Assistive Technology for Supplementary Reading Instruction for Children with Disabilities: Current Status & Potential for Application in Practice

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# Table of Contents

[Table of Contents 2](#_Toc133559823)

[Acknowledgements 3](#_Toc133559824)

[Executive Summary 4](#_Toc133559825)

[Main Findings 5](#_Toc133559826)

[Introduction 8](#_Toc133559827)

[Research Questions 10](#_Toc133559828)

[Methodology 10](#_Toc133559829)

[Phase I: A Systematic Review of the Use of Assistive Technology to Provide Supplementary Reading Instruction for Children with Disabilities 12](#_Toc133559830)

[Method 12](#_Toc133559831)

[Phase I Results 15](#_Toc133559832)

[Summary of Findings 20](#_Toc133559833)

[Phase II: Teacher Perspectives on Assistive Technology for Supplementary Reading Instruction for children with neurodevelopmental disorders. 21](#_Toc133559834)

[Methodology 21](#_Toc133559835)

[Phase II Results 23](#_Toc133559836)

[Summary of findings 32](#_Toc133559837)

[Phase III: Student Perspectives on Literacy Instruction delivered via Assistive Technology 33](#_Toc133559838)

[Method 33](#_Toc133559839)

[Phase III Results and Discussion 34](#_Toc133559840)

[Discussion 36](#_Toc133559841)

[Research Challenges and Limitations 36](#_Toc133559842)

[Overall Key Findings and Implications 36](#_Toc133559843)

[References 40](#_Toc133559844)

[Appendices 45](#_Toc133559845)

[Appendix A - Reliability of Data Extraction Checklist 45](#_Toc133559846)

[Appendix B – Table 1. Summary of included studies evaluating AT to support literacy instruction 46](#_Toc133559847)

[Appendix C - Table 2 Description of AT Supports Used Within Included Studies 66](#_Toc133559848)

[Appendix D - Teacher Survey 84](#_Toc133559849)

[Appendix E - Child Assent and Survey 92](#_Toc133559850)

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# Executive Summary

Researchers at the University of Galway and Trinity College Dublin conducted a series of studies, funded by the National Disability Authority of Ireland, to explore the use of Assistive Technology (AT) to support reading instruction for children with neurodevelopmental disorders. The research addressed each of the following research questions:

* What ATs for supporting literacy instruction with children with intellectual disabilities (ID) and/or autistic children have been evaluated in the literature?
* Does the literature indicate that stakeholders consider AT to be acceptable and feasible for teaching literacy skills?
* What are the barriers and facilitators to incorporating AT into the classroom to support literacy instruction?
* What are the most commonly used ATs for literacy instruction with children with neurodevelopmental disorders in schools in Ireland?
* What do Irish teachers report are the benefits, limitations, and disadvantages of incorporating ATs into the classroom to supplement literacy instruction?
* Is literacy instruction using AT deemed acceptable from the perspective of children with neurodevelopmental disorders? What are their preferences and perspectives on the use of AT versus paper-based lessons?

The rationale for this research is based on the need to identify and make available the most effective and accessible teaching and learning approaches for attaining literacy skills, and in particular for children with complex learning needs. International student assessments consistently demonstrate that a proportion of children have problems with literacy attainment; however, increases in spending have not yielded substantive improvements in learning outcomes for students.

Children with complex learning needs require approaches and supports that are tailored to their needs. Incorporating Assistive Technology (AT) to supplement learning might, at least in part, offer a solution for providing a more inclusive learning environment and to assist educators to meet the needs of their learners with complex needs. However, the extent to which AT is incorporated into Irish classrooms for literacy instruction is relatively unknown. Research is necessary to better understand the current use of AT and the barriers and facilitators to adopting such methods into classroom environments to supplement literacy instruction.

The current research was conducted in three phases. Phase I consisted of a systematic review of the literature evaluating literacy interventions using AT for improving literacy skills with children with neurodevelopmental disorders. In Phase II, a survey was constructed and distributed to teachers in Ireland to explore the acceptability and feasibility of the use of AT in the classroom for literacy instruction. Barriers, facilitators, benefits and limitations, as well as the most commonly used ATs were explored. Phase III explored the preferences and perspectives on the use of AT versus paper-based lessons via a survey with children during which they took part in both formats and subsequently provided feedback to the researchers. The methodology is outlined on page 9 and in more detail each of the relevant sections below.

## Main Findings

### Phase 1 systematic literature review

Evaluations of AT to teach literacy skills demonstrate predominantly positive outcomes for children with neurodevelopmental disorders. A list of ATs evaluated in the literature reviewed, including literacy learning apps, assistive devices and assistive applications, and their characteristics are provided in Appendix C Table 2. Headsprout Early Reading was the literacy learning app most commonly evaluated in the literature (18% of studies).

The literacy interventions using AT that were included in the literature were predominantly regarded as positive by all stakeholders whose perspectives were reported. Students regularly indicated that they enjoyed using AT during literacy instruction and wanted to continue using it. Parents also had positive views on the use of AT for literacy interventions. A number of teachers reported that some aspects of incorporating AT into the classroom were time consuming (e.g., individualising items for each student) and that adopting AT in the classroom would not be effective in the absence of comprehensive training.

Eight of the 34 reviewed published studies reported barriers to adopting the use of AT in the classroom. The most common barriers were time, need for training, and resources. In three studies, teachers identified that existing technological equipment or facilities in their schools were inadequate to support the use of certain literacy interventions requiring AT.

Five of the 34 reviewed published studies reported facilitators to adopting the use of AT in the classroom. The inclusion of additional supports for students to access the AT literacy interventions was recognised as a beneficial implementation support. In contrast to the reported barrier of high costs, other studies reported that AT interventions were cost effective.

### Phase II teacher survey

A total of 54 primary school teachers’ responses were analysed in a survey exploring Irish teachers’ perspectives on AT for supplementary reading instruction for children with neurodevelopmental disorders. Most respondents (n=50) indicated that literacy goals are included in Individualised Education Plans (IEPs) for all learners in their classroom. A high proportion of respondents to the teacher survey reported using AT for children with disabilities for literacy instruction, assessment, and/or progress monitoring. Only four respondents said that they did not use AT to support literacy instruction in their classroom.

Teachers named 54 ATs including literacy learning apps and websites, assistive devices, and assistive applications used to support literacy instruction, assessment and progress monitoring. Most teachers reported the use of AT to support literacy instruction frequently with 76% reported using it daily, 14% reported using it most days (at least 3 days per week), 8% weekly, and 2% not regularly.

Respondents reported that the use of AT to support literacy instruction in their classroom is feasible (85% n=46), beneficial (96%, n=52), and useful to support literacy instruction (98%, n=53).

Most respondents (n=50) reported that there are barriers to incorporating AT into their classroom for supporting literacy instruction and/or assessment. These barriers include time, training needs, finance, lack of knowledge, lack of resources, inaccessibility to learners, learners’ lack of prerequisite skills, difficulties with devices and/or internet coverage, parents and teacher openness to the student using AT, fear of technology, AT training not being included in teacher training, and additional teacher support being required to help the learner navigate and focus on the AT.

An increase in access to continuous training in the use of AT for literacy instruction was highlighted by most teachers when asked about overcoming barriers to the use of AT. An increase in the funding available for AT was also commonly cited as a pathway to overcome barriers. Multiple teachers cited the need for reliable and sufficient internet access to support the use of AT.

Most respondents (94%) believed that there are benefits to using AT in their classroom for supporting literacy instruction and/or assessment. These benefits included increasing the intensity of instruction, increasing students’ motivation to engage with lessons, requiring less intensive support from the teacher, AT being effective and appealing to learners’ enjoyment of technology. Teachers also reported that the ability to individualize work to each learner, to facilitate special education interventions taking place in the classroom without having to withdraw learners, to facilitate learners to work at their own individual pace and level and to allow learners with additional needs to co-learn alongside typically developing peers were all very valuable. In addition, teachers liked that it allowed the teacher to assess a learner’s understanding, kept learners engaged and active, uses a multisensory modality, allowed learners to perceive it as a game rather than a lesson, and that it was child-centred, and a fun way to learn.

### Phase III pupil survey

Eight autistic students participated in a child friendly assessment of preference between AT and paper-based literacy lesson. All students indicated that they liked reading on the iPad. Seven students reported that they liked reading in the paper-based session. When offered the choice between the paper-based literacy lesson and the AT-based literacy lesson, one student selected the paper-based lesson, while seven students selected the AT literacy lesson.

Conclusion

Further work should be carried out with regard to engaging with teachers and students on the use of AT. Increased participant numbers, controlled evaluation studies and qualitative approaches are necessary to better understand efficacy, preferences, and logistical barriers regarding the incorporation of AT into classrooms to support learning. However, given the reported benefits, emerging evidence in the literature, and potential to impact intensity and effectiveness of literacy instruction, it seems that an increased focus on training and resources to improve the use of technology in the classroom for literacy instruction would be of benefit.

Recommendations

* There was not a close correspondence between the ATs evaluated in the literature for supporting literacy instruction and the ATs reported as commonly used in classrooms in Ireland. Commonly used ATs should be empirically evaluated. ATs that are recommended for use to support literacy instruction in the classroom should be informed by evidence of effectiveness.
* Large, controlled studies evaluating AT to support literacy instruction should be conducted to facilitate evidence informed decisions by teachers in classrooms.
* Stakeholder opinions on the use of AT for supporting literacy instruction are not well explored in the literature. Teacher and student perspectives on the use of AT and how it might be incorporated meaningfully into classrooms to support instruction are pivotal. Further research and engagement with stakeholders are necessary for successful integration of AT in schools.
* A number of barriers to incorporating AT to support literacy instruction were outlined by teachers including time, resources, and training needs. Teachers reported that barriers could be overcome by the provision of additional teacher training in AT as well as the provision of IT supports for schools. Additional funding for devices and reliable broadband in schools is necessary to incorporate AT successfully.
* The use of AT in the classroom could be facilitated by using software and devices that clearly support students to access the core curriculum and by the provision of additional supports and training for teachers to facilitate their students to engage meaningfully with technology.
* Given the reported benefits of incorporating AT to support literacy instruction, and the predominantly positive perspectives on AT from both teachers and students, an increased focus on training and resources to improve the use of technology for reading instruction would be of benefit in classrooms in Ireland.

**Introduction**

Learning to read is one of the most essential life skills that we can obtain in order to live a fulfilled and independent life. From the moment we start our education, we begin learning to read, from learning letter sounds, to blending and segmenting, to reading words, then passages, then books until eventually we are reading to learn. Literacy skills are a core area of learning in education that support attainment in other academic domains.

To participate fully and meaningfully in society, proficient reading skills are of the utmost importance. Health outcomes are associated with reading ability, for example, Rothman et al. (2006) investigated comprehension of food labels amongst participants with chronic illnesses and how it related to literacy and numeracy skills. They found that poor label comprehension was highly correlated with low-level literacy. Such daily routines that we take for granted, like reading and understanding nutrition labels, are extremely important for health outcomes.

Literacy skills expand opportunities for employment in later life and allow a person to access and adapt to the work environment more easily. A report from the National Literacy Trust in 2014 outlined how literacy in the UK impacts potential employment and economic outcomes as well as health outcomes and inequalities (Morrisroe, 2014). Amongst the conclusions of this report was that improvements in literacy can impact individuals and the wider society to create positive long-lasting change (Morrisroe, 2014). Morrisroe’s report focused largely on outcomes for those in areas of socioeconomic disadvantage; however, a group of people who warrant further attention with regard to literacy attainment and associated outcomes are children and adults with neurodevelopmental disorders.

Results from the Programme for International Student Assessment (PISA; OECD, 2018) consistently demonstrate problems with literacy attainment with findings in 2018 demonstrating that one in four 15-year-olds in OECD countries did not attain minimum levels of proficiency in reading. It was also reported that even though expenditure on schooling rose by more than 15% over the past decade, there had been no real overall improvements in learning outcomes for students. It’s clear that effective and accessible approaches to teaching literacy skills need to be identified for all learners. However, for children with complex learning needs, this might be more challenging and require more intensive supports (Schleicher, 2019).

Research has demonstrated significant delays in reading ability for children with neurodevelopmental disorders. Nally et al. (2018) found that amongst 126 autistic children in Ireland, all had at least one severely impaired reading component skill. Reading comprehension was the most severely impaired as well as phonological awareness with 62% scoring within the lowest possible range. Concurrent analyses revealed high inter-relationships with many components as well as language and autism severity. Low literacy levels increase the vulnerability of individuals and communities to inequality, thus increasing the risk of social exclusion (Morrisroe, 2014). The issue of low literacy levels needs to be addressed in order to provide children with neurodevelopmental disorders with equal opportunities to learn and participate fully and meaningfully in society.

Research has also demonstrated that children with neurodevelopmental disorders can attain literacy skills when provided with intensive and appropriate learning environments; however, providing such learning environments can be a challenge for educators given restraints on resources and training. Irish teachers have expressed dissatisfaction and statements of frustration with their capacity to meet the complex needs of pupils they teach (Banks et al., 2016; Horan & Merrigan, 2019).

Much evidence has demonstrated the effectiveness of incorporating AT into the learning environment in order to assist with reading instruction with children with neurodevelopmental disorders (e.g., Cerga Pashoja et al., 2019; Cullen et al., 2014; Grindle et al., 2021; Nally et al., 2021; O’Brien et al., 2018). Adding assistive technology (AT) to the classroom as learning aids represents a feasible approach to increasing intensity of individualised and effective instruction for children with neurodevelopmental disorders which may lead to a more inclusive learning environment. The 2022 World Health Organization and UN Children’s Fund report on assistive technology highlight that when AT is used and welcomed in school settings by teachers and students, pupils with disabilities are less likely to be marginalised, will achieve better educational outcomes and be presented with more opportunities for social interaction (UNICEF, 2022). The incorporation of assistive technology (AT) could support educators to meet the needs of their learners with complex needs.

Given the potential benefits of incorporating AT into the classroom, the overall aim of the current research was to explore the use of AT to provide supplementary literacy instruction for children with neurodevelopmental disorders. An initial systematic review of the literature was conducted including studies that evaluated literacy interventions using AT for children with neurodevelopmental disorders (Phase I). Literacy interventions include literacy learning apps, assistive devices, and assistive applications. The literature was summarised with respect to the types of ATs which have been used, the literacy skills that have been targeted via AT, the acceptability of those technologies, and the barriers and facilitators highlighted in the literature for using those technologies.

The extent to which ATs are incorporated into Irish classrooms for literacy instruction is relatively unknown. Phase II aimed to address this gap in knowledge by conducting a survey of Irish teachers to identify the most commonly used ATs for literacy instruction with children with neurodevelopmental disorders and the perceived barriers, facilitators, benefits, limitations, and disadvantages. Phase III of the research aimed to explore the perspectives of children with neurodevelopmental disorders with regards to literacy lessons delivered via AT.

## Research Questions

* What ATs have been evaluated in the literature for teaching literacy skills to children with intellectual disabilities (ID) and/or autistic children?
* Are ATs deemed acceptable and feasible by stakeholders in the literature evaluating their use for teaching literacy skills?
* What are the barriers and facilitators to incorporating ATs into the classroom to support literacy instruction?
* What are the most commonly used ATs for literacy instruction with children with neurodevelopmental disorders in schools in Ireland?
* What do Irish teachers report are the benefits, limitations, and disadvantages of incorporating ATs into the classroom to supplement literacy instruction?
* Is literacy instruction using AT deemed acceptable from the perspective of children with neurodevelopmental disorders? What are their preferences and perspectives on the use of AT versus paper-based lessons?

The methodology adopted to address these research questions is set out in the next chapter.

# Methodology

The following methodology was adopted to address the research questions:

* Phase 1: A systematic review of the literature evaluating literacy interventions using AT for improving literacy skills with children with neurodevelopmental disorders was conducted. Literature over the past thirty years was included and reviewed using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) as a guide. PRISMA was designed to help systematic reviewers transparently report aims and objectives of the review, the review process, and their finding (Page et al., 2021). Literature was summarised with respect to types of ATs which have been evaluated, the literacy skills that have been targeted via AT, the acceptability of those technologies, and the barriers and facilitators highlighted in the research for using those technologies.
* Phase II: A survey was constructed using Qualtrics and distributed online and directly to schools and teachers in Ireland via email. The survey instrument included a combination of closed and open-ended questions aimed at collecting the information outlined in the objectives above. Teachers were recruited via social media and direct email to complete the survey.
* Phase III: A survey of children was conducted to ascertain preferences for AT or paper-based lessons for literacy instruction. Children completed a literacy lesson using AT and a paper-based literacy lesson and provided feedback to the researcher regarding their preferences as well as what they liked and disliked about the use of AT.
* Ethical approval was obtained from University of Galway Research Ethics Committee in order to conduct the surveys targeted at teachers and children. Research information sheets and consent forms were included at the beginning of the survey questionnaire for teachers and consent obtained from each participant before they proceeded. Parental consent and child assent was obtained before proceeding with the child survey. No identifying information was collected ensuring anonymity of participants.
* Quantitative data were analysed using IBM SPSS Statistics Viewer-Version 27. Descriptive statistics including means (M) and standard deviations (SD) were calculated for continuous variables and frequency data were analysed for categorical variables. Questions which invited teachers to add additional information if they selected ‘Other’ for any question were coded in order to group and classify answers.
* A detailed description of the methodology employed within each phase is outlined in the following chapters, beginning with Phase I: A Systematic Review of the Use of Assistive Technology to Provide Supplementary Reading Instruction for Children with Disabilities.

# Phase I: A Systematic Review of the Use of Assistive Technology to Provide Supplementary Reading Instruction for Children with Disabilities

A systematic review of the literature was conducted to investigate literacy interventions using AT to supplement reading instruction for children with neurodevelopmental disorders. The DSM-5 defines Neurodevelopmental Disorders as “a group of conditions with onset in the developmental period. The disorders typically manifest early in development, often before the child enters grade school, and are characterized by developmental deficits that produce impairments of personal, social, academic, or occupational functioning” (American Psychiatric Association, 2013). Neurodevelopmental disorders encompass a wide range of diagnoses including Intellectual Disorders (ID), Communication Disorders, Autism Spectrum Disorder (ASD), Attention-Deficit/Hyperactivity Disorder, Specific Learning Disorder, Motor Disorder, Tic Disorder, and “Other Neurodevelopmental Disorders”. For this review, children with ID and autistic children were the focus.

The literature was summarised with respect to the types of ATs which have been used, the literacy skills that have been targeted via AT, the acceptability of those technologies, and the barriers and facilitators highlighted in the research for using those technologies.

## Method

### Search Procedures

Systematic searches were conducted of the following five electronic databases: Academic Search Complete (ASC), Educational Resources Information Centre (ERIC), PsycINFO, Web of Science, and Scopus. Searches were limited to published, peer-reviewed studies written in English. Search terms "computer assisted in\*" or "computer aided in\*" or “computer based in\*" or “assistive products" or "assistive technology" or "assistive device\*" or "consumer products" or "technolog\* in\*" were inputted in combination with "special education" or "autis\*" or "intellectual dis\*" or "developmental dis\*" or "learning dis\*" in combination with "child\*" and "read\*" or "literacy".

An additional combination of “barrier\*" or "facilitator\*” or "perception\*” or "perspective\*" was also added to identify literature on perspectives on AT for literacy instruction, as well as barriers and facilitators to their use. Search term combinations were used as in the table above with an additional combination of “barrier\*" OR "facilitator\*" OR "perception\*" OR "perspective\*".

### Inclusion Criteria

In order to be included in this review studies were required to meet the following criteria: (a) Studies are published in English and peer-reviewed; (b) participants were students aged 5-12 years; (c) participants had been diagnosed with ID or ASD[[1]](#footnote-2) (d) the study must have evaluated the use of AT for literacy instruction and/or explored perspectives (from teacher, parent, and child) on the use of AT for literacy instruction; (e) instruction must have been conducted in a school setting; the study was not a case study (i.e., AB designs); the study was published between 1990 and 2022.

Returned articles were then screened by title and abstract to identify studies for exclusion and remaining articles were screened by full text. The searches were conducted in February of 2022. Returns were exported to end note and screened for duplicates. Returns were then screened using Rayyan, an online screening software to ensure objectivity. See Figure 1 PRISMA flow diagram for a summary of search procedures.

**Figure 1 Summary of Search and Screening Procedures**

Summary of Search and Screening Procedures 

### Reliability of search procedures

In order to ensure the accuracy of applying inclusion and exclusion criteria, two researchers conducted the searches of each database and screened articles for inclusion independently. Each author produced a separate list of articles for inclusion and exclusion after screening articles by title and abstract, and again after screening by full text. The reliability of each stage of screening was calculated by the number of articles agreed to include and exclude over the total number of articles for which reliability searches were completed. The percentage agreement when screening by title and abstract was 81%. These reliability checks of title and abstract were done on all 526 articles. The percentage agreement when screening by full text was 96%. Reliability checks were done on 73% (n=69) of articles at this stage. Conflicts were discussed between the first and second authors until 100% agreement was reached.

### Data Extraction

Relevant information was extracted from included studies and summarised in relation to

(a) participants (number, gender, age, diagnosis);

(b) setting;

(c) study design;

(d) ATs used (description, intervention facilitator, materials required, intensity, web-based or app-based interventions, presence or absence of requirement for internet access, type of device used);

(e) dependent variable or target literacy skills (only dependent variables related to academic skills);

(f) results/outcomes

(g) social validity (i.e., qualitative data from teachers and students on their experiences of AT, acceptability, barriers and facilitators).

Qualitative and quantitative data regarding barriers and facilitators to using AT in the classroom were also extracted and summarised, as well as a comprehensive list of ATs which have been evaluated in the literature.

### Reliability of Data Extraction Procedures

An initial summary of the included studies was developed, and a second researcher used a reliability checklist to evaluate data extracted and conduct inter-rater checks of extracted information. An 18-item checklist was used to evaluate extracted data (please see checklist in Appendix A below). Items on the checklist included, for example, ‘is this an accurate description of the participants? Is this an accurate description of the dependent variable?’ Inter-rater agreement was conducted for 612 items (i.e., 34 studies with 18 checklist items per study). A calculation was conducted to determine the percentage of items agreed upon by both authors. Initial agreement was 95%, with authors meeting to discuss disagreements on 33 items until 100% agreement was achieved.

## Phase I Results

### Participants

Thirty-four studies published between 1992 and 2022 were included in the review, thirty-three quantitative and one qualitative. A total of 514 students and 109 teachers participated across the studies. Of the 109 teachers who participated across studies, 46 identified as female, five identified as male and gender was not reported for 58 teachers. Of the 514 students who participated across studies, 91 identified as female, 200 identified as male and gender was not reported for 223 students. All studies had at least one participant within the 5-12 years age range as specified in the inclusion criteria. Twelve of the 34 studies had participants outside of the 5-12 years age range. One study had students younger than age five and 11 studies had students who were older than age 12. Due to the use of group designs, the exact number of students outside of the specified age range could not be calculated nor could these students be excluded from the analysis. Age was not reported for 176 students, it was typically reported that they were school aged, or their class was reported. It was decided that those studies would be included as a number of the participants were between the ages of 5-12. Therefore, across all included studies, the age of students who participated ranged from 3-19 years old.

Just over 14% of participants had a diagnosis of autism (n=74). Over 75% percent of participants were diagnosed with ID (including LD, n=383) while almost 3% of participants had a dual diagnosis of autism and ID (n=15). For 45% (n=24) of the participants their specific neurodevelopmental disorder was unclear. Descriptions of disabilities included foetal alcohol syndrome, cerebral palsy, muscular dystrophy, significant developmental delay, other health impairments, auditory impairment, emotional disabilities, speech impairment, and vision impairment. Numerous participants presented with a range of comorbid diagnoses including Fragile X syndrome, Down’s Syndrome, Turner Syndrome and Lowe Syndrome.

### Setting and Intervention Facilitator

Twenty-six percent (n=9) of the literacy interventions were implemented within the students’ general education classroom. Twenty-six percent (n=9) were implemented in external classrooms outside of the students’ general education classroom. Just over 20% (n=7) of the literacy interventions were implemented across settings in the school (general education classrooms, external classrooms, computer lab, library). Six studies did not report the specific setting *within* the school where the literacy interventions were implemented (18%). Three studies reported that literacy interventions were implemented in other settings within the school including the library, students’ home, or a quiet room in a university (9%).

Teachers facilitated the implementation of the literacy intervention in 47% (n=16) of the studies. In five of these studies SNAs were also listed as intervention facilitators. Researchers accounted for 32% of intervention facilitators (n=11). Twelve percent of studies used other intervention facilitators including a teaching intern, Applied Behaviour Analysis tutor, therapist, and graduate assistant (n=4). Three studies did not report the intervention facilitator (9%).

### Targeted Literacy Skills

Of the 33 quantitative studies included in the review, 68% aimed to improve at least one of the five key areas for instruction when teaching children to read (n=23). Target skills were described as phonemic awareness (27%), phonics (15%), vocabulary (39%), comprehension (33%), and fluency (35%). Other variables that were evaluated related specifically to decoding (18%), student behaviour (9%), handwriting (12%), and spelling (18%).

### Literacy Interventions

Twenty-six studies used a single AT literacy intervention (77%). Three studies used more than one AT literacy intervention (9%). Five studies did not specify what AT was used (15%). Headsprout Early Reading was the literacy intervention most evaluated in the literature (18% of studies). For a full list of AT literacy interventions evaluated in the included studies, please see Table 2, Appendix C.

### Resource requirements

Only 29% of articles reported on both software and internet requirements to run the literacy intervention. Seven studies stated that the literacy intervention required internet (21%), two stated internet was not required (6%) and the remaining 25 did not report on internet requirements (74%). Seventeen studies reported that the literacy intervention studied made use of software (50%), one stated that software was not required (3%), the remaining 15 did not report on software requirements (44%). Of those studies that did report the software required (n =17), seven were web-based and seven were app-based and the remaining three involved other software.

Almost all studies reported the devices employed to deliver the AT intervention (94%). A tablet or iPad (33%) and PC (33%) were reported equally and were the most commonly employed devices. Laptops were employed in three studies. A combination of devices and other devices including Fly Pentop Computer, Videoplayer, or Lightwriter were reported in three studies each also. Combinations and other devices are outlined in detail in Table 2 in Appendix C.

### Implementation intensity

Most studies (85%; n=28) reported on the intensity with which the literacy intervention was implemented to some degree. For the purposes of this review, intensity was coded across three variables (a) minutes per session (b) number of sessions per week (c) intervention length in weeks or total number of sessions. Of the 28 studies that reported intensity 13 (46%) reported on all three intensity variables, 10 (36%) reported on two out of three intensity variables and five reported on only one intensity variable (18%). Sessions per week was the variable most commonly reported on (78%, n=22), followed by minutes per session (75%, n=21). Intervention length was the least common variable reported within 71% (n=20) of the articles that reported intensity.

The average session length reported was 24 minutes with a range of 10 to 60 minutes. The average number of sessions per week was 3.86 (whole number 4) ranging from one to five sessions. The average number of weeks the intervention was in place for was 11.59 (12) weeks ranging from 2.5 to 24 weeks. The average number of sessions the interventions were in place for was 38 ranging from three to 80 sessions. See Table 2, Appendix C for implementation intensities associated with each literacy intervention. In the case where the total number of sessions was not reported, but the number of sessions per week and the number of weeks of intervention were reported, a calculation was completed to determine the number of intervention sessions. The same approach was adopted if the number of weeks were not reported; however, the number of sessions per week were reported and the total number of intervention sessions.

### Study Design

Single case research design was the most common design employed across studies, accounting for 62% (n=21). In a single case research design, an individual acts as their own control. Their behaviour is measured before an intervention is implemented, during the intervention, and after it ends, and comparisons are made across all phases to assess the effectiveness of the intervention. Of these, 33% were alternating treatment design (n=7) and, 67% were multiple probe design (n=14). Between-subjects design was used in 18% of studies (n=6). Single group, pre- and post-test designs were used in 12% of studies (n=4). Two studies (6%). implemented a Randomised Control Trial (RCT). One study used a qualitative design (3%). Six studies included a comparison control group (18%).

### Literacy Intervention Outcomes

All quantitative studies (n=33) reported that the literacy intervention using AT produced positive changes in the targeted literacy skill. The literacy intervention resulted in favourable outcomes in both RCTs included in the review. However, only one study found the literacy intervention produced statistically significant better results, while the other showed a greater improvement in literacy skills over the control group that was not statistically significant.

The literacy intervention produced better results on outcome measures in four of the five studies that employed a between-subjects design, with three demonstrating statistically significant differences. All four studies employing single group, pre- and post-test designs reported that participants performed better post intervention, with 75% producing statistically significant outcomes. In the case of multiple baseline design, participants performed better with the AT intervention over baseline in 79% (n=11) of the studies. Of the seven studies that used alternating treatments designs to compare the effects of the AT literacy intervention to another approach, the AT intervention produced better outcomes in two (29%).

### Social Validity

Fifty six percent (n=19) of included studies evaluated social validity (i.e., the perspectives of key stakeholders on the literacy intervention - particularly its acceptability, feasibility, benefits, limitations, barriers, facilitators associated with it). Reported measures of social validity were interviews (32%, n=6), surveys (37%, n=7), questionnaires (16%, n=3), or a combination of these (11%, n=2)[[2]](#footnote-3). One study (5%) indicated that social validity was recorded but did not indicate how this was measured. Of the 19 studies that evaluated social validity, 32% of studies sought views on the acceptability of and satisfaction with AT literacy interventions from teachers (n=6), 5% sought views from teachers and paraprofessionals/SNAs (n=1), 21% sought views from students (n=4), 32% sought views from teachers and students (n=6), and 11% sought views from teachers, students, and parents (n=2).

Interventions using AT were predominantly regarded as positive by all stakeholders whose perspectives were reported. Students regularly indicated that they enjoyed using AT during literacy instruction and wanted to continue using it in this area. Many students also wanted to begin using AT in other subjects. Most teachers viewed the use of AT as a beneficial support for teaching literacy skills. It was seen as a practical, useful tool that could be used in the classroom, and several teachers indicated that they would continue the use of AT after the intervention ended or begin using it with other students. Some teachers highlighted that their students became more confident and independent in reading-related activities. However, other teachers commented that some aspects of the intervention were time consuming (e.g., individualising items for each student), or that adopting AT in the classroom would not be effective if the technology itself or how to use it during instruction was not well-explained. Studies that reported parents’ views indicated that parents were supportive of the use of AT for literacy instruction, with one parent seeking more information on the device used as she wanted her child to continue using the device outside of the study.

### Barriers to the use of AT in the Classroom

Twenty four percent (n=8) of the 34 studies reported barriers to adopting the use of AT in the classroom. Seven of those studies also evaluated an AT literacy intervention while one of the studies was a qualitative study solely investigating barriers and facilitators in relation to the use of AT (Flanagan, Bouck & Richardson 2013). The most common barrier was that the use of AT was time and resource intensive. Some literacy interventions needed to be individualised to suit each student, while others required additional time to set-up and use. Issues with technology was the next most frequently cited barrier. This refers to difficulties with internet access or connection, applications glitching on smartphones or tablets, or slow computer start-up times. Needing to undertake additional training on the use of specific AT literacy interventions, applications, or physical devices was another barrier mentioned by teachers. Several teachers identified that existing technological equipment or facilities in their schools were inadequate to support the use of certain AT literacy interventions. Other barriers reported across the studies included the high cost of implementing AT interventions, difficulty using AT (for both teachers and students), little support available on how and when to use the intervention, and lack of knowledge of the product used.

### Facilitators of the use of AT in the Classroom

Fifteen percent (n=5) of the 34 studies reported facilitators to adopting the use of AT in the classroom. Four of those studies also evaluated an AT literacy intervention while one of the studies was a qualitative study solely investigating barriers and facilitators in relation to the use of AT (Flanagan, Bouck & Richardson 2013). The addition of behavioural components to interventions, e.g., differential reinforcement, contingent reinforcement, was recognised as a beneficial implementation support. Researcher presence and fading of intervention support was also highlighted as a facilitator that maintained the use of AT in the classroom. In contrast to the reported barrier of high costs, other studies reported that AT interventions were cost effective. The ability to use AT with several students at a time, the ease of use for student and teacher, the ease of integration into instruction and the classroom at wide, familiarity with products used, and not needing much additional training were also cited as facilitators in the included studies.

## Summary of Findings

The results of the systematic literature review highlighted that the use of AT for literacy interventions positively impacted on literacy skills for children with neurodevelopmental disorders. Research was primarily carried out in schools, where school staff such as teachers, teaching interns, and tutors comprised the majority of intervention facilitators. Resource requirements were variably reported e.g., whether the intervention required use of the internet or software. Interventions involving the use of AT were viewed favourably by both students and teachers in general. Several barriers to the adoption of AT use in the classroom were noted, including hardware and software difficulties, the need for additional training for teachers, and the inadequacy of existing equipment to facilitate the use of AT interventions. Facilitators to the use of AT for literacy instruction were discussed in some studies and included the provision of additional intervention components to support engagement, initial presence of the researcher, ability to use AT with several students at once, cost effectiveness, and ease of integration of AT into the classroom.

# Phase II: Teacher Perspectives on Assistive Technology for Supplementary Reading Instruction.

Phase II explores commonly used ATs in an Irish context, as well as teacher perspectives on acceptability, feasibility, barriers and facilitators to incorporating AT to support literacy instruction in Irish classrooms. This study surveyed the use of AT to support literacy instruction with children in a sample of schools in Ireland. The survey identified the most commonly used and favoured AT used by the sample of participating teachers. These included literacy learning apps (e.g., Reading Eggs, Typingclub), assistive devices (e.g., iPad, smartpen) and assistive applications (e.g., Microsoft Excel, Apple keynote).

## Methodology

### Survey dissemination strategy

In April 2022, 2,727 primary schools across the Republic of Ireland were emailed inviting them to participate by completing the online questionnaire. Recruitment was also conducted online through three online platforms: Facebook (@ATLiteracyIrl), Instagram (@assistivetechnology\_literacy), and Twitter (@AT\_LiteracyIrl). Social media posts were supplemented with ALT text to increase the accessibility of our survey. All teachers interested in participating could follow the link to the online survey on Qualtrics. Paper surveys were left with stamped addressed envelopes in the two schools that agreed to participate in the child survey element of the project.

### Participants

A sample of primary teachers from the Republic of Ireland were recruited for this survey. Schools and teachers were contacted via social media and direct email and requested to complete the survey if they worked alongside students with disabilities between the ages of 5-12 years. Consent forms were completed by 114 participants. However, four were excluded because they did not teach students with disabilities, 18 were excluded because they did not teach students between 5-12 years old. A total of 40 respondents partially completed the survey. Only two of the 40 partial respondents two who completed 80% or more of the survey were included in analysis. A total of 52 teachers completed the survey in full and met the inclusion criteria. A total of 54 teacher’s responses were included in the final analysis.

### Teacher Survey

The survey began with a participant information sheet and consent form. After participants indicated their consent, they were invited to complete the survey in full, as outlined below. After teachers submitted their responses, they were thanked for their time and provided with the lead investigator’s email address should they have any questions. The full version of the survey can be found in Appendix D.

#### **Demographics**

The demographic questionnaire was a brief questionnaire constructed by the research team which was used to screen for inclusion criteria and collect demographic information including age and gender. Participants completed this survey initially before progressing to the classroom context questionnaire.

#### Classroom context

This was a short survey constructed by the research team which gathered information on job title, setting, students’ disability and age range, and class size. Information was also gathered on the selection of literacy goals as part of students’ Individualised Education Plans (IEPs).

#### Use of Assistive Technology

The participants then progressed to the survey on teachers' use of AT in the classroom to support literacy instruction. The survey provided teachers with some background information to begin, specifically, AT is defined as “any item, piece of equipment, or product, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of a child with a disability” (IDEA, 2004). Examples of AT used in the classroom include; interactive whiteboards, laptops, PCs, tablets, iPads, learning apps and software, and digital assessment tools.

Teachers were then asked to answer a series of questions on whether or not they used AT to support literacy instruction, what elements of assessment or instruction they used it for, and to list the types of AT they use and the frequency with which they use it. Finally, the survey gathered teachers’ perspectives on the barriers, benefits, and limitations of AT in the classroom to support literacy instruction. Teachers had the option to select multiple responses to the questions related to the core components of literacy and the benefits, limitations and barriers to AT. Teachers were also asked to give any additional information they could regarding the AT they used, the benefits, limitations and barriers to using AT and how these barriers may be overcome. The full survey is available to view in Appendix D.

### Data Analysis

Quantitative Data were analysed using IBM SPSS Statistics Viewer-Version 27. Data were cleaned and screened in order to make sure all participants met the inclusion criterion (a) teaching students between 5-12 years old (b) teaching in the Republic of Ireland (c) teaching students with intellectual and/or neurodevelopmental disorders. Descriptive statistics including means (*M*) and standard deviations (*SD*) were calculated for continuous variables and frequency data were analysed for categorical variables.

Narrative responses to open questions were analysed and classified into codes. Narrative data was collected in the following instances: (1) teachers selected *‘Other’* as a response and were invited to add additional information (2) lists of AT tools used for instruction, assessment, progress monitoring (3) details of the regularity with which AT tools are used (4) assessments of the most useful AT’s (5) suggestion for overcoming barriers, (6) reasons for not using AT to date.

## Phase II Results

### Demographics

The responses of 54 primary school teachers were analysed. Most respondents were female (93%, n=50) and 7% of respondents were male (n=4). The mean age of respondents was 39.61 years (SD=9.90) ranging from 24 to 64 years. Primary teachers in a mainstream classroom accounted for 19% (n=10), 33% worked as a learning support or resource teacher in a mainstream school (n=18), 32% worked as a primary teacher in a special education classroom (n=17), and 15% worked in other roles (n=8). These other roles encompassed a music teacher in a special school, an assistive technology teacher, art teacher and school principals.

The number of students reported in teachers’ classrooms or that teachers worked with throughout the week, in the case of learning support/resource teachers, was analysed by role. When grouped by role, primary teachers in a mainstream classroom had the largest class size (M=23.00 SD=4.52, range=16-31), followed by learning support/resource teachers in a mainstream school (M=22.50, SD=9.68, range=2-40) and teachers with ‘other roles’ (M=8.33, SD=5.86, range=4-15). Primary teachers in a special education classroom reported smallest class size (M =7.82, SD=6.13, range=5-28). Student ages ranged from three to 19 years. All teachers were required to meet the 5-12 years age range as specified the inclusion criteria in order to participate. However, a number of teachers also taught students outside this age range. Mean age range in a classroom was 4.17 (SD=3.78). Two participants were excluded from class size calculation as they reported number of students in the school. Respondents were asked “Are you currently teaching children/ a child with a developmental disability (e.g., intellectual disability, autism, Down’s syndrome), to which 82% selected yes. “Other” was selected by 18% of respondents after which they listed the following disabilities; Dyslexia, Dyspraxia, Attention Deficit Hyperactivity Disorder, Dysgraphia, Developmental Language Disorder, Prader-Willi Syndrome and physical, intellectual, sight, hearing, and speech impairments.

### Settings

Mainstream classrooms accounted for 48% of the settings respondents worked in (n=26), 9% worked in autism units (n=5), 33% worked in special schools (n=18), and 9% worked in other setting (n=5), including special education classroom in mainstream school. See Figure 2 below.

**Figure 2. Respondents’ School Settings**

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### Literacy Goals and Classroom Context

Most respondents (n=50) indicated that literacy goals are included in Individualised Education Plans (IEPs) for all learners in their classroom. Primary teachers in mainstream classrooms had a mean of 5.38 students (SD=3.46) with goals in their IEP related to literacy. Learning Support/ Resource teachers in mainstream schools had a mean of 18.54 students with goals in their IEP related to literacy and primary teachers in special education classroom had a mean of 7.29.

Figure 3 below illustrates the proportion of respondents targeting each of the five core components of literacy, 83% of respondents targeted vocabulary (n=45), 59% targeted phonemic awareness (n=32), 76% targeted comprehension (n=41), 67% targeted phonics (n=36), and 63% targeted fluency (n=34). Participants could select more than one component meaning that some of the respondents were teaching students who were working on literacy goals across a number of the core instructional areas listed above.

**Figure 3.** IEP Goals Targeting the Five Core Components of Literacy

Four respondents (8%) indicated that literacy goals were not included in IEPs for all learners in their classroom. Reasons for literacy goals not being included were lack of prerequisite skills (n=3) and other goals being prioritized (n=1). Another reason cited by one participant was ‘a wide range of learners in the classroom with different levels of physical and intellectual disabilities’. Behavioural difficulties were not selected as a reason for not including literacy goals in IEPs by any participants. Participants could select more than one reason for not including literacy goals.

Regarding how literacy IEP goals are selected for students, standardized achievement tests were used by 48% of respondents (n=26), classroom assessments of literacy skills were used by 52% (n=28) and selecting goals from standardized curricula was used by 30% (n=16). Again, participants could indicate more than one means of selecting literacy goals. Other means of selecting literacy goals reported by more than one teacher include the Verbal Behavior Milestones Assessment and Placement Protocol (VB-MAPP) (n=6), teacher observation (n=4), speech and language assessments (n=4), teacher/school designed assessment (n=3), parent consultation (n=3), teacher judgement (n=3), psychological reports (n=2) and the Assessment of Basic Language and Learning Skills (ABLLS) (n=2). Other individual responses included The New Group Reading Test, spelling test, fluency assessments, Alpha to Omega assessment, Nessy assessment[[3]](#footnote-4), Drumcondra tests, Special Education Support Service, screening tests, and benchmarking.

Assistive Technology to Support Literacy Instruction in the Classroom

Most teachers (n=50) reported that they used AT to support literacy instruction in their classroom. Only four reported not using AT to support literacy instruction. Regarding the five core components of literacy, 72% of respondents targeted vocabulary through AT (n=39), 37% targeted phonemic awareness through AT (n=20), 46% targeted comprehension through AT (n=25), 59% targeted phonics through AT (n=32), and 44% targeted fluency through AT (n=24) (see Figure 4 below). Participants could select more than one component on all the AT questions.

The types of AT used by teachers to support literacy instruction can be broken down into literacy learning apps, assistive devices and assistive applications. The most common AT devices were iPads (n=23), followed by laptops (n=14), interactive whiteboards (n=9), and tablets (n=8). Less common were desktop computers (n=5) and smart-pens (n =4). Connect 12 digital magnifier, pencil grips and large keyboards were all mentioned by one respondent respectively. Teachers said they used storytelling apps (n=1), book creation apps (n=2), early literacy toys (n=2), speech to text software (n=3) and text to speech software (n =5) as AT to support literacy instruction. Teachers named 39 ATs including literacy learning apps, assistive applications and assistive devices used to support literacy instruction. Most teachers cited different apps; however, some were cited by more than one teacher including Touch Type Read Spell (n =5), Starfall (n=5), Nessy Learning (n=4), Splingo (n=3), Immersive Reader (n=2), Clicker writing app (n=2), Lexia Core 5 (n=2), Jolly Phonics (n=2) and ABCYA (n=2). A full list of the ATs teachers reported using can be found in Table 3 below. Of the 49 teachers who reported the frequency with which they used AT to support literacy instruction, 75.5% reported using it daily, 14.3% reported using it most days (at least 3 days per week), 8.2% weekly, and 2% not regularly.

Over half of the respondents (59.3%, n=32) reported using AT to support the assessment of literacy skills with students in their classroom. Twenty-two reported that they do not use AT to support the assessment of literacy skills. AT was used to support the assessment of vocabulary by 42.6% (n=23), 27.8% used AT to assess phonemic awareness (n=15), 44.4% used AT to assess comprehension (n=24), 38.9% used AT to assess phonics (n=21), and 27.8% used AT to assess fluency (n=15) (see Figure 4 below).

Thirty teachers also provided information on AT devices and programmes they used to support literacy assessment. Again, iPads were the most common device cited to support literacy assessment (n=8), followed by tablets (n=3), interactive whiteboards (n=2), laptops (n=2) and Augmentative Alternative Communication Devices (n=2). PCs and smartpens were each cited by one teacher [[4]](#footnote-5). Twenty-three ATs were listed by teachers for supporting literacy assessment. The most commonly cited were Nessy learning (n=4), Touch Type Read Spell (n=3), Jolly Phonics (n =2), Lexia Core 5 (n=2), and Seesaw (n=2). ATs unique to the assessment list included New Group Reading Test, Fast Forword, See Saw, Socrative, Microsoft Reading Assessment, and Reading a-z. The frequency with which AT assessment tools were used was reported by 29 teachers. Over half of the teachers reported using some AT for assessment daily (52%), 10% reported using an AT tool for assessment most days, 21% reported using them weekly. Two teachers reported using AT for literacy assessment monthly (7%) and once per term (7%) respectively. One teacher reported using AT for literacy assessment fortnightly.

Similarly, just over half of respondents (54%, n=29) reported using AT to monitor the progress that their learners make with literacy skills. Vocabulary was the most common component for which AT was used to track progress (41% n=22), 24% used AT to monitor phonemic awareness (n=13), 32% used AT to monitor comprehension (n=17), 33% used AT to monitor phonics (n=18), and 30% used AT to monitor fluency (n=16) (see Figure 4 below).

**Figure 4. Use of AT to Support Five Core Literacy Components**

Twenty-two teachers also provided information on the AT they used to monitor progress on literacy goals. The data indicate that a wide range of ATs are used to track literacy progress (see Table 3 below). The most common devices reported were tablets (n=4), iPads (n=4), and laptops (n=2). Interactive whiteboards was the least commonly cited device (n=1). Nessy Learning (n=3), Seesaw (n=2), Spelling for me (n =2) and Touch Type Read Spell (n=2) were the most common ATs cited for tracking progress. Vocaba-z and Boom learning was a unique literacy learning app for tracking progress on literacy goals. Thirteen teachers reported using AT to track progress daily, one said they used it most days, five said they used it weekly, two fortnightly, and two monthly.

**Table 3. Assistive Technology used by Teachers**

| **List of AT to Support Literacy Instruction** | **List of AT to Support Literacy Assessment** | **List of AT to Track Literacy Progress** |
| --- | --- | --- |
| 1. ABCYA 2. Apple Keynote 3. Big Mac 4. Clicker 5. Dolchword 6. Dragon Natually Speaking 7. Duo Learning 8. Edmark 9. Epic reading 10. Gotalk App 11. Immersive Reader 12. IXL Learning 13. Jolly Phonics 14. Kahoot 15. Khan Academy 16. Kidspiration 17. LAMP App 18. Lexia core 5 19. Microsoft Edge Read Aloud 20. Nessy Learning 21. Otter 22. Oxford Owl 23. Proloquo2go 24. Read With Phonics 25. Reading Eggs 26. Renaissance Accelerated Reader 27. Snapcore T D 28. Spelling City 29. Splingo 30. Starfall 31. Step-by-step clicker 32. Storyberries 33. Teach your monster to read 34. Touch Type Read Spell 35. Typing Club 36. Typing.com 37. Wizard Writing 38. Wordshark 39. Write For Google Chrome | 1. Big Mac 2. Clicker 3. Fast Forword 4. Google Classroom 5. Jolly Phonics 6. Kahoot 7. LAMP app 8. Lexia Core 5 9. Microsoft Reading Assessment 10. Nessy Learning 11. New Group Reading Test 12. Oxford Owl 13. Reading a-z 14. Reading Eggs 15. Readtheory.org 16. Renaissance Accelerated Reader 17. See Saw 18. Snapcore TD 19. Socrative 20. Spelling for me 21. Teach Your Monster to Read 22. Touch Type Read Spell 23. Write For Google Chrome | 1. Big Mac 2. Boom Learning 3. Lexia Core 5 4. Microsoft Excel 5. Microsoft Word 6. Nessy Learning 7. Reading a-z 8. Reading Eggs 9. See Saw 10. Slingo 11. Snapcore TD 12. Spelling For Me 13. Spellingcity 14. Teach Your Monster to Read 15. Touch Type Read Spell 16. Vocaba-Z 17. Word bingo |

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### Barriers to use of AT

Forty-six respondents reported that the use of AT to support literacy instruction in their classroom is feasible (85%), while 15% said it was not feasible. Almost all respondents believed it was beneficial 96% (n= 52), with two indicating it is not beneficial. All but one believed AT is useful to support literacy instruction (98%, n=53). However, respondents also provided beneficial information on the barriers to including AT in the classroom. Most respondents (n=50) reported that there are barriers to incorporating AT into their classroom for supporting literacy instruction and/or assessment. These barriers include time (46%, n=25), training needs (69%, n=37), finance (59%, n=32), lack of knowledge (46%, n=25), lack of resources (50%, n=27), and inaccessibility to learners (26%, n=14) (see Figure 5 below). Participants could select multiple barriers. Multiple additional barriers were recorded using the open-ended option for responding (37%, n=20), such as learners lacking prerequisite skills, difficulties with devices and/or internet coverage, AT training not being included in teacher training, and additional teacher support being required to help the learner navigate and focus on the AT, children not allowed to use AT unless lower than the second percentile in two areas.

**Figure 5.** **Barriers to Use of AT**

### Overcoming Barriers to use of AT

Forty-six teachers provided suggestions for how such barriers may be overcome or how teachers might be facilitated to incorporate AT into the classroom more frequently. The most common suggestion was to provide teachers with more training in AT, suggested by 22 teachers (48%). Teachers mentioned that more training was needed in initial teacher training but also in the form of continuous professional development courses. Teachers also mentioned general AT training was required as well as training on the use of specific software and devices. The next most common suggestion to facilitate incorporation of AT was the need for more funding (n =13, 28%). Eight teachers suggested that more devices would help overcome the barriers (17%). Six recommended ensuring all schools have reliable broadband (14%). Five teachers suggested that more time should be allocated to AT programmes which are evidence based (12%). Other suggestion included having IT support for schools (n =2), that AT programmes demonstrate their link to curricula (n =2), and decreased curricular content (n =2). Finally, the following suggestions were mentioned by only one teacher: free trials on AT programmes, more staff, individualised AT, AT through the Irish language, peer support groups, AT devices that can be run through teacher’s desktop.

### Benefits to use of AT

Fifty-one respondents (94%) believed that there are benefits to using AT in their classroom for supporting literacy instruction and/or assessment. Participants could select as many of the five benefits suggested by researchers as applied to them and add any additional benefits under “other”. These benefits include increasing the intensity of instruction (35%, n=19), increasing students’ motivation to engage with lessons (87%, n=47), requiring less intensive support from the teacher (28%, n=15), and AT being effective (59%, n=32) (see Figure 6 below). Twenty-one teachers reported other benefits using the open-ended option for responding. The most common benefit identified was that AT appeals to learner enjoyment of technology (n=7, 33%), ability to individualize work to each learner as programmes are at learners ‘own pace and level’ (n=6, 29%), reflects the world we live in as we use AT outside of school (n =2), increases independence (n=2). Other benefits include AT is game like, promotes self-assessment, promotes record keeping.

**Figure 6. Benefits to Use of AT**

### Limitations to the use of AT

Most respondents (83%) believe that there are limitations to using AT in their classroom for supporting literacy instruction and/or assessment. Participants were encouraged to select all limitations that they believed applied. Selected limitations included lack of time to incorporate AT (28%, n=15), lessons being too prescriptive (15%, n=8), learners prefer not to use AT (7%, n = 4), and engagement with teachers and peers may decrease (39%, n=21) (see Figure 7 below).

Twenty respondents also provided other limitations when given an open text option. The most common of these included AT being reliant on broadband (n=4), devices needing to be charged (n=3), and all students requiring different devices or programmes (n =2). Other unique limitations mentioned by one respondent each were benefits of physically writing being lost, that it is easier for student to guess using AT, set up time results in loss of lesson time, difficulty with accents and pronunciation on AT programmes, AT devices are breakable, requires planning, students may be self-conscious if other students in the class are not using AT, can cause behavioural issues regarding transitioning away from the device, AT programmes aren’t tailored to match curriculum, need for constant monitoring of students using devices, students have difficulty with transferring knowledge, student’s become over reliant on AT.

**Figure 7. Limitations to Use of AT**

### Training in the use of AT

Regarding training in AT, 39% of respondents (n=21) reported that they had received training in the use of AT to support learners in their classroom, while the majority had not received training (57%, n=31). Specifically, regarding training in AT to support literacy instruction, 39% of respondents (n=21) reported receiving training in this area, again the majority had not (57%, n=31).

### Future use of AT

When asked about future use of AT in their classroom to support literacy instruction and/or assessment, 52 participants responded. Of those teachers 61% (n=33) reported that they already use AT to support literacy instruction and/or assessment. The remaining 35% (n=19) indicated that they would consider the use of AT in their classroom to support literacy instruction and/or assessment in the future. No respondents stated that they would not consider using AT in the future.

### Reason for not using AT to date

Twenty-eight teachers provided reasons for not using AT to date, this number included teachers who do not use AT or teachers who would like to use it more. The most common reason for not using AT was lack of resources, primarily not enough devices (57%, n =16). Lack of knowledge and training was the second most common reason for not using AT to date (43%, n=12). Seven teachers (25%) reported that the lack of funding and expense of AT was the reason for not using AT/ using AT more to date. Time was a contributing reason for six teachers (21%). Other reasons included not having found the right fit/ AT, Wi-Fi issues, need for IT support, lack of staff, children get fixated on AT, fear of technology, skills taught through AT aren’t transferable.

## Summary of findings

The findings of phase II show that most respondents use AT in their classroom. Of those using AT in their classroom, AT was most commonly used to support literacy instruction, followed by assessment of literacy skills. AT was least commonly used to support progress monitoring with literacy skills. Regarding the five core components of literacy, vocabulary was the most common core component targeted in AT literacy instruction and progress monitoring. Comprehension was the most common component assessed using AT. Respondents referenced a wide range of literacy learning apps, assistive devices and assistive applications incorporated in their classrooms to support literacy instruction. Most respondents believed that the use of AT to support literacy instruction in Irish classrooms is feasible, beneficial, and useful. However, they also referenced a range of barriers to adopting AT in the classroom and provided suggestions for how such barriers might be overcome.

# Phase III: Student Perspectives on Literacy Instruction delivered via Assistive Technology

Phase III: explores student perspectives on the use of AT to support literacy instruction. A child preference assessment was conducted to ascertain the perspectives of children with neurodevelopmental disorders on the use of AT for learning to read (i.e., preference for AT or paper-based lessons, likes and dislikes with regard to AT).

## Method

### Participants and Setting

Eight autistic students participated in a child friendly assessment of preference between AT and paper-based literacy lessons. Three students were from a special school in the east of Ireland, school one. The other five students were from school two, a mainstream school in the midlands. Five male students and three female students took part. Students ranged in age from 6 years 11 months to 11 years 3 months (M = 9.01, SD =1.85). Reading sessions for students in school one were conducted in a quiet corner of the child’s classroom with their teacher and four other students present. Students in school two completed the reading session in an external classroom with the researcher present and the door left open.

### Procedure

The reading session preference assessment was conducted by a member of the research team. Consent forms signed by parents were collected on arrival at the school. The researcher then introduced themselves to the participant and went through the participant information sheet (Appendix E) with them. Once the participant information sheet was complete the researcher obtained the child’s assent by asking them to point to or circle yes or no to the question on the assent form in Appendix E. All students assented to participate. Students were also given a break card which was placed in sight and in reach throughout the reading session.

The reading session consisted of an AT lesson on iPad and a paper-based lesson. For the AT lessons students were introduced to and engaged with “Headsprout Early Reading (HER)” programme using an apple iPad. HER was ran on a smartphone for one student who did not have previous experience using a computer mouse and associated the iPad with break time. All students completed the inbuilt HER placement test and were assigned to a specific episode of the programme which took between five and 10 minutes. The researcher and the student then worked through the assigned episode for an additional 10-15 minutes. Between 15 and 20 minutes were spent on the AT reading session. Students ranged from episode five HER to episode one of HER comprehension (equivalent to episode 101).

The paper-based reading session consisted of HER paper-based lesson which included short story, sight word practice sheets and new sounds/ phonemes practice sheets. Students completed these activities with the researcher in a similar manner to AT reading session. Paper based session lasted between 15-20 minutes. Students ranged from benchmark lesson 10 to HER comprehension 10 (equivalent to lesson 110).

HER programme was used for all participants with the exception of one who already had an AT programme in place for literacy, namely Raz-Kids. This programme was used for the AT session for that student. The student conducted a 10-minute session on the classroom PC on the A-Z Learning Raz-Kids web-based programme. The AT session involved reading two online books with interactive pictures. For paper-based lesson the student read a chapter their class reader which was at a first class reading level called hidden treasure titled ‘at the beach’ followed by some basic comprehension questions.

After both sessions had been completed students were asked to complete a brief social validity/ preference assessment (Appendix E) and indicate their preference. Three students did not have prerequisites to answer open-ended questions; therefore, the specific components that were liked and disliked were not assessed on this occasion. For the remaining five students they were asked to talk about what they liked and disliked about both.

## Phase III Results and Discussion

All students said they liked working with the researcher, seven said they liked paper-based reading session, one said they did not like the paper-based reading session. All students said they liked reading on the iPad. When offered the choice between the paper-based literacy lesson and the AT-based literacy lesson, one student selected the paper-based lesson, while seven students selected the AT literacy lesson. Quotes about student preference include:

*“I liked the iPad, ‘cause it was very cool and had cool activities in it. I like reading on it too. My favourite part was finding the missing words.”*

*“iPad was more funnier because its more alive and stuff… I liked reading on the iPad and liked the pictures. I found getting kicked out of the level after each activity funny”*

*“I liked the iPad the best because there was fun mini games and we were able to read on the iPad”*

It may be concluded that the interactive nature of HER and its game like qualities increased student engagement. Also, the accuracy of the placement test ensured that the AT lessons were at an appropriate level for the student and prevented material being introduced too fast. Paper-based lessons were not as well matched to student ability, as highlighted by quote below.

*“Book had too many complicated words. iPad was easier.*

One student reported that the AT instruction was not age appropriate (student’s reading ability was classified as an early reader).

*“I didn’t like iPad animations they were very childish.”*

Overall, the child survey indicated positive views of literacy lessons delivered via AT. This is only a preliminary, initial exploration of eight participants’ perspectives. Larger, more robust studies must be conducted in order to fully understand child perspectives and preferences for literacy instruction via AT as opposed to paper-based literacy lessons.

# Discussion

## Research Challenges and Limitations

There were some challenges and limitations which must be considered within the current research. There were a low number of respondents to the teacher survey which limits the external validity of the findings. Recruitment began in April 2022 and ran until the end of December 2022 and the survey was widely distributed. The difficulties experienced by schools due to the pandemic likely meant that schools prioritised other core responsibilities as well as being mindful of burnout and stress experienced by staff and students. A high proportion of respondents indicated that they already use AT for literacy instruction. It is possible that teachers who do not currently use AT in their classroom for literacy instruction may not have been inclined to complete the survey.

As noted, the respondents to the teacher survey were predominantly teachers who use AT currently in their classrooms for literacy instruction; therefore, there is a bias towards perspectives of those who are already open to and using AT, and perhaps those who have received training to do so. These are important perspectives, but it should be noted that there may be a cohort of teachers who do not currently use AT, who may be more reluctant to do so, and who may face additional barriers to its use who are not represented in these findings.

The survey was designed in such a way that learning support and resource teachers were categorised together. However, these are very different roles supporting children with differing needs. This categorisation led to difficulties interpreting the data for each unique role with regards to number of students served and technologies used within each unique role. Future research should ensure that both roles are evaluated separately to attain more specific information relating to each unique role.

The participant numbers for Phase III, the child survey, represents only a preliminary exploration of children’s perspectives of the use of AT for literacy instruction as only eight students participated. This limits the external validity of the findings. Future studies investigating children’s perspectives should be conducted to ensure student voices are reflected in the literature and decision making related to the incorporation of AT into teaching and learning for literacy skills.

## Overall Key Findings and Implications

The systematic review of the literature investigating literacy interventions delivered via AT for children with ID and autistic children yielded a total of 34 studies for inclusion. A total of 514 students and 88 teachers participated in the included studies. All quantitative studies (n=33) reported that the literacy intervention produced positive changes in the targeted literacy skill. Headsprout Early Reading was the AT literacy intervention most evaluated in the literature (18% of studies). There was some crossover between the AT used in literacy interventions evaluated in the literature and the ATs listed by teachers in phase II (teacher survey); however, not a close correlation. This may point towards a need to empirically evaluate the preferred and most prevalent ATs that are used for literacy instruction in schools in Ireland.

The current findings, both from the systematic review and the teacher survey, provide a list of some of those ATs which researchers can use to design future studies and evaluations which are informed by teacher’s voices and opinions regarding the most useful ATs in the classroom. The number of RCTs evaluating interventions in this area is low. Increasing the number of larger controlled studies should be a focus for future research. A relatively low number of studies included measures of social validity (i.e., opinions on the goals, outcomes, and intervention itself) from both teachers and students. Stakeholder opinions are of the utmost importance and should be incorporated in all evaluations in order to improve the impact of research on AT literacy interventions in practice. It would also be advantageous for researchers to ensure that internet and software requirements are reported as part of their description of ATs used.

The findings from Phase I can also serve to inform teachers on AT literacy interventions that have been empirically evaluated with children with disabilities, including the intensity with which they have been implemented. Most of the respondents in Phase II (teacher survey) reported that they believed that there are benefits to using AT to support literacy instruction, for example, lessons are motivating and appeal to learners’ enjoyment of technology, less intensive support from teachers might be required while maintaining intensive instruction for students, learners can work at their own pace and level while increasing independence, and the use of AT is reflective of the world we live in.

Limitations were also reported, for example, some teachers reported that they did not have enough time to incorporate AT or monitor the use of devices, that it does not appeal to all learners and would decrease engagement with teachers and peers or increase reliance on devices and technology. Some feared that lessons might be too prescribed and that students might have less time to work on writing skills or that students might feel self-conscious about using AT. An additional concern was that managing access to devices may in some cases trigger behavioural difficulties. An important concern reported by teachers was that literacy interventions using AT may not be tailored to match the curriculum. This is important to consider within the context of having also reported little time to incorporate AT. It is less likely that the incorporation of AT in the classroom would be prioritised if it does not support teachers to cover the curriculum with their students.

Overall, respondents were supportive of the use of AT to support literacy instruction, as evidenced by the high proportion already using AT and the remaining respondents indicating that they would consider it’s use to support literacy instruction in the future. It’s clear from the current sample of teachers that they believe there are several important benefits for children which can result from the incorporation of AT into their classrooms.

In terms of student preference, in Phase III, all eight students reported that they liked reading on the iPad and seven of eight students indicated a preference for literacy lesson delivered via AT over paper-based literacy lesson when asked. Although these are only preliminary findings, and more research with larger participant numbers are required, as well as explorations of small group lessons delivered via AT, initial findings indicate positive opinions regarding AT to support literacy instruction. Teachers also outlined some valuable limitations regarding current use that would be of benefit for educators to consider with regards to future planning for the use of technology to support learning in schools. Teacher opinions specifically regarding barriers and facilitators will also be of benefit.

Both Phase I and II provide useful information on barriers and facilitators to incorporating AT into the classroom to support literacy instruction. Time, resources, and training needs were the most common barriers named across both the literature review and the teacher survey. In Phase II (teacher survey), respondents suggested that barriers could be overcome by increased training in AT (both during initial teacher training and via CPD) as well as the provision of supports with specific software and devices (e.g., IT support for schools). Respondents suggested that increased funding for example, for devices, and reliable broadband would facilitate the incorporation of AT. A number of other valuable suggestions for facilitating the use of AT included a clear link between intervention and core curriculum, AT interventions for Irish language speakers, and peer support groups. Fourteen respondents in Phase II reported that inaccessibility to learners was a barrier to implementation and some respondents noted that some children can become fixated when using AT device. Related to this, respondents in Phase I identified additional intervention supports such as reinforcement (to support engagement) as beneficial to support implementation. Overall, it seems that much more research with regards to ways to support learner engagement would be of benefit.

Given the reported benefits, emerging evidence in the literature, and potential to impact intensity and effectiveness of literacy instruction, it seems that an increased focus on training and resources to improve the use of technology in the classroom for reading instruction would be of benefit. The number of respondents to the teacher survey was low and there was a skew towards teachers who already use AT in their classrooms. An increased awareness of AT, what it incorporates, how it can be used and a general increase in awareness and motivation for technology in the classroom might be a beneficial first step to encouraging a more widespread adoption into classrooms. From a research perspective, further work should be carried out with regard to engaging with teachers and students on the use of AT. Increased participant numbers, controlled evaluation studies and qualitative approaches are necessary to better understand efficacy, preferences, and logistical barriers regarding the incorporation of AT into classrooms to support learning.

**Summary of Key Implications**

* There was not a close correspondence between the ATs evaluated in the literature for supporting literacy instruction and the ATs reported as commonly used in classrooms in Ireland. Commonly used ATs should be empirically evaluated. ATs that are recommended for use to support literacy instruction in the classroom should be informed by evidence of effectiveness.
* Large, controlled studies evaluating AT to support literacy instruction should be conducted to facilitate evidence informed decisions by teachers in classrooms.
* Stakeholder opinions on the use of AT for supporting literacy instruction are not well explored in the literature. Teacher and student perspectives on the use of AT and how it might be incorporated meaningfully into classrooms to support instruction are pivotal. Further research and engagement with stakeholders are necessary for successful integration of AT in schools.
* A number of barriers to incorporating AT to support literacy instruction were outlined by teachers including time, resources, and training needs. Teachers reported that barriers could be overcome by the provision of additional teacher training in AT as well as the provision of IT supports for schools. Additional funding for devices and reliable broadband in schools is necessary to incorporate AT successfully.
* The use of AT in the classroom could be facilitated by using software and devices that clearly support students to access the core curriculum and by the provision of additional supports and training for teachers to facilitate their students to engage meaningfully with technology.
* Given the reported benefits of incorporating AT to support literacy instruction, and the predominantly positive perspectives on AT from both teachers and students, an increased focus on training and resources to improve the use of technology for reading instruction would be of benefit in classrooms in Ireland.

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# Appendices

## Appendix A - Reliability of Data Extraction Checklist

| **Systematic Review**  **Reliability of Data Extraction Checklist** | Yes | No |
| --- | --- | --- |
| 1. Was the number of participants, correct? |  |  |
| 1. Was the Gender breakdown correct (1. Male, 2.Female, 3.Other (give info))? |  |  |
| 1. Was the age range correct? |  |  |
| 1. Was the diagnosis classification correct (1. ASD, 2. ID, 3. ASD & ID, 4. LD 5. Other)? |  |  |
| 1. Was the setting classification correct (1. In Classroom, 2. In Canteen, 3. External Classroom Outside of Main Classroom, 4. Other (give info))? |  |  |
| 1. Was the study design classification correct (1. Randomised Control Trial, 2. Single Case Research Design, 3. Within Subjects (Pre-Post), 4. Between Subjects, 5. Qualitative, 6. case study)? |  |  |
| 1. Was the intervention / program name, correct? |  |  |
| 1. Was the information on the levels of IV, correct? |  |  |
| 1. Was the type of device classification correct (1. PC, 2. Laptop, 3. Tablet / iPad, 4. Smartphone, 5. Other)? |  |  |
| 1. Was the information correction on Internet Requirement correct (1. Internet based, 2. No internet required 3. Unclear)? |  |  |
| 1. Was information on whether the AT component was Web-based App-based correct (1. Web-based, 2. App-based, 3. Other)? |  |  |
| 1. Intervention Agent/ Facilitator classification correct (1. Teacher, 2. SNA, 3. Researcher/ Psychologist, 4. Peer, 5. Other (give info))? |  |  |
| 1. Was the information on intervention intensity, correct? |  |  |
| 1. Was the classification of DVs correct (1. Decoding, 2. Phonemic Awareness, 3. Phonics, 4. Vocabulary, 5. Comprehension, 6. Fluency 7. Other (give info))? |  |  |
| 1. Was the information on quantitative results, correct? |  |  |
| 1. Was the information on teachers’ perspectives on social validity/ acceptability, correct? |  |  |
| 1. Was the information on the Barriers of AT intervention, correct? |  |  |
| 1. Was the information on the facilitators of the AT intervention, correct? |  |  |

## Appendix B – Table 1. Summary of included studies evaluating AT to support literacy instruction

| **Reference** | **Participants** | **Setting and Intervention Facilitator** | **Intervention Name** | **Study Design** | **Dependent Variable / Outcome Measure** | **Effects/Result** |
| --- | --- | --- | --- | --- | --- | --- |
| Bryant et al. (2015) | 4 students with learning disability, 50% male (n=2), 50% female (n=2) 9 years 5 months-9 years 10 months | External classroom with researcher | K12 Timed Reading Practice, Howie Finding Vowel, ABC Phonics Word Family Writing | Single case research design (alternating treatments design) | Fluency Student Engagement | Visual analysis of data demonstrated intervention progress over baseline for both approaches, consistent preference of intervention over teacher-directed instruction Consistently higher engagement during intervention for all students Students performed better in teacher-directed instruction  Intervention effects maintained over time |
| Chai, Vail, & Ayres (2015) | 3 students with developmental delay, 33% male (n=1), 66% female (n=2) 5-8 years of age | External classroom with researcher | Touch Sound | Single case research design (multiple probe design) | Phonemic awareness | The use of Touch Sound with 0- to 5-s constant time delay procedures was successful to teach receptive identification of initial phonemes  Most of the skills were generalized and maintained after intervention |
| Coleman, Hurley & Cihak,  (2012) | 3 students, 2 with ID (66%) and 1 autistic student with an ID (33%), 100% male (n=3) 10-12 years of age | Main classroom with teacher | PowerPoint | Single case research design (alternating treatments design) | Vocabulary | Teacher-directed constant time delay- mean percentage of words read correctly increased to 78.11% and students reached criterion with a mean of 19 sessions Computer-assisted constant time delay - mean percentage of words read correctly increased to 77% and students reached criterion with a mean of 24 sessions Teacher-directed constant time delay was more effective for two participants |
| Coleman et al. (2015) | 3 students, 33.3% with ID & seizure disorder (n=1), 66.66% autistic students with ID (n=2), 33.33% male (n=1), 66.66% female (n=2) 9 years 8 months - 11 years 4 months | External classroom with teaching intern | Intellitools Classroom Suite Software | Single case research design (alternating treatments design) | Sight Words | Acquisition of sight words occurred in both conditions for all 3 participants; however, each participant either clearly responded better in the teacher-directed condition or reported a preference for the teacher-directed condition when performance was similar with computer-assisted instruction being more efficient 2 students met criterion after 12 sessions in teacher-directed condition, did not reach criterion in computer-assisted condition  1 student met criterion within 9 sessions of both conditions |
| Coyne et al. (2012) | 16 students with ID and various comorbidities, 54.5% male (n=11), 45.5.% female (n=5) 5 years 1 month - 9 years 9 months | Main and external classrooms with teacher | Literacy By Design ebooks  Scholastic WiggleWorks e-books Riverdeep's Island Adventure and Ocean Adventure | Between-subjects design 8 experimental group 8 control group | Phonemic Awareness Phonics Fluency Vocabulary Comprehension Achievement on standardised test | The differences between adjusted post test scores of the intervention and control groups were statistically significant (in favor of the intervention group) at the p = .02 level on Passage Comprehension  After controlling for initial reading achievement, the intervention group, on average, made significantly higher gains in comprehension than did the control group |
| Cullen et al. (2013) | 4 students, 3 with ID, and 1 with ADHD (25%), 75% male (n=3), 25% female (n=1) 4th grade students (ages not reported) | Main classroom with researcher | Name not specified | Single case research design (multiple probe design) | Vocabulary | All students showed immediate acquisition of sight words as indicated by steep upward trends during intervention, ranging between 60% and 100% Performance was maintained and generalized  Maintenance responding ranged between 84% and 100% correct |
| Doughty et al. (2013) | 3 students, 2 with ID (66%) and 1 Foetal Alcohol Syndrome (33%), 100% male (n=3) 8-10 years of age | Main classroom with teacher | FLYPen® | Single case research design (multiple baseline across participants design) | Phonemic awareness No. of words spelled correctly | Students increased their academic engagement when using the FLYPen® and maintained or continued this increase through the maintenance condition Results indicated little to no improvement over traditional instruction in spelling accuracy |
| Felix et al. (2017) | 12 students with ID & Down Syndrome, 58% male (n=7), 41% female (n=5) 6-15 years of age | Main classroom with therapist | HATLE | Between-subjects design 6 experimental group 6 control group | Letter identification Reading Spelling Handwriting | The HATLE group, on average, made significantly more progress on Letter Identification, Single-Word Reading, and Handwriting-Form measures than the control group The intervention had a positive, but insignificant, impact on Handwriting Legibility and Spelling outcomes |
| Flanagan, Bouck & Richardson (2013) | 51 teachers, 90% female (n=46), 10% male (n=5) | Setting not reported Teacher as intervention facilitator | Name not specified | Qualitative paper | Not reported | No significant relation between amount of AT use and perceived effectiveness |
| Goo et al. (2020) | 3 students with ID, 66% male (n=2), 33% female (n=1) 7-10 years of age | External classroom with researcher | PowerPoint | Single case research design (multiple probe design) | Phonemic awareness Fluency | Results established a functional relationship between using visual supports presented through an iPad and the improvement of phonemic segmentation Findings in regard to generalization (34.2%–44.7%) of the acquired skills were inconclusive |
| Grindle et al. (2021) | 55 students with ID (78%), autistic with ID (22%), 69% male (n=38), 31% female (n=17) 5-17 years of age | Main or external classroom with teacher or special needs assistant | Headsprout Early Reading (HER) | Randomised control trial | Decoding Phonemic awareness Phonics Vocabulary Fluency | Phoneme Segmentation Fluency scores at follow-up were 1.82 times higher in the HER group (Incidence Rate Ratio; IRR = 1.82, p = .012) in comparison with the Reading as Usual group Nonsense Word Fluency scores at follow-up were 2.27 times higher in the HER group (IRR = 2.27, p = .006) when compared to the Reading as Usual group Scores at follow-up did not significantly differ on any of the four other outcomes between the Reading as Usual and HER groups (all p’s < .05) |
| Grindle et al. (2013) | 4 autistic students, 75% male (n=3), 25% female (n=1) 4-6 years of age | Main classroom with ABA tutor | MimioSprout | Within-subjects design | Decoding Phonemic awareness Phonics Vocabulary Fluency | Number of correct responses recorded in 1 minute improved across all measures from baseline to time 2 for three participants |
| Heimann et al. (1995) | 30 students, 11 autistic students (37%) and 9 with ID, 10 preschool children. 50% male (n=15), 50% female (n=15) 6-13 years of age | Not reported | Alpha | Within-subjects design | Phonemic awareness Reading comprehension | The Autism group progressed from Alpha Lesson 5 (M = 4.9, SD 6.7) to lesson 22 (M = 22.2, SD = 15.6)  The ID group on average went from lesson 7 (M = 7.3, SD = 7.2) to lesson 19 (M = 19.9, SD = 8.2).  The neurotypical preschool group progressed from Lesson 3 (M = 2.6, SD = 1.9) to lesson 22 (M = 21.5, SD = 112)  On Alpha built-in test all three groups learned both words and sentences through the program Reading significantly increased for autism and ID group, but no significant difference noted at follow up Statistically significant increase in Phonological Awareness for autistic group and ID group from baseline at both post-test and follow-up |
| Henderson-Faranda, Newbury, & Sutherland (2022) | 4 students, 75% were autistic (n=3) and had a range of comorbidities, 25% autism & ID (n=1), 50% male (n=2), 50% female (n=2) 9 years 4 months - 10 years 11 months | Quiet room at a university clinic or at participants’ school or home with researcher | Reading Eggspress | Single case research design (multiple phase across participants) | Reading Comprehension Level of independence using the graphic organiser to support comprehension Change in the children’s enjoyment of reading | Two participants made significant gains on a standardised measure of reading at post-test  Three participants made gains in median reading comprehension probe scores  Both phases appeared equally supportive of reading comprehension Reading Eggspress plus teacher directed instruction did not appear to result in higher gains compared to the Reading Eggspress alone condition |
| Herring, Grindle, & Kovshoff, (2019) | 8 students with ID and severe learning difficulty. 88% male (n=7), 12% female (n=1) 7-19 years of age | Setting not reported Teacher as intervention facilitator | Headsprout Early Reading | Single case research design (pre-post assessments) | Decoding Phonemic awareness Phonics Vocabulary Fluency | All four students in the Headsprout‐as‐usual condition showed meaningful change above the Reliable Change Index (RCI) threshold in their ability to identify initial sounds in words and in reading nonsense words, and all except one showed meaningful positive change  above the RCI threshold in word recognition In the no‐negation condition, both participants showed meaningful change above the RCI threshold in reading nonsense words and in recognizing words In the non‐verbal condition, neither participant showed positive meaningful change above the RCI threshold in word recognition |
| Knight et al. (2015) | 4 autistic students with an ID, 75% male (n=3), 25% female (n=1) 11-14 years of age | External classroom with graduate assistant | Book Builder | Single case research design (multiple probe design) | Vocabulary Reading comprehension | Three of four students increased mean number of correct responses from baseline to all intervention phases when explicit instruction was added to Book Builder |
| Ko et al. (2011) | 30 students with ID, 66% male (n=20), 33% female (n=10) 5th-6th grade students | External classroom with researcher | TriAccess System | Within subject’s design | Reading comprehension | The main effect of reading conditions was significant (F = 92.18, df = 29, p = .00)  Participants performed better when reading with cognitive supports |
| Kouo & Visco (2021) | 2 autistic students, 100% male (n=2) 12-13 years of age | External classroom with researcher | TinyTap | Single case research design (alternating treatments design) | Inferential reading skills | TinyTap treatment condition was the most effective in improving inferential reading skills for both participants |
| Marston et al. (2015) | 37 teachers 176 students with ID Gender not reported 1st-6th grade students (ages not reported) | Setting not reported Teacher as intervention facilitator | Name not specified | Between-subjects design 153 experimental group 23 control group | Decoding Reading comprehension Writing Reading aloud Achievements on standardised tests | Students' average achievement gains were greater for only two of the six research models - the microcomputer-assisted model and one of the Direct Instruction models (Direct Instruction with Holt Materials) |
| Nally et al. (2021) | 31 autistic students, 84% Male (n=26), 16% Female (n=5) 4-18 years of age | Computer group - 80% (n=12) engaged in lesson in classroom, 20% (n=3) in computer lab 17 teachers as intervention facilitators | Edmark | Between-subjects design 16 tabletop group 15 computer group | Decoding Phonemic awareness Vocabulary Reading comprehension  Fluency | Both groups showed significant increases, however, tabletop was most effective treatment for increasing reading rate, accuracy, first sound fluency |
| Newell et al. (1992) | 17 students with a range of disabilities, 3 had an ID, 14 unclear including cerebral palsy, muscular dystrophy, downs syndrome, Lowes syndrome, fragile X syndrome, developmental delay Gender not reported  8-19 years of age | Main classroom with teacher | Predictive Adaptive Lexicon (PAL) | Within-subjects design | Spelling error | Spelling error significantly reduced from 25% to 8% post-PAL intervention |
| Pennington et al. (2014) | 5 autistic students, 100% male (n=5) 7-10 years of age | Main or external classroom with SNA (50%) or Teacher (50%) | Pixiwriter software | Single case research design (multiple probe across behaviours design) | Vocabulary Comprehension Story writing Handwriting Storytelling | All participants showed greatest change pretest to post test on vocal tasks (storytelling.) 3 participants made gains on writing tasks.  3 participants gain on untrained story construction  All participants increased number of sight words read |
| Plavnick et al. (2014) | 4 autistic students, 75% Male (n=3), 25% Female (n=1) 5-8 years of age | 75% in classroom (n=3) and 25% external classroom (n=1) with teachers | Headsprout Early Reading | Single case research design (multiple baseline across participants design) | Engagement with HER Engaged in interfering behaviour Correct interactions per minute | All participants low levels of responding with Headsprout only Immediate increase in engagement and correct interactions per minute when behavioural intervention added (differential reinforcement of incompatible behaviour and response interruption and redirection) |
| Plavnick et al. (2016) | 3 autistic students, 100% male (n=3) 6 years of age | Main classroom with teacher (33%) or SNA (67%) | Headsprout Early Reading | Single case research design (multiple probe across participants design) | Correct interactions per minute Total episodes complete Vocabulary - Percentage of words read accurately in HER companion printed books | Low interactions when using Headsprout only Number of correct interactions per minute increased for all participants when contingent reinforcement was put in place Match-to-sample training also increased correct interactions for those whose responding dipped All learners increased the number of episodes read.  Learners applied skills to reading companion books. |
| Rasking et al. (1999) | 39 students with ID 67% Male (n=26),  33% Female (n=13) 9-17 years of age | Not reported | IBM ® VoiceType and four DragonDictate ® discrete speech recognition systems. | Between-subjects design  19 experimental group  20 control group | Comprehension Word recognition Spelling Phonological deletion Orthographics Semantic processing  Metacognitive reading strategies Working memory | Experimental group made significant gains over control group on word recognition, spelling and reading comprehension at midpoint testing, and these significant differences in gains were even more pronounced at post-test as well as significant gains in phonological deletion |
| Regan et al. (2014) | 4 students with a range of disabilities, 50% Male (n=2), 50% Female (n=2) 9-12 years of age | School library  Intervention facilitator not specified | Lexia Strategies for Older Students (SOS)™ | Single case research design (multiple probe across behaviours design) | Decoding | Mastery was met on all skills taught 3 students and 2 of 3 skills taught for another student, however their performance still increased from baseline Skills were maintained and generalised 33% of skills need to additional instruction |
| Rivera et al. (2017) | 3 students, 2 with ID (67%) or 1 DD (33%) 67% Male, 33% Female. 6-8 years of age. | External classroom with researcher | Multimedia Shared Story | Single Case Research Design (multiple probe across participants) | Vocabulary | All students increased their performance from baseline to intervention.  Students required between 9-17 sessions to meet criterion All students maintained and generalised their scores, however one students dropped below criterion but remained above baseline in the final 2 weeks of maintenance checks |
| Roberts-Tyler, Hughes, & Hastings (2020) | 22 students with mild to moderate ID Gender not reported 5-19 years of age | Main or external classroom with SNA or teacher | Headsprout Early Reading | Randomised control trial | Phonics Vocabularly Fluency Reading age | There were significant differences in the Headsprout group at 6 months post-baseline assessment compared to the control group on reading age phonics and vocabulary Marginally significant differences in standardised score, accuracy score and fluency Large effect sizes were found for DRA accuracy score and reading age, a medium effect size was found for fluency and small effect sizes for phonics and vocabulary |
| Schlosser & Blischak (2004) | 4 autistic students with an ID, 100% male (n=4) 8-12 years of age | Main classroom with researcher | LightWRITER-SL3 | Single case research design (alternating treatments design) | Correctly spelled words  Correct letter sequences Number of sessions to criterion | Spelling instruction with LightWRITER-SL3 was effective regardless of whether participants received auditory feedback from synthetic speech output, visual feedback from the print on the LCD, or a combination of both Three participants increased mastery and met criterion across all conditions for spelling One failed to progress in print only condition. Two participants generalised their learning, increasing accuracy on novel words spelled correctly, however conditions in which they increased their accuracy varied |
| Schlosser et al. (1998) | 1 autistic male student  10 years of age | Main classroom or school library with teacher or SNA | LightWRITER-SL3 | Single case research design (alternating treatments design) | Correctly spelled words  Correct letter sequences Number of sessions to criterion | Words spelled correctly and correct letter sequences increased from 0 at baseline to criterion across conditions post intervention and performance maintained 21 session to criterion were require in auditory, 26 in auditory-visual, 31 in visual |
| Seok, DaCosta, & Yu  (2015) | 1 autistic student (33%), 2 ID (67%),  67% Male (n= 2), 33% Female (n= 1)  8-16 years of age | School library with researcher | Play with the Korean Language | Single case research design (alternating treatments design) | Frequency of the writing practices | All learners substantially increased their frequency of spelling practice across conditions Two of the three showed greater increase in tablet condition One showed greater increase in picture cards condition |
| Spooner et al. (2015) | 5 students, 2 autistic students with an ID (40%), 3 with ID (60%).  40% Male (n=2), 60% Female (n=3) 7-11 Years of age | External classroom with researcher | Name not specified | Single case research design (multiple probe across participants design) | Comprehension Vocabulary Student’s independent correct responses for items on the task analysis of the shared story for each adapted chapter of Charlotte’s Web  - identify book title  - identify authors name  - turn pages  - select correct vocabulary word definition  - answer two comprehension questions  - identify repeated storyline | An immediate effect on task analysis within the first three intervention sessions when each participant was entered into the intervention phase, for all five participants Students increased their comprehension and maintained this post intervention Students also demonstrated skill generalization of identifying the title, identifying the author, identifying correct response to vocabulary, and text pointing throughout the book |
| Whitcomb, Bass, & Luiselli (2011) | 1 autistic Male student  9 years of age | Main classroom with teacher | Headsprout Early Reading | Single case research design (multiple baseline across participants design) | Reading accuracy | Increases in accuracy across all 4-word set and all 4 readers when Headsprout intervention was introduced |
| Williams et al. (2002) | 8 autistic students, Gender not reported, 3-5 years of age | Setting not reported Teacher served as intervention facilitator | Name not specified | Matched-sample crossover design | Reading  Use of expressive language | Students spent more time on task in computer sessions than in book condition Students spoke more than x2 as many words in sessions during computer condition 13 verbal requests for help made in computer condition vs 1 in book condition |

## Appendix C - Table 2 Description of AT Supports Used Within Included Studies (Phase I)

| **Reference** | **Name** | **Description** | **Material Requirement (Web- based or app-based)** | **Device Type** | **Intensity** |
| --- | --- | --- | --- | --- | --- |
| Bryant et al. (2015) | K12 Timed Reading Practice, Howie Finding Vowel, ABC Phonics Word Family Writing | K12 Timed Reading Practice is an application for students in Grades K to 4. It focuses on practice fluency by reading short, timed stories. App records number of stories read and words per min student achieved. ABC Phonics - Students use the application to learn to read by finding common sounds among a set of presented words. A word list appears on the left side of the screen, with a blank section on the right side on which students can write words. Students can also practice pronouncing the word through the speak function. Howie Finding Vowel. In the app, students select a missing vowel in each word by listening to the word spoken by the program. | App-based, not reported if internet required | iPad | 30-minute sessions per day for 14 days over a three-week period |
| Chai, Vail, & Ayres (2015) | Touch Sound | Application that incorporates sound, text, pictures, and video Touch Sound reads a task direction, e.g., "This is kite. Please touch the word that begins with the same sound as kite. Kitchen, bee, ice." | App-based, not reported if internet was required | iPad | Two 10-minute sessions per day Number of weeks not reported |
| Coleman, Hurley & Cihak,  (2012) | PowerPoint | PowerPoint slides with pre-recorded audio 0s time delay computer presented audio immediately with visual image and written word Visual image was then removed from slide Multiple presentations were created so presentation of word was randomised | Other - PowerPoint  No internet required | PC | Not reported |
| Coleman et al. (2015) | Intellitools Classroom Suite Software | Individualised activities designed with target sight words on Classroom Suite. When word is shown on screen, software speech synthesizer speaks word simultaneously. | Other - PowerPoint No internet required | Laptop | 6-13 sessions of each type of intervention. |
| Coyne et al. (2012) | Literacy By Design e-books Scholastic WiggleWorks e-books Riverdeep's Island Adventure and Ocean Adventure | Four universally designed digital story books. These scaffolded e-books focus on comprehension, while also addressing phonemic awareness, phonics instruction, vocabulary, and fluency  Supports are levelled to provide appropriate challenge for readers WiggleWorks - Large library of e-books Island Adventure & Ocean Adventure - interactive exercises and games for teaching phonemic awareness and phonics | App-based, e-books, not reported if internet required | PC | One 20–30-minute session 4-5 times per week |
| Cullen et al. (2013) | Name not specified | Students read words along with computer Then engaged in two of the following activities (random) (a) highlighting words when listening to a teacher direction embedded within the program (b) saying the word into a microphone when it appeared on the screen (c) typing the word (d) dragging the correct word to cloze sentences and/or passages (e) spelling words presented by the computer (f) dragging words from a word bank to match a scrambled word (g) matching the spoken form of the word to the written form | Other - Kurzweil 3000 text to speech program Not reported if internet was required | PC | One 20 - 25-minute session, 3-5 times per week, over 6-10 weeks |
| Doughty et al. (2013) | FLYPen® | Device slightly larger than a pen and writes as such Can only be used on FLYPaper® Each pen top computer comes with a Launch Pad®, an introduction book, and includes general activities that can be done with the FLYPen® Additional software purchase for software for spelling Spelling software activity book contains 10 different word lists with up to 20 words per list 5 activity sheets for each spelling list | FLYPen pen top computer with voice output Not reported if internet was required | FLYPen® pentop computer with voice output | One 30-minute session per day over 8 weeks |
| Felix et al. (2017) | HATLE | An application that shows visual information to the user while playing an audio recording about the purpose and steps to perform activities Speech training exercises show pictographic information while playing a related audio, which the user must pronounce adequately to successfully complete each play activity Drawing activities involve correct drawing of words, letters, lines, and geometrical shapes | Not reported if app- or web-based or if internet was required | Android tablet | One 60-minute session per day over 16 weeks |
| Goo et al. (2020) | PowerPoint | Delivered through voice recorder and PowerPoint slides with built-in audio | Other –  PowerPoint  no internet required | iPad | One 20-minute session, 3-4 times per week until student met mastery criterion (80% correct or above) |
| Grindle et al. (2021) | Headsprout Early Reading | Programme that contains episodes that are individualized and adaptive in that content is altered based on a child’s correct and incorrect responses to preceding instructional stimuli.  Targets five key areas of reading; phonemic awareness, phonics, fluency, vocabulary, and comprehension  Employs four key learning strategies: reduced errors, mastery criterion, guided practice, and cumulative review.  Has an inbuilt rich reinforcement schedule with praise delivered by characters and in-built token economy | Web-based programme | PC Laptop | Three sessions per week (19%) One episode per week (65%) Two episodes per week (16%) |
| Grindle et al. (2013) | MimioSprout | Beginning reading program, delivered over the Internet, which provides a complete instructional program package for teaching the five essential reading components (decoding, phonemic awareness, phonics, vocabulary, and fluency) | Web-based programme | PC | One 15 - 20-minute session at least 3 times per week until 80 episodes completed |
| Heimann et al. (1995) | Alpha | Facilitates language learning through multichannel feedback (voice, animation, video, and sign language) Four main working modes: Individual Words (IW), Creating Sentences (CS), Testing Words (TW), and Testing Sentences (TS) | Not reported if app- or web- based or if internet was required | PC Videodisc player | Group A - Average 25.6 sessions over 16.9 weeks Group MH - Average 21.8 sessions over 17.7 weeks Group NP - Average 7.8 sessions over 6.3 weeks Each session lasted 21-32 minutes |
| Henderson-Faranda, Newbury, & Sutherland (2022) | Reading Eggspress | Teaches literacy skills to primary school age students (5.5–12+ years) through a series of scaffolded lessons that focus on phonics, word recognition, vocabulary, and comprehension | Computer programme, not reported if internet required | iPad | Two 45-minute sessions twice per week totalling 16 for a total of 16 sessions across 8 weeks Additional 15 minutes for sessions also involving a reading comprehension probe |
| Herring, Grindle, & Kovshoff, (2019) | Headsprout Early Reading | As above | Web-based | Not reported | Two sessions per week over 13-18 weeks |
| Knight et al. (2015) | Book Builder | Free, online, authoring tool that allows users to create electronic books  Includes explanatory resources (definitions, etc.), illustrative resources (pictures, etc.), translational resources (simplified definitions), enrichment (background information), and instruction (coaches) | Not reported if app- or web-based or if internet was required | Not reported | Not reported |
| Ko et al. (2011) | TriAccess System | Provides individualised physical, sensory, and cognitive access for learners and also attends to needs of instructors and material developers Database stores curriculum materials and users' profiles, elements of articles (e.g., texts, pictures, video clips) stored separately in database A profile for each learner is used to manage which supports are required | Web-based programme | Laptop | Three sessions Duration of sessions and number of weeks not reported |
| Kouo & Visco (2021) | TinyTap | Social platform app in which educators create and share interactive lessons and games | App-based, not reported if internet was required | iPad | One 20-minute session 5 days per week for 15 weeks |
| Marston et al. (2015) | Name not specified | Instruction included decoding, sight word recognition, and comprehension | Not reported if app- or web-based or if internet was required | PC | One 45-minute session No. of sessions per week not reported, over 10 weeks |
| Nally et al. (2021) | Edmark Reading Program | Whole-word reading curriculum that aims to expand word-discrimination repertoires by teaching the recognition of words as single written symbols that represent an entire word or phrase, without indicating its pronunciation. Feedback was provided through an automated voice as part of the software and there were additional sounds/animations for correct and incorrect responses.  Corrections are all delivered automatically. Programme contains automatic data collection system which records data uses and performance.  Records are also printable | CD-ROM | 87% PC 13% laptops | Average of one 10-minute lesson per day, 5 days per week, over 10 weeks |
| Newell et al. (1992) | Predictive Adaptive Lexicon | A predictive text entry programme that is used in conjunction to a word processor.  It exploits redundancy in natural language to reduce the number of character entries necessary to produce a piece of text | Not reported if app or web based or if internet was required | PC | Not reported |
| Pennington et al. (2014) | Pixiwriter software | Pixiwriter software contained story templates. A series of words were displayed in grids from which students had to construct sentences and stories. | Not reported if app- or web-based or if internet was required | PC | Not reported |
| Plavnick et al. (2014) | Headsprout Early Reading | As above | Web-based | iPad or Tablet | One session per day Duration of session or number of weeks not reported |
| Plavnick et al. (2016) | Headsprout Early Reading | As above | Web-based | Tablet | One session per day, with the length of sessions varying depending on the phase the child was in Number of days or weeks not reported |
| Rasking et al. (1999) | IBM ® VoiceType and DragonDictate ® | Discrete speech recognition systems  No other information provided | Not reported if app or web based or if internet was required | PC | 50 minutes per week over 16 weeks |
| Regan et al. (2014) | Lexia Strategies for Older Students (SOS)™ | Interactive reading software which is highly interactive and follows a structured sequences of reading skills.  The software monitors student progress so that students may only progress to a new skill once the previous has been mastered.  Lexia SOS contains a series of game-based activities (e.g., matching words to pictures, word sorts, mazes, and cloze exercises) that directly target specific phonological awareness and/or phonics-based skills.  Programme provides audio feedback on performance and visual feedback in the form of a bar graph display | Not reported if app- or web-based or if internet was required | Laptop | One 15-minute study session, 5 days per week during the school remediation block |
| Rivera et al. (2017) | Multimedia Shared Story | Created through iBooks Author Books were comprised of two pre-teaching pages with target vocabulary, the story (approximately 14–15 pages), and two review pages at the conclusion of the story (i.e., same as pre-teaching pages)  There were 10 books which aimed to teach the same vocabulary.  Books contained embedded YouTube videos and photographs through different themes | App-based, not reported if internet was required | iPad | 10-12 minutes per day over 2-3 weeks |
| Roberts-Tyler, Hughes, & Hastings (2020) | Headsprout Early Reading Programme | As above | Web-based programme | PC | Three 20-minute episodes per week, over 6 months. |
| Schlosser & Blischak (2004) | LightWRITER-SL3 | Speech-generating device or voice output communication aid  It provides text-to-speech synthetic speech output along with orthographic feedback for the letters and words selected.  It displays information on two screens one for speaker and one for the listener | Not reported if app- or web-based or if internet was required | LightWRITER-SL3 is a device with technology inbuilt | One 5-minute session, 2-3 days per week Number of weeks not reported |
| Schlosser et al. (1998) | LightWRITER-SL3 | As above | Not reported if app- or web-based or if internet was required | LightWRITER-SL3 is a device with technology inbuilt | Not reported |
| Seok, DaCosta, & Yu. (2015) | Play with the Korean Language | App displays pictures of 20 fish and other sea animals with their respective names shown below each picture.  The pictures are accompanied by music from a well-known children's song without the lyrics.  Each name shown with its respective picture is initially comprised of only two or three letters.  When the picture of the sea animal is tapped, its name is pronounced, and the animal's full name appears.  The student then spells the letters displayed | App-based, not reported if internet is required | Tablet | One 15-minute session, 4-5 times per week, over 52 sessions |
| Spooner et al. (2015) | Name not specified | Adapted chapter of Charlotte’s Web presented on iPad 2. The text was programmed to be read aloud using the text-to-speech function.  When the student touched a highlighted vocabulary word, the program was formatted to immediately jump to the vocabulary response choice page to assess student knowledge of the vocabulary word, and then returned to the story when the correct definition was selected.  A modified system of least prompts was used to provide students with rereads of the text if needed to answer the listening comprehension questions.  Once the page was read, the student would touch the iPad2® to activate the reading of the question.  If the student chose the question mark, the student was referred to the page of text with a portion (approximately two sentences) highlighted to direct the student to the correct answer | Not reported if app or web based or if internet was required | iPad | One 15-minute session, 44 sessions total, over 14 weeks |
| Whitcomb, Bass, & Luiselli (2011) | Headsprout Early Reading programme | As above | Web-based programme | PC | ~20-minute lesson, 23 lessons total Number of lessons per day/week not reported |
| Williams et al. (2002) | Name not specified | Books were scanned into the computer. Sounds for characters would play when you clicked on them with a mouse A voice over reading of highlighted words took place when sound button was activated  Card games could be played using pick and grab features. Auto narrated option Positive cheering sounds associated with success | Not reported if app- or web-based or if internet was required | PC | One 15-minute session, 5 days per week, 10 weeks per condition |

## Appendix D - Teacher Survey

**Assistive Technology for Supplementary Literacy Instruction for children with Disabilities: Current Status & Potential for Application in Practice.**   
    
Dr. Aoife Mc Tiernan 1, Dr. Olive Healy2, Shauna Diffley1, Aoife Ryan1, 3, Dave O’ Regan3.

1. School of Psychology, University of Galway.

2. School of Psychology, Trinity College Dublin.

3. Ability West

This research is funded by the National Disability Authority of Ireland.   
   
Turn the page to continue to the survey.

To avail of an online survey format, scan the QR code

Left - University of Galway logo
Right - National Disability Authority logo

**Participant Information Sheet**

**Invitation**  
We would like to invite you to take part in a research study. We are aiming to evaluate assistive technology for teaching literacy/reading skills to children with complex needs.   
    
This research is being conducted by Dr. Aoife McTiernan, C.Psychol., Ps.S.I., BCBA-D at the National University of Ireland, Galway and is funded by the National Disability Authority.   
    
We are inviting teachers who teach children with developmental or intellectual disabilities between the ages of 5-12 years to take part. This Information Sheet will explain more about the research and what it will involve, as well as the benefits of taking part, to help you to decide if you would like to take part. If there is anything that you are not clear about or if you have any questions, we will be happy to discuss those with you. Please take as much time as you need to review this information. This research has been approved by the Research Ethics Committee in National University of Ireland, Galway.  
   
**Introduction and Purpose**  
Learning to read is one of the most essential life skills that we can obtain in order to live a fulfilled and independent life. From the moment we start our education, we begin learning to read, from learning letter sounds, to blending and segmenting, to reading words, then passages, then books until eventually we are reading to learn. Learning to read can be difficult for children with complex needs who may sometimes require more intensive and focused supports. Much evidence has demonstrated the effectiveness of incorporating assistive technology into the learning environment in order to assist with reading instruction with children with complex needs. The addition of assistive technology to the classroom for learning represents a feasible approach to increasing intensity of individualised and effective instruction. To incorporate assistive technology to supplement learning might, at least in part, offer a solution for providing a more inclusive learning environment and to assist educators to meet the needs of their learners with complex needs. However, the extent to which assistive technology is incorporated into Irish classrooms for reading instruction is relatively unknown. Research is necessary to better understand the current use of assistive technology and the barriers and facilitators to adopting such methods into the classroom from educators’ point of view.  
   
**Participation: What does it involve?**  
We would like to learn about teachers’ perspectives on the use of assistive technology to support literacy instruction for children with complex needs. You will be asked to complete a survey which will ask you about your classroom for context, followed by a number of questions relating to your use of assistive technology, the benefits and limitations, and facilitators and barriers to its use in the classroom. The survey will take approximately 15-20 minutes to complete. We will ensure that you and your organisation will not be identifiable within the study. Your participation will be anonymous. You will also be given the opportunity to review your answers before submitting your completed survey.  
   
**Potential Risks or Inconveniences**

There are no foreseeable risks, side effects or inconveniences involved in taking part in this study.

**Potential Benefits**

This study will help us to understand the extent to which assistive technology is used in Irish classrooms to support literacy instruction. Teachers’ insights into the benefits, limitations, barriers and facilitators for incorporating assistive technology in the classroom will be helpful in making recommendations for its future use.  
   
**Your Rights**  
It is up to you to decide whether or not you would like to take part in this research. If you decide that you would like to take part, please check the box below and proceed to the survey. Participation is voluntary. You are free to withdraw at any time up to the point of submitting your responses. Withdrawal after submitting responses will not be possible as your participation is anonymous and your responses will not be identifiable after submission.  
   
**Further Information and Queries**  
When the study is complete, a 1-2 page summary of the results will be available by contacting the researcher. A report will be published outlining the results and will be made available. No participant will be identified in any publication or presentation.  
   
If you would like any further information, please do not hesitate to contact the principal researcher: Dr. Aoife McTiernan, at any time.If you have any questions about this study and wish to contact someone independent and in confidence, you may contact:  
   
The Chairperson of the NUI Galway Research Ethics Committee, c/o Office of the Vice President for Research, NUI Galway, ethics@nuigalway.ie.  
 or   
  
 Principal researcher  
 Dr. Aoife McTiernan, C.Psychol., Ps.S.I., BCBA-D  
 Email: aoifemaria.mctiernan@nuigalway.ie  
 Tel: +35391494448  
   
Thank you kindly for your time and your consideration to participate in this study.

## Consent

I confirm that I have read the above information about the study and have had the opportunity to ask questions o Yes o No

I am satisfied that I understand the information provided and have had enough time to consider the information o Yes o No

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason. o Yes o No

I agree to take part in the above study o Yes o No

Skip To: End of Survey If Consent = No

Do you teach students between 5 and 12 years of age?

o Yes

o No

Skip To: End of Survey If Do you teach students between 5 and 12 years of age? = No

Are you teaching in the Republic of Ireland?

o Yes

o No

Skip To: End of Survey If Are you teaching in the Republic of Ireland? = No

## Section 1 Your Classroom

Q1 Please state your age in years \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q2 What gender do you identify as?

o Male

o Female

o Non-binary / third gender

o Prefer not to say

Q3 Please select one of the following that best describes your school setting:

o Mainstream classroom

o ASD Unit

o Special School

o Other please specify \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q4 Please select one of the following that best describes you:

o Primary Teacher in Mainstream Classroom

o Learning Support/ Resource Teacher in Mainstream School

o Primary Teacher in a Special Education Classroom

o Other (please specify) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q5 Are you currently teaching children /a child with a developmental disability (e.g., intellectual disability, autism, Down syndrome, or other)?

o Yes

o No

o Other Information (optional) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q5(i) How many students are in your classroom?

If you are a resource or special education teacher, please state how many students you typically work with throughout the week.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q5(ii) Please indicate the age range of the students in your current classroom (in years).

o age of youngest student \_\_\_\_\_\_\_\_\_\_

o age of oldest student \_\_\_\_\_\_\_\_\_\_\_\_

Q6 Are literacy goals included on Individualised Education Plans (IEPs) for all learners in your classroom

o Yes

o No

Q6(i) If yes, approximately how many students in your classroom have IEP goals related to literacy? \_\_\_\_\_\_\_\_\_\_

Q6 (ii) If yes, indicate what core components are currently targeted:

▢ Vocabulary

▢ Phonemic awareness

▢ Comprehension

▢ Phonics

▢ Fluency

Q6 (iii) If no, please indicate the reasons why literacy goals are not included on Individualised Education Plans for learners in your classroom

▢ Behavioural difficulties

▢ Lack of pre-requisite skills

▢ Other goals prioritised

▢ Other \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q7 How are literacy IEP goals selected for students in your classroom?

▢ Standardised achievement tests

▢ Classroom assessments of literacy skills

▢ Goals are selected from standardised curriculum

▢ Not Applicable

▢ Other (please specify) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## Section 2 Use of Assistive Technology in the Classroom

Assistive technology is defined as “any item, piece of equipment, or product, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of a child with disability” (IDEA, 2004)

Examples of Assistive Technology used in the classroom include; interactive whiteboard, laptops, PC's, tablets, iPad, learning apps and software, digital assessment tools.

Q8 Do you use Assistive Technology to support literacy instruction with the students in your classroom?

o Yes

o No (If not go to Q9)

Q8 (i) If yes, indicate which core components are targeted through AT:

▢ Vocabulary

▢ Phonemic awareness

▢ Comprehension

▢ Phonics

▢ Fluency

▢ Not sure

Q8 (ii) If yes, list the AT tools that you use below

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q8 (iii) If yes, how regularly do you use the tools listed?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q8 (iv) If yes, what are the most useful ATs for supporting literacy instruction?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Q9 Do you use AT to support the assessment of literacy skills with the students in your classroom?

o Yes

o No (If ‘no’selected, go to Q10)

Q9 (i) If yes, indicate which core components are assessed using AT:

▢ Vocabulary

▢ Phonemic awareness

▢ Comprehension

▢ Phonics

▢ Fluency

▢ Not Sure

Q9 (ii) If yes, list the tools that you use below

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q9 (iii) If yes, how regularly do you use the tools listed?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q9 (iv) If yes, what are the most useful ATs for assessing literacy skills?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Q10 Do you use AT to monitor the progress that your learners are making with literacy skills?

o Yes

o No (If ‘no’ selected, go to Q11)

Q10 (i) If yes, indicate which core components are monitored using AT:

▢ Vocabulary

▢ Phonemic awareness

▢ Comprehension

▢ Phonics

▢ Fluency

▢ Not sure

Q10 (ii) If yes, list the tools that you use below

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q10 (iii) If yes, how regularly do you use the tools listed?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Q10 (iv) If yes, what are the most useful ATs for monitoring progress with literacy skills?

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\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q11 Do you think that the use of AT to support literacy instruction in your classroom is:

Feasible o Yes o No

Beneficial o Yes o No

Useful o o Yes o No

Q12 Do you believe that there are barriers to incorporating AT into your classroom for supporting literacy instruction and/or assessment?

o Yes

o No (if ‘no’ selected, go to Q13)

Q12 (i) If yes, please specify barriers to incorporating AT:

▢ Time

▢ Training needs

▢ Financial barriers

▢ Lack of knowledge

▢ Lack of resources

▢ Not accessible to learners

▢ Other (please specify) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q12 (ii) If yes, suggest how such barriers may be overcome or how teachers might be facilitated to incorporate AT into the classroom more frequently.

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Q13 Do you believe that there are benefits in using AT to support literacy instruction and/or assessment?

o Yes

o No (If ‘no’ selected, go to Q14)

Q13 (i) If yes, please specify the benefits:

▢ It increases the intensity of instruction

▢ It makes lessons more motivating

▢ Less intensive support from teacher necessary

▢ AT is effective

▢ Other (please specify) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q14 Do you believe that there are limitations to using AT to support literacy instruction and/or assessment?

o Yes

o No (If ‘no’ selected, go to Q15)

Q14 (i) If yes, please specify the limitations of using AT:

▢ There is no time to incorporate AT

▢ The lessons are too prescribed

▢ Students prefer not to use AT

▢ Engagement with teacher and peers may decrease

▢ Other (please specify) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q15 Have you received training in the use of AT to support:

Learners in your classroom o Yes o No

Literacy instruction o Yes o No

Q16 If you do not use AT to support literacy instruction and/or assessment with the learners in your classroom, would you consider using AT in the future?

o Yes

o No

o I use AT to support literacy instruction

Q17 Please specify the reasons for not using AT to date (e.g., lack of resources, not much knowledge on AT and literacy instruction)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Thank you for participating in this study.

The study was designed to evaluate assistive technology for teaching literacy/reading skills with children with complex needs.

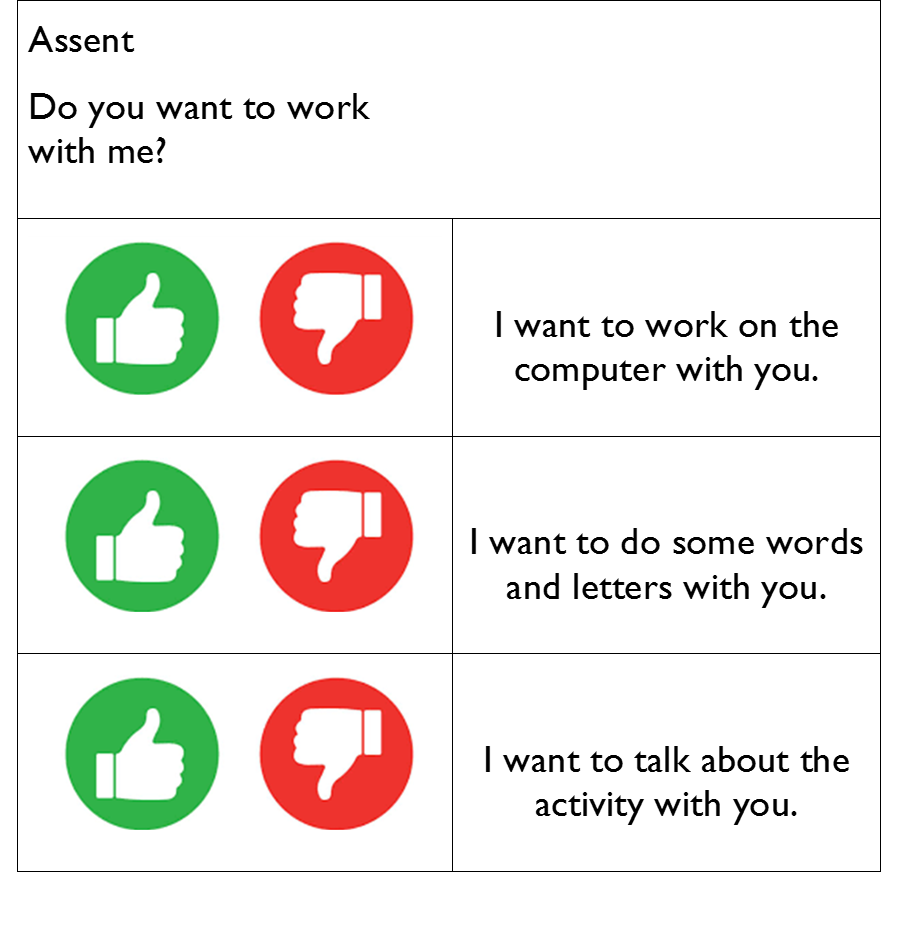
Please use stamped and addressed envelope to return to research team.

What if I want to know more?

If you would like any further information, please do not hesitate to contact the principal researcher: Dr. Aoife McTiernan at anytime aoifemaria.mctiernan@univerisityofgalway.ie Tel: +35391494448

## Appendix E - Child Assent and Survey

Child Assent and Survey 





Preference Assessment

 Child Assent and Survey

1. “Learning disability” is sometimes used interchangeably with ID; therefore, studies were included if participants were described as having a “learning disability” as equivalent to ID but not when described as having a Specific Learning Disorder, e.g., dyslexia. [↑](#footnote-ref-2)
2. The terms 'questionnaire' and 'survey' were taken directly from the relevant studies. No specific distinction was made between them. [↑](#footnote-ref-3)
3. An online screener that identifies those at risk for dyslexia for ages 5-11. Game-based tests include rapid automatic naming (RAN), working memory, phonemic awareness and phonological awareness. [↑](#footnote-ref-4)
4. Thirty participants responded to this open ended question. Some teachers mentioned more than one AT. Teachers weren't required to specify devices and were not restricted to selecting 1 device. Thus numbers do not add exactly to thirty. [↑](#footnote-ref-5)