Learning Technologies for Adult Literacy: State of the Research and Opportunities

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BARBARA BUSH FOUNDATION *for* FAMILY LITERACY

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Executive Summary

The use of technology appears to hold great promise for addressing some of the needs in adult basic education for adult literacy. While arguments around the promise of technology have persisted for over two decades, in this review we show that the actual research in this area is quite sparse. In the same way that funding for adult literacy significantly trails that of K-12 literacy initiatives, research on adult literacy – and specifically on the use of learning technologies for adult literacy – pales in comparison to studies on K-12 learners. However, adult learners have unique needs, and adult education programs face a complex set of challenges in meeting highly variable needs. These should be taken into consideration for the design, development, and implementation of learning technologies for adult literacy learners.

In this report, we summarize the state of the research and provide an "evidence and gap map" that helps to visualize the state of the research. There is a clear need to expand the research in this space to provide a better evidentiary basis to support funding, policies, and programmatic decision making on the use of learning technologies for adults developing their literacies.

We also summarize themes from the existing research that provide insights into promising strategies and approaches to guide the use of learning technologies for adult literacy: use of technologies that are authentically used in day-to-day life for adult learners; use of technologies that afford flexibility and autonomy for adult learners; integration of technologies with in-person learning (rather than replacement); and instructional designs of the technologies that feature practice and feedback, situated learning, and direct instruction. Through these themes in the research, we can better understand how the right questions do not center on which technologies are better but instead center around which design features and implementation decisions influence the efficacy, feasibility, and usability of a tool and therefore lead to effective implementations.

To address these gaps and provide a more evidence-based framework for the use of technologies for adult literacy learning, we recommend the creation of a research network and an agenda that prioritizes usability and feasibility along with efficacy as three important cornerstones to inform technology selections and implementations.

Overview

In 2020, the Barbara Bush Foundation for Family Literacy established a Fellows program, seeking to engage researchers on various needs relative to adult literacy. The focus for one of those fellowships is the use of learning technologies for adult literacy. Dr. Stephanie Moore, then at the University of Virginia and now at the University of New Mexico, was selected for this fellowship, and as part of that she was asked to conduct a review of the research on adult literacy and learning technology. This report is a summary of the work conducted by her and her team at UNM.

The need to address low literacy levels among adults is well-established. According to the latest data from the United States Department of Education, 52% of adults in the US scored below Level 3 on the Program for the International Assessment of Adult Competencies (PIAAC) (U.S. Department of Education, 2020). Level 3 is the level at which adult readers are considered proficient and is roughly equivalent to a 6th grade reading level (National Center for Education Statistics [NCES], n.d.). However, 33% of adults in the United States read at Level 2 on the PIAAC, and 19% read at Level 1 or below. Level 2 means an individual has some degree of reading proficiency but struggles with text-based information, especially if it requires them to critically evaluate the information they are reading or to make meaning across two or more sources. Level 1 means the reader may have difficulty using or comprehending print materials and struggles to draw inferences or combine multiple sources (NCES, n.d.). In raw numbers, Mamedova & Pawlowski (2019) calculated that 65.1 million US adults scored at Level 2, another 26.5 million scored at Level 1, an additional 8.4 million scored below Level 1, and another 8.2 million could not participate due to various barriers (language, cognitive, or some other inability to be interviewed). This totals over 108,200,000 adults in the US who are struggling with text-based information or unable to access it.

Access Barriers

While the need is significant, adult learners encounter numerous barriers to adult education programs and services that endeavor to address this gap. Common barriers cited for adult learners in place-based programs includes changing work hours, access to transportation, reliability of transportation options, childcare needs, and related costs for all the above (Alamprese et al., 2011; Greenberg, 2008; Greenberg et al., 2011; Hock & Mellard, 2011; Miller et al., 2011; Sabatini et al., 2011). These studies also document how known barriers translate into retention and persistence issues among in-person adult literacy programs. Participation rates tracked annually by ProLiteracy reflect the significant gap between the number of adults at Level 2 or below and the number of adults who access adult education services (ProLiteracy, n.d.).

Adult literacy programs also face additional challenges. Many have open enrollments so an adult learner can start and enter any time, but this also means students are entering and exiting programs at highly variable points and have highly variable needs and existing abilities. High attrition rates and unpredictable participation patterns make it difficult to evaluate interventions and learner progress (Belzer & St. Clair, 2007; Dirkx & Jha, 1994). Pickard (2019) also observed that federal accountability policies have further erected barriers to access by inadvertently disincentivizing programs from serving adults with reading difficulties because literacy participants often do not show enough improvement over time on required standardized tests for a program to meet federally mandated targets for funding. This leads to a scarcity of adult literacy classes. Larger literacy gaps can be difficult to close in the mandated windows, motivating programs to focus on learners closer to federal funding targets, such as high school equivalency or workforce credential (Pickard, 2019; see also [a public report from ProPublica](#)).

Many of these issues were exacerbated by the COVID-19 pandemic. ProLiteracy's annual reports document a drop in participation, showing 219,313 adult learners participating in programs prior to the pandemic compared to 148,170 during the initial year of the pandemic. OECD detailed similar drops in adult learning, especially for low-skilled workers (2021). Given the dated nature of the PIAAC data and the impact of the pandemic, it is possible that the need is growing and the barriers to access are also growing.

In response to the pandemic and the need to enact emergency remote teaching (Hodges et al., 2020), adult education programs – like schools and universities – made a significant shift to online and digital tools to maintain instructional continuity. Surveys of programs document increased use of virtual meetings (e.g., Zoom), email, texting, and mail or home delivery (Belzer et al., 2020; ProLiteracy, 2022). Some adult education programs also reported using other technologies such as Google Classroom, YouTube, and gaming or quizzing tools such as Kahoot (Belzer et al., 2020; ProLiteracy, 2022). Belzer et al. (2020) also documented a dramatic increase in the use of online or remote education as a result of the pandemic, noting that the majority of programs did not have distance learning solutions before, but 97 percent reported some use of remote teaching to reach students during the pandemic. Their report also documented that a full 70 percent of programs who previously had no online instruction had moved all of their instruction online. Such moves may have a lasting impact of increasing the digital readiness of adult education programs and educators alike (Belzer et al., 2020).

Possibilities Afforded by Learning Technologies

Technology is not a panacea to all of these challenges, but it can afford options and capabilities that expand the portfolio of adult literacy educational opportunities. Learning technologies that are either designed specifically for or adapted to support

adult literacy may help reduce barriers to access, afford more flexible learning options for busy adult learners, and better meet widely-variable learner needs. In 2000, Snyder stated, "In a world increasingly mediated by communication and information technologies, literacy researchers simply cannot afford to ignore the implications of the use of new technologies for literacy" (p. 98). Rose & Vanek (2017) argued that technologies may offer learners opportunities to improve their reading skills without having to disclose their difficulties more publicly and provide access to learning for adults who cannot or choose not to attend site-based adult education. They also describe technologies such as text-to-speech software that afford more practice opportunities along with the ability to adapt and individualize instruction for learners without disrupting class settings.

In a comprehensive report prepared in 2010 for the National Institute for Literacy, Warschauer & Liaw summarized examples of technologies in use at the time into five categories: multimodal communication, collaborative writing, language analysis and structure, online networking, and one-to-one mobile computing. The report includes descriptions of the uses of these technologies, but their report did not summarize the state of research or whether any researcher indicated the use of these tools helped to address learning needs or bridge barriers to access.

A Persistent Research Shortage

Other researchers in this area have repeatedly noted a significant shortage of empirical research on the use of learning technologies for adult literacy. Rose & Vanek, for example, observed that the research providing actual evidence on the use of learning technologies for adult literacy was "quite thin" (2017, p. 56). Graesser et al. (2020) also recently commented that integration of – and therefore the study of – digital technologies into adult learning has been minimal or absent in major programs that prepare teachers and tutors of adult literacy. Housel & Oranjian (2021) similarly observed that "evaluations of instructional practices in adult EAL programs in the US, including any ed tech used, were not abundant in the recent extant research literature" (p. 61).

It is clear that, while learning technologies may hold promise for adult literacy, there is a sizeable evidence gap. This gap makes it difficult to develop policies and initiatives that are informed by such evidence.

Mapping the Research: The Current State

Given the scope of the problem, the possibilities of technologies to address at least some of the needs and barriers, and the apparent lack of research at the nexus of adult literacy and learning technologies, we sought to map the research terrain at this intersection. By doing so, we can better understand what empirical evidence exists, what that evidence suggests, and what the research gaps and future opportunities are for establishing a better empirical foundation that can inform technology selection and integration practices for adult literacy. Because the literature suggests existing research may be very limited, our primary objective was to search for, identify, and synthesize all peer-reviewed, empirical research on the use of any learning technology for adult literacy. We did not limit our review by methodology (e.g. qualitative or quantitative) or quality of the research or to any particular technology or any theoretical or philosophical definition of literacy. Studies grounded in socio-cultural theories of adult literacy are included alongside studies that focus more on component skills. Rather than limiting the review of research based on a definition and theoretical approach that we may adopt, we wanted to be as comprehensive as possible.

The research questions that guided our review include the following.

- What research has been conducted since 2010 on the use of learning technologies for adult literacy, to include formal, informal, and social contexts?

- What are the substantive features of the included studies, such as context of study (formal education, informal, etc.), literacy levels of the participants (and ways in which this is defined and assessed), country, technological interventions, instructional strategies, and language (English as primary, secondary, or different language)?

- What are the methodological features of the included studies, such as the research methods employed?

- Which literacy skills are targeted in the included studies?

- What are themes or patterns across the included studies, and what are the apparent gaps as indicated by what is not represented in the included studies?

A more formal research paper has been published in Educational Technology Research & Development (Moore et al., 2023 at https://doi.org/10.1007/s11423-023-10270-9). That paper details methodological decisions, inclusion and exclusion criteria, and descriptive statistics and thematic analysis of the findings. In this report, we provide a public summary of those findings along with a discussion on promising directions and implications for policy and funding.

Method

One systematic way to review the literature is a family of methodologies called systematic literature reviews. These are commonly used in many fields such as medicine to summarize findings across multiple studies that focus in the same area or on the same intervention. A scoping review is a specific approach in this family of research methods that was developed to map the relevant literature in an area of interest. Scoping reviews are intended to be as inclusive as possible of research, often including both qualitative and quantitative studies. The primary emphasis is on locating research, which means that opinion pieces and white papers that may be descriptive but are not actually a research study are not included.

Additionally, we also chose to create an evidence and gap map (EGM) as a complementary tool for analyzing and visualizing the state of the research in the field. An EGM is a visual representation that can help both in organizing the findings and in identifying gaps and opportunities for further research. This can become a helpful tool in setting priorities for research, funding, and policy.

For the full study, we searched four major research databases for peer-reviewed research: Education Research Complete, ERIC, PsycINFO and the Web of Science Core Collection. We also conducted an additional hand search using Google to identify any potential "gray literature" (such as reports from non-profit organizations) that may not have been indexed in these databases. We specifically looked for research published since 2010 so as to keep the results recent. We used a combination of search terms combining "adult literacy / literacies" and "adult reading" with both generic terms such as "learning technologies" or "educational technologies" and specific technologies, such as "online learning," "virtual learning," "mobile learning," "mobile app," "AI," "intelligent tutoring," and the like.

Search processes like this can yield many false positives. Part of the systematic process for review involves reviewing the title and abstract for all results returned in the database searches. Two members of our team reviewed the title and abstract for every article in the search results. In the event of a disagreement, the third member reviewed to break the tie. We also reviewed an initial set of 10 together to discuss and strengthen inter-rater reliability, as by the tenth result, we regularly reached consensus. The initial database search yielded 2,861 records. After title and abstract review, 87 records were identified as potentially relevant research.

Studies were included if they met six specific criteria. They had to be research studies. The studies had to include a clear use of a technology as a learning intervention for literacy. The population of the study had to focus on adults clearly (in some papers, the authors were not clear about the population they studied). The

study had to focus on learners who were developing literacy, not using participants who already had strong literacy skills (for example, in some studies, they used a convenience sample of college students for testing, which does not reflect the target population). If we could clearly determine that the participants in the study already had literacy proficiency or proficiency in one language but learning a second language, they were excluded. Studies in developing basic literacy in any language were included. If literacy in a primary language was unclear – as was the case in several instances – those studies were included so as to be as inclusive as possible. Finally, studies had to be conducted since 2010 so we could identify recent research trends and gaps.

We then conducted a full-text review of the initial 87 records. Of those, 66 were excluded because they were not research, they did not have a technological intervention, it was not actually focused on literacy, the focus was not on an adult learner population, the literacy levels of participants in the study were high, or the study was too old. This left a total of 21 studies on the use of learning technologies for adult literacy.

Descriptive Trends in the Research

While 21 studies may seem like a lot of studies to draw from, the studies were conducted across a range of contexts using very different technologies and varying instructional strategies. This makes it difficult to draw conclusions about the efficacy of a given technology or strategy because so few studies (or none at all) exist at any given intersection. For example, the contexts for the studies varied greatly. Eight of the studies were conducted in adult education centers or programs. However, four were conducted in college courses, four in an informal learning context, and the context was unclear in three of the studies. One was conducted in a formal open education initiative, one with incarcerated adults, and one that the authors described as "post literacy" (adults in non-school settings – it is unclear what that means exactly).

The technologies used also varied greatly. Our team identified 15 different types of technologies used across the 21 studies. This makes it very difficult to identify any patterns, as in many cases there is only a single study on a given technology. The largest grouping is of six studies that examined the artificial intelligence (AI) tool, AutoTutor (see for example Fang et al., 2018 and Fang et al., 2021). The second largest grouping of four studies focused on mobile learning. The third largest grouping simply described the technology as "information communication technology" (ICT), which is a very generic term that provides little insight into the actual tools and features.

We also coded the interventions based on the learning strategies employed, such as practice or scaffolding reading (to the extent we could determine the strategy from the study). Often, it is the specific strategy that accounts for learning differences rather than a specific tool, and a type of tool (like online or mobile learning) can employ any number of learning strategies. In the studies we reviewed, we identified 10 different strategies used in the learning technology designs. Again, this makes it difficult to compare or draw any insights about effective strategies because so few studies exist for any one given strategy. The most widely used strategy was gamification (4) followed by practice (3) and direct instruction (3). More generally, there is a larger body of evidence supporting both practice and direct instruction as effective strategies, but the body of research on gamification is emergent.
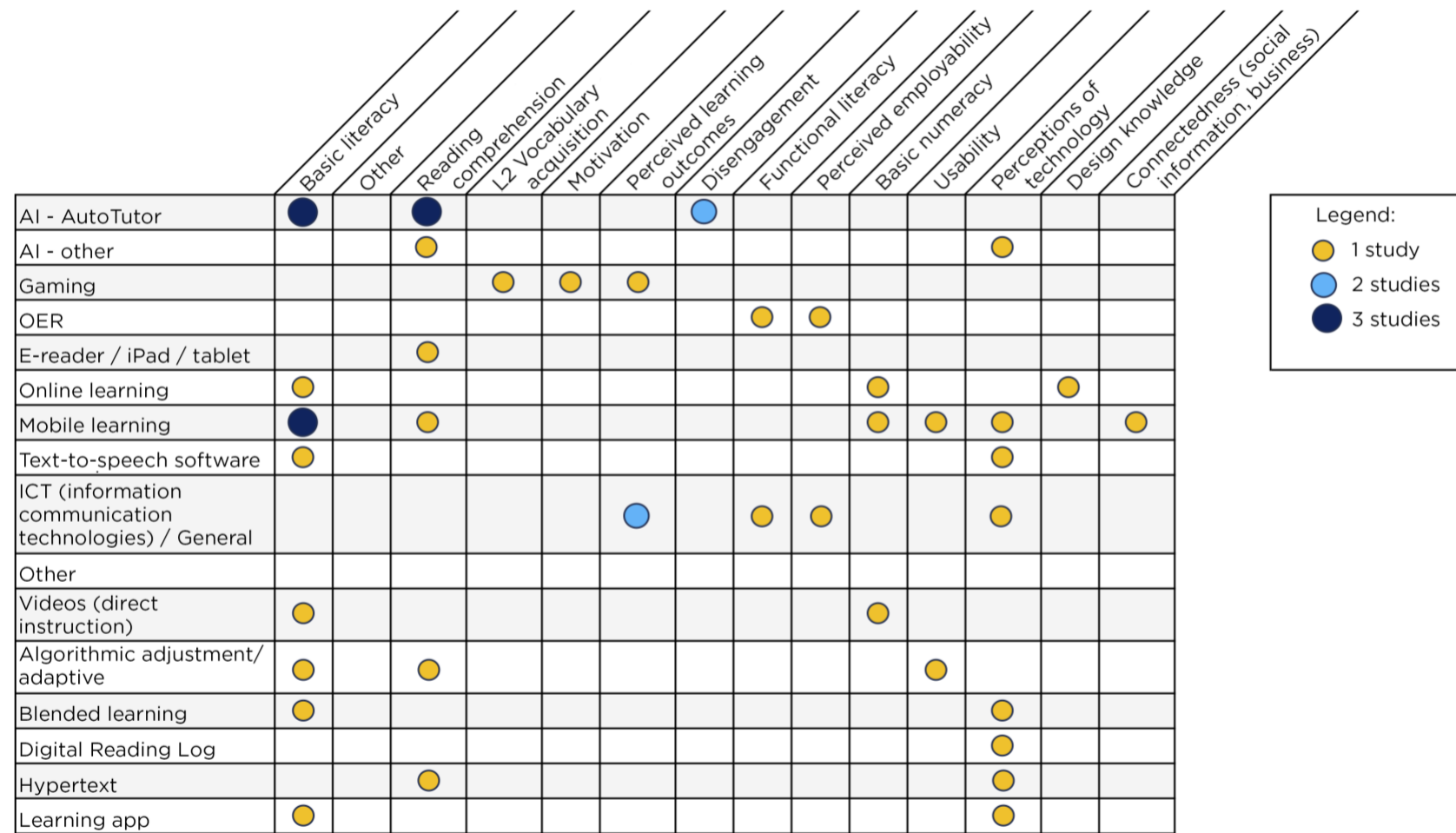
It was also difficult to compare or cluster studies based on the outcomes examined in studies. Although our primary interest and review emphasized literacy, which might suggest an emphasis on literacy outcomes, we identified 13 different outcomes measured in the studies. In many of the studies, the authors measured literacy or reading comprehension as well as other variables, like numeracy, motivation, usability, or disengagement. Eight of the included studies focused on basic literacy, seven focused on reading comprehension, and six focused on perceptions of technology. An additional three did not measure actual learning outcomes but instead measured "perceived learning outcomes," a problematic construct as learners often mis-assess their own knowledge and learning. At this stage, we did not control for quality in the research design and reporting, again opting to be as inclusive as possible.

It is also important to note that literacy levels and what instruments were used to define and measure literacy were equally as non-standard as the other variables. We identified 10 different instruments for determining participant literacy levels. Out of 21 studies, eight did not even clarify or define how they were measuring literacy or what instrument they were using. Two used self-report from participants, meaning the participants estimated their literacy levels. This introduces reliability and validity concerns for those studies. Of the remaining studies, instruments or measures of literacy included use of PIAAC, the B2-C1 in English, Woodcock-Johnson II, CASAS B, CASAS C, Accuplacer, the Gates-MacGintie, and a low-literacy test that was insufficiently detailed. While some of these can be statistically standardized for comparison, others cannot, further limiting the ability to draw cross-comparison insights.
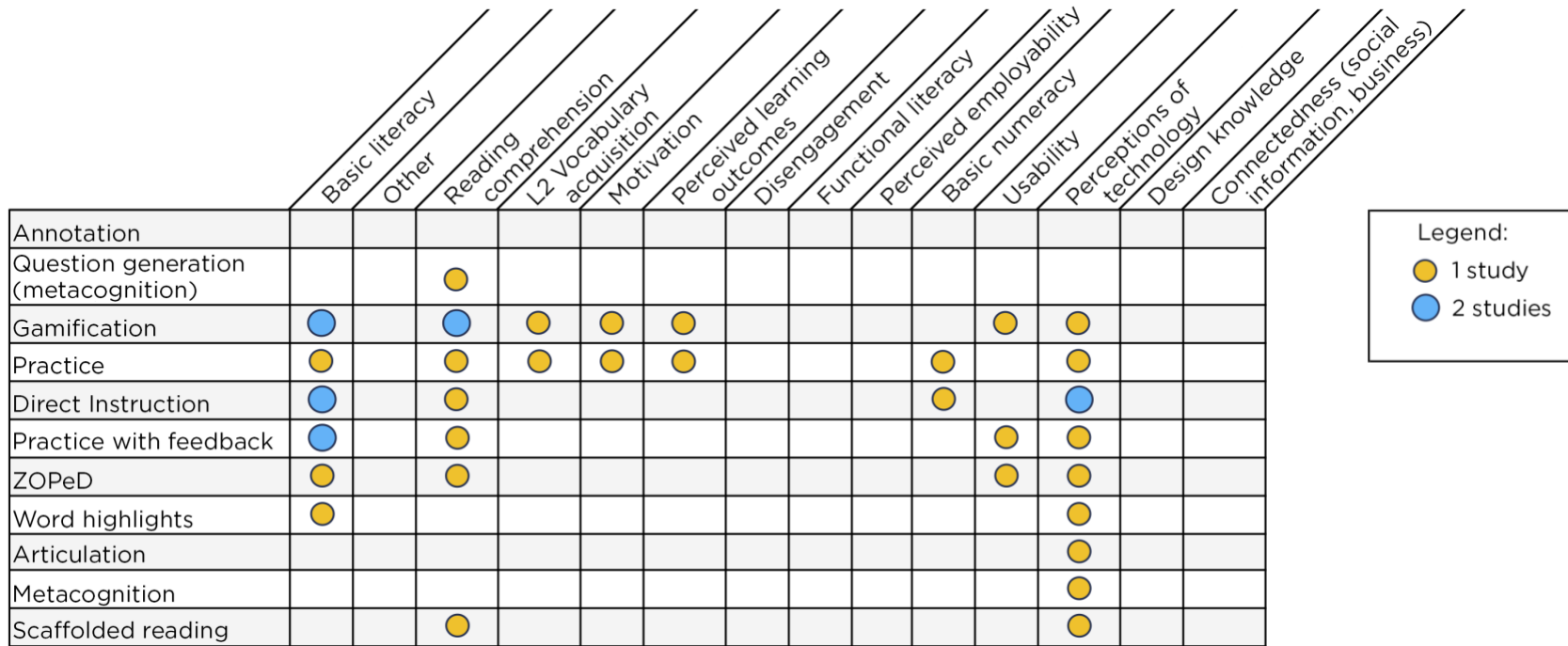
Evidence and Gap Map

The following chart depicts the landscape of research on learning technologies for adult literacy. Small, yellow dots indicate that one study has been conducted on that technology, cross-walked with the outcome measured in that study. Larger light blue dots indicate the presence of two studies at that intersection. The largest dark blue dots indicate three studies. Any blank field indicates that no studies have been conducted with that technology looking at those outcomes (note, not all are desirable combinations).

Figure 1. Evidence and Gap Map (EGM) for learning technologies, mapped to measures and outcomes used in the studies.

Technology	Basic literacy	Other	Reading comprehension	L2 Vocabulary acquisition	Motivation	Perceived learning outcomes	Disengagement	Functional literacy	Perceived employability	Basic numeracy	Usability	Perceptions of technology	Design knowledge	Connectedness (social information, business)
AI - AutoTutor	● (3)		● (3)			◐ (2)								
AI - other		○										○		
Gaming				○	○	○								
OER							○	○						
E-reader / iPad / tablet			○											
Online learning	○									○			○	
Mobile learning	● (3)		○							○	○	○		○
Text-to-speech software	○											○		
ICT (information communication technologies) / General					◐ (2)		○	○				○		
Other														
Videos (direct instruction)	○									○				
Algorithmic adjustment/ adaptive	○		○								○			
Blended learning	○											○		
Digital Reading Log												○		
Hypertext			○									○		
Learning app	○											○		

Legend:
- ○ 1 study
- ◐ 2 studies
- ● 3 studies

We also wanted to examine the gaps related to different learning strategies, since strategy is often a more important variable than the tool. The following chart depicts the research on adult literacy and learning technologies but re-coded based on the strategies used.

Figure 2. Evidence and Gap Map (EGM) for learning strategies employed in learning technologies for adult literacy.

	Basic literacy	Other	Reading comprehension	L2 Vocabulary acquisition	Motivation	Perceived learning outcomes	Disengagement	Functional literacy	Perceived employability	Basic numeracy	Usability	Perceptions of technology	Design knowledge	Connectedness (social information, business)
Annotation														
Question generation (metacognition)			1 study											
Gamification	2 studies		2 studies	1 study	1 study	1 study				1 study	1 study			
Practice	1 study		1 study	1 study	1 study	1 study			1 study		1 study			
Direct Instruction	2 studies		1 study						1 study		2 studies			
Practice with feedback	2 studies		1 study							1 study	1 study			
ZOPeD	1 study		1 study							1 study	1 study			
Word highlights	1 study										1 study			
Articulation											1 study			
Metacognition											1 study			
Scaffolded reading			1 study								1 study			

Legend:
- 1 study
- 2 studies

Interactive Data Set: An open, interactive version of this data set is available at https://eppi.ioe.ac.uk/eppi-vis/login/open?webdbid=125 using EPPI Visualizer. Using this, you can access and visualize the underlying data from this study and generate charts or customize cross-tabs. The EGM generated for this report can be replicated there by selecting Learning Technologies (under Interventions) then "Set Y axis" under the Maps (3D) & Crosstabs (2D) section in the lower right corner, then selecting Outcomes then "Set X axis," then select "Get Crosstab" when that option becomes available. The results will display a table with numerical data. Users can also switch to a Bubble map for visualization to depict the data more visually.

Promising Strategies for Learning Technologies that Support Adult Learners

Although the research remains thin at present, there are some patterns in the research that suggest promising directions and important considerations for design, development, policy, and implementation of learning technologies for adult literacy. Across many of the studies, regardless of the technology being studied, certain themes predictive of effective use and learning are emerging: use of technologies that are authentically used in day-to-day life for adult learners; use of technologies that afford flexibility and autonomy for adult learners; integration of technologies with in-person learning (rather than replacement); and instructional designs of the technologies that feature practice and feedback, situated learning, and direct instruction. What is important to emphasize is that these are not simply technologies that can be plugged in but rather are indicative of the types of tools that may be better (and weaker) fits for adult literacy learning as well as what features in a given tool design may be more desirable. A mobile app, for example, may be poorly designed and not take into account learning sciences and adult learning principles. Conversely, a mobile app may be well-designed based on general evidence-based approaches to learning and also more likely to support out-of-class use because adults may already be using mobile devices, making them easier to integrate with in-person as a more blended approach to instruction.

Evidence-anchored Strategies for Adult Learners

Digital Promise has created a "Learner Variability Navigator" that highlights a suite of evidence-based strategies. They have mapped those strategies to learner characteristics or needs that will vary such as background, social and emotional, cognitive, and types of literacies. Such a resource can greatly inform both technology evaluation and selection as well as the design and development of tools for adult literacy.

Technology That Is Situated and More Authentic

The studies on mobile technologies do not all focus on the use of the same app on the devices. However, the authors of these studies separately suggest that part of the reason for increased outcomes in their studies is the ubiquity of mobile phone use by adults. Across these studies, the use of mobile devices as a form of remote or distance learning suggested that the devices support sustained literacy engagement for adults as they use them in their workplaces and daily personal contexts. For example, Semali & Asino (2014) studied the use of mobile phones to support literacy through two case studies in Namibia and Tanzania. They observed how mobile devices support literacy retention and expansion of skills through situated uses reflective of functional literacy. For example, they observed the use of mobile devices for texting family members and clients, paying for goods, transferring money to friends and family, and engaging in political discussions and processes. This study provides insight into how mobile devices could potentially be useful in sustaining literacy practices. Another study by Chib & Wardoyo (2018) indicates that functional literacy is influenced by digital skills that are supported by mobile devices. This suggests that digital skills training situated in a mobile environment may be a promising approach for developing functional literacy, especially among marginalized learners.

> ### Technology as Situated and Authentic – The Family Place Public Charter School's Use of Mobile Devices
>
> In a report on multiple literacies for learner empowerment (Cacicio et al., 2023), an example of this is reflected in the decision of the Family Place Public Charter School in Washington, D.C. to shift some literacy skill building activities from Chromebooks to mobile devices. The program places particular emphasis on contextualized, real-world learning and integration of English language instruction with digital literacy skills training. They seek to support learners in engaging in daily digital literacy activities by adding mobile phone-based lessons to their suite of tools. Their lead digital literacy and English language instructor, Carlye Stevens, noted, "I realized it is more beneficial to create mobile phone-based lessons because that's the type of device students most often use."

In a third study on mobile learning, Aker et al. (2012) compared the standard adult education program to a program that added a mobile phone learning component. Their study was situated in Niger and looked at learning in 113 villages across two regions. They examined both literacy and numeracy and found that scores for adult learners who received the additional mobile phone component were statistically significantly higher than their counterparts in the standard curriculum control group. In exploring the possible reasons for the differences, they observe that mobile technology may be an effective augmentation to adult basic education where "higher quality" teachers are present and also possibly serve as substitute for lack of access to teachers or the presence of "lower quality" teachers (p. 112-113). They did

find that households in the mobile phone condition were 7% more likely to have and use mobile phones for daily use than those in the control condition. As a result, they also suggest that there could be a positive effect for learners who use mobile apps which require more advanced literacy and numeracy. This can foster higher degrees of learner interest and motivation and also lead to more reinforcement and practice of what they are learning.

Integration with In-Person Learning (Augmentation, not Replacement)

In some of the mobile phone studies as well as others, the researchers described the use of technology as augmentation of adult education and integration of the technology with the standard curriculum rather than replacement or displacement of in-person and site-based approaches. In addition to the examples cited above, one study focused on Newsela PRO describes how an adult literacy and English as a second language program integrated Newsela PRO into their program (Housel & Oranjian, 2021). Learners in their program used the Newsela app on their mobile devices or computers in their personal time away from the in-person instruction, but the program also integrated the use and support of the Newsela app in their in-person instruction. Additionally, the app supported integration of content (in this case, the day's news) that is more suitable and authentic for adult literacy learners, another common challenge for literacy resources and technologies that focus primarily on the K-12 market.

Taken together, these studies start to suggest that the most effective uses of learning technologies for adult literacy center around those that can both be integrated into a program's in-person curriculum and be used by learners outside of any in-person sessions. Promising tools also appear to afford programs ways they can augment their programs, especially with limited resources. In considering the use of a mobile app for adult literacy, one program in a large metro New Mexico setting observed that it could enable them to get learners started while they wait for a spot within in-person classes, especially as the program struggles to keep up with demand due to limited budgets and resources (personal communication).

Opportunities for Differentiated Practice and Feedback

A specific feature of learning technologies that appears to facilitate adoption and integration is whether the design affords opportunities for differentiated practice and feedback. Technologies themselves present different affordances and constraints, and the design of learning apps or software similarly provide varying affordances and constraints. In the study on Newsela PRO, the authors noted how instructors felt the reports provided by the tool supported their ability to adapt instruction to individual learners' needs and provide them more targeted and differentiated content and feedback. That program concluded that the additional

cost associated with Newsela PRO was justifiable because of the additional insights into learners' needs and instructional supports provided in the PRO version. The content in the tool was easily adaptable both for class needs and for individual learners' needs and interests, which appeared to motivate students to read more and develop higher confidence and competencies more quickly by using the tool. They also observed that the tool's design made it easy for instructors to differentiate for learners without making it obvious how the instructors were differentiating instruction. The researchers noted how this can also help to remove learners' sense of "shame," which can be a common barrier or demotivating factor in adult basic education.

This same theme emerges in some other studies as well. For example, in the Aker et al. (2012) study on the mobile app Cell-Ed, they observe that implementation on a range of mobile devices creates expanded opportunities for learners to reinforce their learning and practice targeted areas of need until learners achieve mastery. The curriculum scope and sequence for Cell-Ed reflects a curricular architecture that affords learners the ability to start at the point of instruction they are ready for and complete micro-lessons that include practice activities and assessments that measure application of learning as well as access to remote coaching. These features afford the ability for learners to pursue differentiated learning paths where practice and feedback reinforce their learning without locking them into a one-size-fits-all design.

Learner Flexibility and Autonomy

Adult learning theory posits that adult learners differ in their needs in a number of ways. In particular, adults prefer and even demand learning options that provide them more flexibility and more autonomy (or control) over their learning process. As noted earlier, many of the common barriers to access involve busy and complicated realities of adult lives. Tools that enable more flexible options appear to better facilitate use and adoption, which better supports learning outcomes. In the example of Cell-Ed, the design choice around micro-lessons appears to support the desired flexibility and autonomy of learners as they can easily access lessons on their own time and fit those into their busy daily lives. They also can access that learning option remotely, providing them an additional form of flexibility that in-person instruction does not. Furthermore, the differentiated scope and sequence allows learners to pursue the micro-lessons that they deem most relevant and salient, contributing to motivation to persist.

The study on Newsela similarly highlighted how a flexible tool design can better support learner autonomy and dignity. In the app, learners are able to adjust the reading settings of the content to their reading levels. The team observed that learners would often adjust the reading level to a more accurate or even a higher level for content with which they were more familiar or comfortable. However, when

they encountered more technical or less comfortable content, learners would often adjust the reading level down then readjust it as they developed more comfort or confidence. Similar to a study on wikis by Pellet (2012), they found that the tool can be used to promote autonomy by supporting frequent instructor feedback that is timely and targeted, which scaffolds learners towards becoming more self-regulated in their learning.

It's the Design, Not the Technology

Although the research on the use of learning technologies for adult literacy may be small in scope, there is plenty of research on the use of technology for learning that suggests that it is the design of a given system or tool that influences its efficacy, effectiveness, and uses. Hundreds of comparison studies on online versus face-to-face learning, for example, repeatedly show "no significant differences" between the two modes. One way to understand these findings is through the lens of design rather than technology: carefully designed instruction works in any environment, and designs can leverage the affordances of any given environment (Clark & Mayer, 2016). As we unpack what research exists on learning technologies for adult literacies, we can similarly start to see how design features and decisions play an important role in whether the tools provide additional benefits and how they may be integrated into program planning and curricula to augment programs in ways that afford additional opportunities and reduce barriers to access. Consistent with this broader finding on educational technologies, our analysis has focused on strategies and design features rather than specific technologies.

A Call to Action

The findings from this review of the literature indicate a significant need to invest in and expand quality research on the use of technologies for adult literacy. The two EGMs together highlight many gaps that are also opportunities for expanded research. While we have some notable areas of activity such as the work on AutoTutor, at many of the intersections there is no research (or no recent research) looking at the use of a specific technology or strategy for adult literacy. At other intersections, we only have one study providing one data point. Some of these studies are also qualitative, meaning they do not provide the sort of analysis that can determine comparative efficacy although they do provide other important insights. In a few instances, the studies reviewed have methodological issues, raising concerns about whether the data provided by that study is reliable or valid. At present, we do not have enough studies to do a meta-analysis, which would enable analysis of a specific intervention to assess its efficacy across multiple studies. Some

studies included here would likely be excluded from such an analysis because of quality concerns or methodologies that are not amenable to meta-analysis.

As investments in technologies may be growing, the body of evidence on their use – which can clarify what is working, how well it is working, for whom do different interventions work better, and in what contexts a given technology may be more applicable – remains worryingly thin. Little has changed since other authors' observations on the state of the research. Furthermore, there are no studies that examine implementation and integration that can support those efforts in programs. The EGM for strategies also underscores that as we move past a focus on "things" (the tools) to the underlying strategies and design decisions, there is work to do both in clarifying these features in studies and reports and in further studying what works, how, and for whom.

Learning technologies may hold promise for addressing adult literacy gaps and barriers, but they require more than sales pitches and anecdotes to determine what is actually effective and therefore worthwhile of the investment of resources, time, and programs' efforts.

The Need for a Research Network

What is needed is a coordinated research network and cross-disciplinary community to kickstart a national research initiative. This network should be multi-disciplinary, drawing on expertise, educational technology, literacy, and learning sciences. The research network should also be reflective of the different ways in which literacy is theorized, including both studies that examine component skills as well as studies that are informed by socio-cultural theories of literacy and learning. The mission of this research network should include both expanded research on efficacy and effectiveness of learning technologies for adult literacy as well as implementation and adoption research that can better support programs as the intended adopters and users of any given system. That would include expanded research on the digital literacy skills of instructors and supporting educator instruction and their decision making and instructional uses of technologies (see Vanek, 2022 for a good discussion on this). Finally, we would encourage that such a research network includes educational design research expertise so that the design and development of effective technologies and practices can be documented and studied to capture usability and feasibility considerations in addition to efficacy and effectiveness.

Additionally, not every outcome identified in this review may be of equal priority. Some gaps in the EGM may be acceptable gaps while others may not. And some gaps that appear to be "filled" really only reflect three studies in that space. A clear national research agenda could contribute an articulation of priority areas to focus on and also suggest standard or at least bounded recommendations that could create more consistency in the research on what is studied, what measures are used, and what is reported in studies that allows for better comparison not only of tools

but also across strategies, contexts, learner populations and characteristics, and other important contextual features.

The newly created CREATE Adult Skills Network (https://createadultskills.org/) is a significant effort in realizing this vision for a research network. Technology plays a central role in that network's vision and agenda, with two separate research teams: one dedicated to content-integrated language instruction for adults with technology support and a second focused on further developing the AutoTutor for Adult Reading Comprehension (AutoTutor-ARC). As extensive as this network is, there appears to be still more that an even broader research community could continue to develop. For example, although the research shows interesting trends around mobile apps in particular, mobile solutions do not yet feature prominently in CREATE initiatives. CREATE also has a dedicated team focused on teaching skills, but there are no clear research efforts around technology integration and adaptation in adult education programs.

Through this report, we call upon funding agencies such as the Institute of Education Sciences (IES) and National Science Foundation (NSF) to adopt adult literacy and innovation to address this significant social need as a high-priority research and development agenda. We similarly encourage fellow foundations and non-profit organizations seeking to impact adult literacy and education to adopt research funding in this area as a priority. Funding efforts that can bring more researchers into the fold can help fill these significant research and development gaps. Specifically, multi-disciplinary teams that include literacy researchers, educational technology and instructional design researchers, technical expertise from computer science and engineering, and adult education researchers could be organized around this critical "grand challenge" (https://allinliteracy.org/). Without a robust funding agenda for this research and development, the research communities lack the resources they need to advance this work. Together, we can grow a larger community around evidence-grounded solutions and supports.

We also further encourage other collaborators to identify projects that can help to extend this work. For example, although there are several "seals of approval" and other tools for helping educators select technologies for their content area, etc., at present no such seal of approval exists for learning technologies for adult literacy specifically or adult education broadly. A collaborative effort with an entity such as Digital Promise could contribute just such an evaluation and decision-making support tool to better support adult education programs in sorting through the myriad of products and vendor marketing.

A Proposed Research Agenda

While evidence of efficacy is an important part of the research agenda, we propose a research agenda that considers various facets that are equally as important for technology adoption and implementation. In addition to efficacy, programs often

weigh other factors that can be categorized as feasibility and usability or implementation evidence and information (see Figure 3). Feasibility studies or components in studies can help address factors such as affordability, resourcing and support to provide insights on what considerations should inform technology design, development, marketing, and pricing. Usability and implementation studies can document factors that influence the actual use – or barriers to use – among programs and instructors and also capture important qualitative implementation details that can better support other programs and instructors in integrating a given learning technology to support their learners. These studies should also aim to capture contextual details that shape decisions and uses of technologies so that others considering the technology may better determine whether a given tool may be a strong or poor fit for their particular context and learners' needs.

Figure 3. A proposed research agenda for the use of learning technologies to support adult literacy learning.
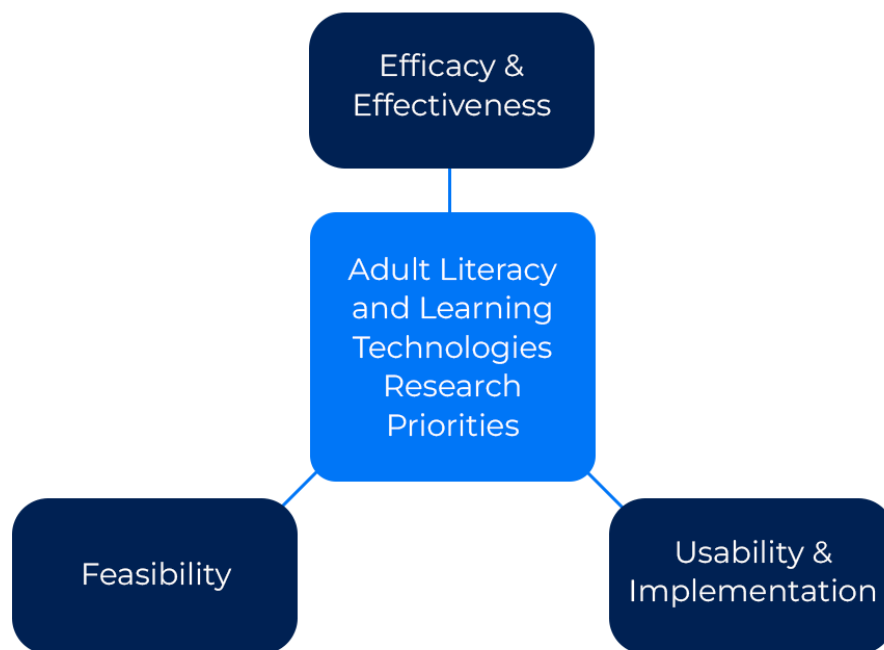
This proposed agenda is similar to Standards for Excellence in Education Research proposed by the Institute of Educational Science (see https://ies.ed.gov/seer/). Those standards encourage research that is "transparent, actionable, and focused on consequential outcomes" through research principles such as identifying core intervention components, documenting intervention implementation and contrast to better inform contextual differences and situated decision making, analyzing costs as well as efficacy or effectiveness, and focusing on outcomes that are meaningful to learners' success.

Conclusion

A clear need and gap exist on evidence of whether learning technologies can help address the significant needs related to adult literacy in the United States. This also presents an opportunity for national partners, federal funding agencies, foundations, and scholarly communities to shape a research agenda that advances multiple lines of research and development while also seeking to grow the community engaged on this grand challenge. Building on the Barbara Bush Foundation's research fellows program, the CREATE Adult Skills Network, and the coalition of partners in the Adult Literacy & Learning Impact Network, we can further advance R&D around efficacy and effectiveness, usability and implementation, and feasibility.

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