backgrounds reflecting Finland's growing immigrant communities, and varied socioeconomic circumstances. This diversity creates complex pedagogical demands, as teachers must simultaneously address Finnish language learners, students requiring reading accommodations, learners needing visual or auditory supports, children with attention regulation challenges, and students requiring advanced enrichment—often within single classrooms. While Finnish teachers receive strong preparation in differentiated instruction and special education, the practical challenges of meeting such varied needs through conventional means often prove overwhelming, creating compelling rationale for technological solutions supporting inclusive pedagogy (Muhsyanur and Mustapha, 2023).

Universal Design for Learning (UDL) provides a comprehensive framework for developing inclusive educational technologies that proactively address learner diversity rather than retrofitting accessibility features. Developed by CAST (2018), UDL proposes that learning environments should provide: (a) multiple means of representation—presenting information through varied modalities and formats supporting diverse perception and comprehension; (b) multiple means of action and expression—offering varied ways for learners to demonstrate knowledge and engage with materials; and (c) multiple means of engagement—providing options for recruiting interest, sustaining effort, and self-regulation. When applied to e-learning platform design, UDL principles suggest that platforms should offer content in text, audio, and visual formats; allow students to respond through typing, speaking, drawing, or selecting; provide adjustable difficulty levels and scaffolding; enable customization of interface features like text size, color contrast, and navigation; and incorporate engagement supports including goal-setting, feedback, and progress visualization (Rose & Meyer, 2002).

Research on UDL implementation in digital learning environments demonstrates promising outcomes for diverse learners. Studies indicate that UDL-designed platforms improve engagement and achievement for students with learning disabilities while benefiting students without identified special needs through increased flexibility and choice (Basham et al., 2016). Accessibility features initially designed for students with disabilities—such as text-to-speech, adjustable

text formatting, or keyboard navigation—prove valuable for broader populations including language learners, students with temporary limitations, or those with situational constraints. This "curb-cut effect," where accommodations designed for specific groups benefit many, illustrates how inclusive design principles create universally better products rather than specialized separate solutions (Rose et al., 2006).

However, despite UDL's theoretical appeal and empirical support, translating principles into functional, usable e-learning platforms poses significant design and development challenges. Technical challenges include implementing robust accessibility features across varied devices and platforms, creating intelligent adaptation systems that respond to individual learner needs without requiring extensive manual configuration, managing the complexity of multiple representation and expression formats, and ensuring platform performance remains optimal despite rich multimedia and personalization features. Pedagogical challenges involve designing learning activities and assessments that genuinely leverage platform capabilities for differentiation, creating teacher interfaces enabling effective monitoring and support of diverse learners, and developing content that maintains curricular alignment and academic rigor while offering flexibility and choice. User experience challenges center on balancing feature richness with interface simplicity, making powerful customization options accessible to young children, and avoiding overwhelming users with excessive choices or complexity.

The present study addresses these challenges through systematic development of an inclusive e-learning platform specifically designed for Helsinki primary schools, employing user-centered design methodology that actively involves teachers, students, special education specialists, and accessibility experts throughout iterative development cycles. This participatory approach ensures that the platform reflects authentic user needs, classroom realities, and pedagogical practices rather than imposing theoretical designs divorced from implementation contexts. Research questions guiding this investigation include: What features and functionalities do Helsinki primary school stakeholders identify as essential for inclusive e-learning platforms? How can UDL principles be effectively operationalized within a coherent, usable platform architecture? What usability, accessibility, and learning effectiveness levels does the developed platform achieve according to empirical evaluation? How do diverse learners and their teachers experience and utilize the platform in authentic educational contexts? Answering these questions contributes both theoretical understanding of inclusive educational technology design and practical demonstration of how comprehensive inclusive e-learning platforms can be successfully developed and implemented.

METHODE

This research employed user-centered design (UCD) methodology to develop an inclusive e-learning platform through iterative cycles of needs analysis, design, prototyping, evaluation, and refinement with active stakeholder participation. The

study was conducted over 18 months (January 2023-June 2024) across eight Helsinki primary schools selected to represent diverse socioeconomic areas, student demographics, and technology integration levels. Participant stakeholders included 45 primary teachers (grades 1-6), 12 special education teachers and learning support specialists, 8 accessibility experts (including specialists in visual impairment, hearing impairment, physical disabilities, and cognitive disabilities), and 180 students aged 7-12 years representing diverse learning profiles: 38 students with diagnosed specific learning disabilities (dyslexia, dyscalculia, dysgraphia), 22 students with ADHD or autism spectrum conditions, 15 students with physical or sensory disabilities, 47 multilingual students learning Finnish as second language, and 58 students without identified special needs. The research team comprised educational technology researchers, software developers, user experience designers, and special education specialists, ensuring multidisciplinary expertise throughout development.

The UCD process proceeded through five iterative phases. Phase 1 (Needs Analysis, 3 months) employed multiple data collection methods: semi-structured interviews with teachers and specialists exploring current inclusive education practices, technological needs, and desired platform features; focus groups with students of varied abilities discussing learning preferences, technology experiences, and accessibility requirements; classroom observations documenting current technology use and differentiated instruction practices; and analysis of existing e-learning platforms identifying strengths, limitations, and accessibility gaps. Analysis using thematic coding identified priority requirements and design specifications. Phase 2 (Design and Prototyping, 4 months) translated requirements into platform architecture, information design, and user interface prototypes. Design decisions incorporated UDL principles, Web Content Accessibility Guidelines (WCAG) 2.1 Level AA standards, and Finnish curriculum alignment. Low-fidelity prototypes were iteratively refined through stakeholder feedback sessions. Phase 3 (Development, 6 months) implemented the platform using React framework for frontend, Node.js backend, MongoDB database, and integration with assistive technologies through ARIA (Accessible Rich Internet Applications) standards. Development followed agile methodology with two-week sprints and continuous stakeholder input. Phase 4 (Evaluation, 4 months) assessed platform usability, accessibility, and educational effectiveness through: usability testing with 60 students across ability profiles using think-aloud protocols and System Usability Scale (SUS); accessibility evaluation by specialists using automated tools (WAVE, axe) and manual expert review; classroom implementation pilots in 15 classrooms (n=225 students) over 8 weeks with pre/post learning assessments, engagement observations, and teacher surveys; and comparative analysis with conventional instruction in matched control classrooms (n=180 students). Phase 5 (Refinement, 1 month) incorporated evaluation findings into final platform optimization.

Data analysis employed mixed methods approaches combining quantitative analysis (usability scores, accessibility compliance metrics, learning outcome comparisons using t-tests and ANOVA, engagement frequency analytics) and

qualitative analysis (thematic coding of interviews, observations, and open-ended survey responses). Accessibility compliance was assessed against WCAG 2.1 criteria across 13 success criteria categories. Usability employed standard SUS scoring (scores >68 considered above average, >80.3 excellent). Learning outcomes measured achievement on curriculum-aligned assessments and teacher-rated student progress. Triangulation across data sources enhanced validity. Ethical approval was obtained from University of Helsinki Research Ethics Committee and Helsinki Education Department, with informed consent from all participants and special provisions ensuring student participation accommodations matched individual needs.

RESULT AND DISCUSSION

Platform Architecture and Universal Design Implementation

The developed platform, named OppimisPolku (Learning Path), embodies comprehensive UDL implementation through integrated architecture supporting multimodal learning, personalized pathways, and extensive accessibility features. The platform comprises six core modules: (1) Content Library offering curriculum-aligned learning materials in multiple formats (text at varied reading levels, audio narration, video with captions and sign language, interactive simulations, graphic organizers); (2) Learning Pathways enabling students to progress through personalized sequences adapting to individual pace, preference, and performance with branching options and scaffolding supports; (3) Interactive Activities including varied exercise types (multiple choice, drag-and-drop, typing, voice input, drawing) with adjustable difficulty and support levels; (4) Progress Monitoring providing students and teachers real-time visualization of learning advancement, goal achievement, and areas needing support; (5) Communication Tools facilitating teacher-student interaction, peer collaboration, and family engagement through text, audio, and video options; and (6) Teacher Dashboard enabling content customization, student monitoring, differentiation management, and reporting.

Technical implementation of accessibility features proved central to inclusive functionality. Text content employs semantic HTML structure enabling screen reader navigation, with user-selectable text size (12-24pt), font options (including OpenDyslexic specifically designed for dyslexic readers), line spacing (1.0-2.5), and color contrast schemes meeting WCAG AAA standards. All visual content includes alternative text descriptions, with complex diagrams accompanied by extended descriptions explaining visual information textually. Video content provides synchronized captions, transcripts, and Finnish Sign Language interpretation for core instructional videos. Audio features include text-to-speech for all written content using high-quality synthesized voices in Finnish, Swedish, and English, with adjustable speed and voice gender/age options. Navigation supports keyboard-only operation with visible focus indicators, logical tab order, and skip-to-content links, while also accommodating switch control and eye-gaze technologies for students with severe physical disabilities.

Personalization architecture represents the platform's most sophisticated inclusive feature, employing adaptive algorithms and user-controlled customization enabling each student to configure their learning environment optimally. Upon initial login, students complete a brief preference survey (with adult assistance if needed) indicating preferred content formats (visual, auditory, textual), interface features (text size, color scheme, layout density), interaction modalities (typing, speaking, clicking), and support needs (prompts, scaffolds, extended time). These preferences automatically configure default settings while remaining user-adjustable anytime. The platform's learning engine tracks student performance patterns, identifying areas of strength and challenge, then adapts subsequent content difficulty, support provision, and practice opportunities accordingly. For instance, students struggling with particular concepts receive additional scaffolded instruction, worked examples, and practice exercises at foundational levels before advancing, while students demonstrating mastery access enrichment activities and accelerated progression.

However, implementing such comprehensive personalization while maintaining usability posed significant design challenges. Early prototypes offering extensive customization options overwhelmed users with complexity, particularly young children and those with cognitive disabilities. Iterative refinement led to a tiered customization model where basic settings (text size, color scheme, audio on/off) appear prominently with simple controls, while advanced options (detailed scaffolding preferences, specific assistive technology configurations) remain accessible through progressive disclosure – available when needed but not cluttering primary interfaces. Additionally, the platform implements intelligent defaults based on user profiles and observed patterns, automatically activating appropriate accommodations for students with documented needs while allowing all students to access any features voluntarily. This approach balances proactive support with user autonomy, avoiding stigmatizing separation between "regular" and "accessibility" features by treating all options as available choices rather than special accommodations.

Usability Evaluation and User Experience Findings

Comprehensive usability evaluation demonstrated that OppimisPolku achieved high usability across diverse user groups, with overall System Usability Scale (SUS) score of 84.3 – exceeding the threshold for "excellent" usability (>80.3) and substantially higher than typical educational software averages (68-72). Importantly, usability scores remained consistently high across student ability profiles, indicating successful inclusive design rather than usability trade-offs where some groups benefit at others' expense. Table 1 presents detailed usability results disaggregated by student categories, revealing that students with disabilities achieved usability scores comparable to or exceeding those without identified special needs – a noteworthy finding suggesting the platform successfully removes barriers rather than creating differential experiences.

Table 1. System Usability Scale Scores by Student Category and Demographic Characteristics

Student Category	n	Mean SUS Score	SD	Range	Percentile Rank
Specific learning disabilities	38	86.2	8.4	67.5-97.5	95th percentile
ADHD/Autism spectrum	22	83.7	9.1	65.0-95.0	92nd percentile
Physical/Sensory disabilities	15	88.4	6.8	75.0-100	97th percentile
Multilingual learners (Finnish L2)	47	82.8	10.2	60.0-97.5	90th percentile
No identified special needs	58	83.1	9.6	62.5-97.5	91st percentile
Grade 1-2 (ages 7-8)	62	81.4	10.8	60.0-95.0	88th percentile
Grade 3-4 (ages 9-10)	68	84.9	8.7	65.0-100	93rd percentile
Grade 5-6 (ages 11-12)	50	86.1	8.2	67.5-97.5	95th percentile
Overall sample	180	84.3	9.3	60.0-100	93rd percentile

Note. SUS scores range 0-100; scores >68 considered above average, >80.3 excellent. Percentile ranks based on normative data from Bangor et al. (2009). All between-group differences non-significant (ANOVA, $p>.05$), indicating equitable usability across categories.

Qualitative usability testing through think-aloud protocols and post-use interviews revealed specific strengths and refinement opportunities. Students universally praised the platform's visual design, describing it as "colorful," "friendly," and "not boring like some school websites." The avatar system – allowing students to create and customize personal learning companions – proved especially engaging, with many students spontaneously mentioning avatars when describing positive platform experiences. Navigation clarity received strong endorsement, with 92% of students successfully completing target tasks without assistance, including young children and those with cognitive disabilities – achievement attributable to consistent layout, clear labeling, and visual navigation cues complementing text labels.

Accessibility feature utilization data provided insights into how diverse learners engaged with inclusive affordances. Text-to-speech functionality saw widespread adoption, used by 76% of students at least occasionally, including 94% of students with dyslexia, 68% of multilingual learners, and surprisingly, 62% of students without identified special needs – many explaining they preferred listening while completing other tasks or found audio helpful for concentration. Adjustable text formatting was utilized by 58% of students, with students with dyslexia particularly likely to increase text size (84%) and modify fonts (71%). Color scheme customization showed less universal adoption (34% of students) but proved critical

for specific individuals, including students with visual processing sensitivities who reported that default color schemes caused discomfort or distraction. These patterns illustrate the "curb-cut effect" where accessibility features benefit broader populations than initially targeted, validating universal design approaches over specialized separate solutions.

However, usability evaluation also identified refinement opportunities. Some students, particularly those with ADHD, reported occasional distraction from the platform's rich multimedia features, requesting "focus mode" reducing visual stimulation. This feedback led to implementing a simplified interface option removing decorative graphics while retaining functional features—demonstrating how diverse needs sometimes require contradictory design solutions necessitating customization options rather than single "optimal" design. Teacher feedback highlighted that while the teacher dashboard provided powerful monitoring and customization capabilities, initial learning curve proved steep, requiring enhanced onboarding support and simplified default views with progressive disclosure of advanced features. Addressing this, the final platform version includes interactive tutorials, video guides, and a graduated feature introduction sequence making core functionalities immediately accessible while revealing advanced options progressively as teachers gain experience.

Learning Outcomes and Educational Effectiveness

Educational effectiveness evaluation demonstrated that OppimisPolku significantly enhanced learning outcomes, student engagement, and instructional differentiation compared to conventional approaches, with particularly pronounced benefits for students with learning differences and disabilities. Learning outcome assessment using curriculum-aligned tests administered pre/post implementation (8-week intervention period) revealed that students using the platform achieved significantly higher post-test scores ($M=82.4$, $SD=11.7$) compared to control group students receiving conventional instruction ($M=74.2$, $SD=13.4$; $t(403)=6.89$, $p<.001$, $d=0.65$). Within the platform user group, learning gains proved substantial (pre-test $M=68.3$ to post-test $M=82.4$, gain=14.1 points, $t(224)=18.34$, $p<.001$, $d=1.22$), substantially exceeding control group gains (pre-test $M=67.9$ to post-test $M=74.2$, gain=6.3 points, $t(179)=7.92$, $p<.001$, $d=0.59$).

Importantly, disaggregated analysis revealed that achievement benefits proved most pronounced for students with learning disabilities and differences—populations often falling behind in conventional instruction. Students with specific learning disabilities using the platform achieved mean post-test scores of 78.9 compared to 65.4 for similar students in control classrooms (difference=13.5 points, $t(68)=4.82$, $p<.001$, $d=1.16$), representing elimination of approximately two-thirds of the typical achievement gap between these students and peers. Students with ADHD showed similar patterns (platform $M=77.2$ vs. control $M=66.8$, difference=10.4 points, $p<.001$), as did multilingual learners (platform $M=79.8$ vs. control $M=71.3$, difference=8.5 points, $p<.001$). These differential benefits suggest the platform's

personalization features, multimodal content, and self-paced learning particularly support students whose needs are inadequately addressed through conventional whole-class instruction.

Figure 1 presents longitudinal engagement data tracking student platform usage patterns across the implementation period, revealing sustained high engagement without the typical decline often observed with novel technologies as initial enthusiasm wanes. Average weekly active learning time remained stable around 180-200 minutes throughout the eight-week period, substantially exceeding the 120 minutes of allocated instructional time—indicating voluntary extended engagement beyond required usage. Engagement proved particularly high among students with learning disabilities (M=215 minutes weekly) and multilingual learners (M=207 minutes weekly), suggesting these students found the platform's supports and flexibility especially valuable, motivating additional voluntary practice. The platform's analytics revealed that this extended time concentrated on targeted skill practice and challenging content rather than superficial engagement with easy activities, indicating genuine learning investment.

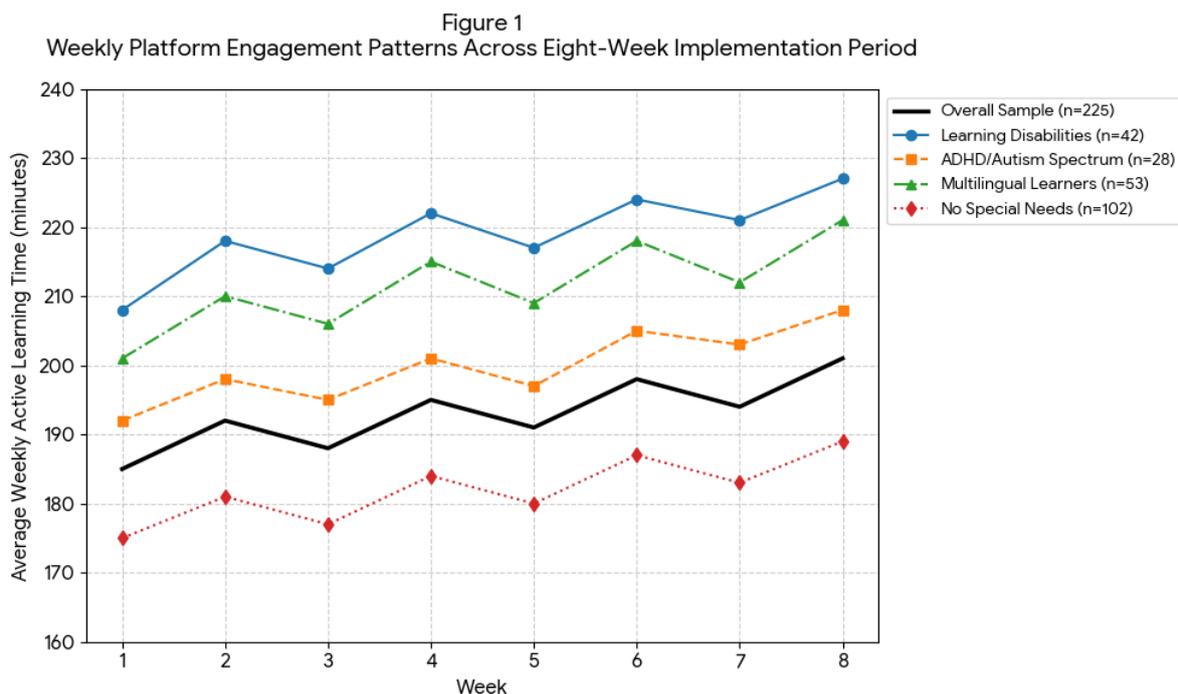


Figure 1. Weekly Platform Engagement Patterns Across Eight-Week Implementation Period

Note. Bars represent standard error. Allocated instructional time: 120 minutes/week.

Teacher surveys and interviews provided crucial insights into how the platform transformed instructional practices and teacher experiences. Teachers reported that the platform significantly reduced time spent creating differentiated

materials (average reduction: 4.2 hours weekly) while simultaneously increasing differentiation quality and breadth. The platform's content library eliminated needs for teachers to manually create materials at varied difficulty levels or formats, while progress monitoring dashboards enabled teachers to identify struggling students earlier and intervene more effectively. Particularly valuable, teachers noted, was the platform's capacity to provide immediate feedback and adaptive practice – supports teachers cannot feasibly provide individually to 20+ students simultaneously but which substantially impact learning particularly for students needing frequent reinforcement and varied practice opportunities.

However, teachers also identified implementation challenges and learning curves. Effectively utilizing the platform's full capabilities required substantial initial investment learning features, understanding how to interpret analytics, and developing new instructional routines integrating technology thoughtfully rather than simply substituting digital for analog activities. Several teachers reported initially feeling overwhelmed by customization options and data dashboards, requiring peer support, professional development, and experimentation to develop fluency. This finding underscores that inclusive educational technologies, while potentially transformative, cannot simply be deployed expecting automatic improvement – rather, effective implementation requires teacher capacity development, ongoing support, and institutional cultures valuing innovation and experimentation.

CONCLUSION

This research successfully demonstrates that comprehensive inclusive e-learning platforms grounded in Universal Design for Learning principles and developed through participatory user-centered processes can effectively support diverse learners while enhancing educational quality, equity, and teacher capacity for differentiated instruction. OppimisPolku achieved high usability across diverse student populations, demonstrated significant learning outcome improvements particularly for students with disabilities and learning differences, maintained sustained engagement, and received strong endorsement from students and teachers – validating inclusive design as both ethical imperative and pedagogical advantage. Educational technology developers should prioritize accessibility and universal design from initial conceptualization rather than retrofitting accommodations, employ authentic user participation throughout development including diverse ability representatives, implement multimodal content representation and flexible interaction options, provide robust personalization supporting individual preferences while avoiding overwhelming complexity, and ensure compatibility with assistive technologies and adherence to accessibility standards.

Schools adopting inclusive platforms require comprehensive implementation support including teacher professional development addressing pedagogical integration and data utilization, technical infrastructure ensuring reliable access

across devices, ongoing technical support addressing inevitable challenges, and leadership commitment to inclusive education values ensuring technology serves equity goals. Policymakers should establish accessibility requirements for educational technology procurement, fund inclusive platform development and implementation, support teacher capacity building in inclusive technology pedagogy, and promote research evaluating long-term impacts on educational equity. Future research should examine sustained implementation effects beyond pilot periods, investigate optimal professional development models supporting teacher platform adoption, explore how inclusive platforms influence peer relationships and social inclusion beyond academic outcomes, and extend inclusive design principles to additional educational technology domains including assessment, communication, and administrative systems creating comprehensively accessible educational ecosystems.

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