Design Opportunities for AIED to Support Parents Learning Literacy

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ABSTRACT

Gaps in adult literacy present major barriers to personal and economic development. In-person adult education has leveraged AI systems to personalize the educational experience, but existing family literacy education programs are often difficult for parents to complete. In this paper, we reframe parents as literacy learners as a rich opportunity for AIED systems to support parents learning literacy with their children. We synthesize prior literature and outline a set of design considerations and design directions for AIED systems to provide unique supports for parents as literacy learners.

KEYWORDS

AIED, family learning, literacy, parents, lifelong learning

1 INTRODUCTION

According to the National Center for Education Statistics, nearly 18% of adults in the United States cannot read at an age-appropriate level [41]. Globally, systemic shocks such as school closures, civil wars and political struggles, and, in many under-resourced contexts, the more mundane but everpresent demands of the agricultural harvest cycle have led to low adult literacy rates, despite rising adult literacy worldwide [41]. These gaps have consequences for people's lives, livelihoods, and wellbeing, with illiteracy limiting access to jobs [27] and, more broadly, presenting obstacles to what educational philosopher Paolo Freire has called "tools for resisting oppression" [20] or, more simply, what the philosopher economist Amartya Sen has called the opportunity for people "to live lives they have reason to value". [44].

For decades, adult education programs have been developed to teach fundamental skills such as literacy [5], but in-person adult education courses face challenges to providing this education at the right time, pace, and level of difficulty for individual learners, in addition to other challenges [28]. Digital learning platforms, such as massive, open, online courses (MOOCs) and educational apps, suggest possible paths forward, and when driven by machine learning technologies, may be able to personalize the learning experience to better support learners. However, despite their equalizing promise, many online educational platforms are primarily used for continuing education by people with a college degree, and are underused by those who lack fundamental literacy skills [11].

Adult learners are more likely to have families than traditional learners. Some have argued that having a family presents "situational barriers" to pursuing lifelong education [38]. While many face-to-face family literacy learning programs have been developed, these face the same challenges to participation as adult education programs more broadly [9], AIED systems *could* offer personalized, targeted support for parents learning literacy, in much the same way as they provide personalized learning opportunities for informal learning and continuing education more broadly. Existing approaches to ML-driven adult learning platforms, however, have largely not addressed the particular needs, desires, and design considerations of *parents* as learners. If they mention parents at all, such systems or interventions treat adults with children as a barrier to learning [39], rather than as an opportunity to leverage parents' interactions with children simultaneously learning literacy to foster mutually supportive and beneficial learning. In this view, parents tend to be seen as being represented by their deficits (Cf. [33]), rather than being agents of their own learning, with their own values, goals, and aspirations.

We focus in this paper on parents learning literacy, as literacy is a fundamental precursor to accessing other forms of education, accessing jobs or economic opportunities, in addition to, as Freire and Sen argue, providing a means by which people may resist oppression and live lives they have reason to value. We contribute here a reframing of parents as learners, from a deficit-based approach to an asset- and opportunity-based approach to supporting their lifelong learning through AIED.

In this paper, we discuss how specific barriers for parents' literacy learning might instead be reframed as opportunities to support their learning, and we begin to map out the design space for AIED systems that can support parents learning literacy by drawing on their strengths, resources, and assets, rather than their obstacles.

2 PRIOR WORK

2.1 AIED for Adult Education

AIED systems and methods have been used in adult education in a variety of ways over the years, from more formal, degree-granting courses, to online learning, to self-directed informal learning opportunities. Much of the work on technology in adult education has focused on what is often referred to as "work and learn", where learners complete certifications or on-the-job training [13] to improve or gain new skills. Some of this AIED work has developed virtual agents as lifelong learning coaches, as in the PAL3 personal assistant [46] to support US naval officers' continuing education. Others have taken a more systemic approach to using ML to support adults' educational development, by developing job advising agents, such as the "Continuous Cognitive Career Companion" [1].

Given the high rates of learner attrition in adult education courses [39] due in part to exogenous factors in learners' lives, some work

has leveraged ML to identify predictors of adult learners' dropout from courses, as in work with English as a second language (ESOL) courses in Turkey [16]. In addition to this work on predicting dropout from in-person courses, prior work has leveraged machine learning to identify predictors of dropout from MOOC courses [39, 53]. To address these dropout risks, other distance learning programs have attempted to use personalized instruction as a means to improve learner retention and outcomes in adult education, with one example from Hong Kong University's lifelong learning program using an intelligent tutoring system (ITS) called SmartTutor to recommend particular content or learning strategies [10].

While some of these approaches for ML-driven supports for adult learning are in online learning environments, others are increasingly leveraging blended learning approaches to supplement online learning with in-person instruction and learning communities [13]. In some cases, particularly in developing contexts where local experts in a particular skill may be scarce, adult education courses are offered which combine online courses (i.e. MOOCs) with in-person meetups to facilitate learners' growth in these courses [15, 32]. This suggests an analogous approach for family learning, where a technology may augment the existing in-person networks of support.

However, many researchers cite conflicts between adults' schedules and the demands of formal adult education courses as reasons for the high rates of dropout in adult education courses [39]. Given this, many ESL adults in the US use everyday technologies like Google Translate and YouTube as sites for language learning across contexts [52]. However, these are typically not explicitly designed to support longitudinal learning, particularly for parents.

2.2 Parents as Learners

A common thread through much of the prior work on AIED in adult learning is that external factors in adult learners' lives such as having a family may be barriers to their learning, rather than resources in their lifeworld that can be leveraged in the design of AIED systems [16]. Parents, like other adult learners, have aspirations for their own growth and development and may want to learn, but they may face unique barriers to completing more formal degree-granting courses due to demands on their time and attention from children - what some have referred to as the "all-hours undertaking" of child-rearing [33].

However, this all-hours undertaking presents unique opportunities for parents to learn while parenting. For instance, in their work on parents' involvement in children's new media learning, Barron et al. describe a variety of roles parents play in their children's learning, from teacher, collaborator, to providing learning resources [4]. DiSalvo et al. extend this taxonomy of roles to also include co-learner, where the parent is also learning along with - or even from - their child [17]. Bannerjee et al. (2018) adopt this frame for their work on English language-learning (ELL) families jointly engaging in computer programming, despite a lack of expertise (or even literacy) on the part of the parents [3].

While decades of research has demonstrated the crucial role that parents play in supporting their children's literacy [31, 45], significantly less research has focused on whether and how parents learn while teaching their children to read. Much of the existing work in this space has instead focused on teaching parents the requisite declarative knowledge about how to teach literacy, suggesting particular letter-naming activities or messages to tell children about reading [55], or designing a coaching program to help parents develop the skills and self-efficacy to foster their children's literacy through joint reading activities [25]. However, prior interventions have largely not assessed parents' literacy (or knowledge of how to teach literacy) either before or after the intervention, and it is thus difficult for those interventions to say what, if anything, parents learned from teaching their children. And yet, significant prior work suggests that teaching others is likely to have learning benefits for the one doing the teaching, if scaffolded effectively for their respective abilities [6, 40]. This prior work, however, has largely focused on peers teaching other peers, or students teaching virtual agents, and has not been designed to provide the scaffolding that low- or non-literate parents might need (and benefit from) when supporting their children's burgeoning literacy. This suggests a need to reframe the idea that having a family is an obstacle to parents' learning - particularly for literacy - in order to see it as an opportunity for AIED to design data-driven scaffolds for parents' literacy learning.

3 DESIGNING AIED FOR PARENT LITERACY

In this section, we propose a set of design considerations for AIED systems to support lifelong literacy learning for parents, and discuss possible design directions for AIED based on these .

3.1 Design considerations for parent literacy AIED

Design to support learning-by-teaching. Substantial prior literature has demonstrated the benefits of learning by teaching - though the majority of this work has been with peer tutoring and virtual agents [6, 40]. In this body of work, students who themselves are not experts in a particular domain (e.g. algebra) receive some scaffolding or support, and then teach or coach their peers, leading to improved learning than if either student were to learn alone [19, 43]. Taking a learning-by-teaching approach would align with prior research on adult learning, which has argued that adult learners are increasingly motivated to learn when they know why and how to use what they are learning, and there is a specific need or goal to learn the content [28]. This suggests that parents may be able to receive "just-in-time" learning supports to foster particular literacy skills just prior to teaching those to their children [7, 35]. However, this requires a sufficiently robust knowledge model of both parents' and their children's literacy abilities in order to provide these just-in-time instructional prompts for the right skills or "knowledge components" that both the parents and their children need.

Some have argued that parents' literacy ability and self-efficacy (or, belief in their own ability) may be an obstacle to their ability to teach their children literacy [26]. However, prior work on Latino-American parents working with their children to teach Spanish literacy suggests that by emphasizing the skills and resources that parents already possess, such as their wealth of cultural knowledge, adults may be able to overcome gaps in explicit domain knowledge [30]. Other work has found that parents' self-efficacy can improve

when they see that their child has learned, and that their instruction was effective [26]. This suggests that an AIED system could provide personalized updates to parents on their children's (and their own) progress, to help motivate parents and bolster their self-efficacy.

Design to support co-learning with children. Literacy is social and cultural in nature, drawing on cultural knowledge and developed through social interactions with others [14, 20]. In intergenerational learning, these social interactions may allow each member of the family to support the others, in mutually beneficial ways [21]. Larrotta and Ramirez found that when low-literate Latino parents were provided with resources to support their children's literacy, their own literacy developed as a result of engaging with the texts their children were reading [30]. In their work on the information-seeking practices Latino American families, Yip et al. found that bilingual children acted as "information brokers" in accessing and communicating online information to their parents [54]. While this work doesn't focus on literacy learning explicitly, it suggests possibilities for mutually beneficial co-learning between children and parents. In a different domain, Roque et al. studied parents co-learning with their children while developing computational media using Scratch and Makey Makey, and found them developing and using skills that neither had when they started [42].

All of this suggests that an AIED system might provide or identify structured "teachable moments" in which parents and their children could engage in co-learning for literacy. This might involve providing reading materials at an appropriate level of difficulty for both child and parent (Cf [2, 48]) or automatically generating structured reading comprehension questions or prompts (Cf. [24]) based on texts that parents and children choose together (as in [30]). Building off of the idea of parents learning-by-teaching discussed previously, in a co-learning approach, AIED systems might suggest complementary knowledge components or literacy skills to learn, by developing a learner model for both parents and children. That is, AIED systems might identify those sets of skills that are mastered by one party (parent or child) and not the other, and design activities to foster the benefits of co-learning that may otherwise occur only serendipitously.

Design to engage other adults, other parents, and community members in the family learning ecology. Finally, we widen the lens of focus from parents teaching or co-learning with children to other adults in the family and adults in other families and the community with whom parents may engage in their learning process. Prior work suggests that literacy learning - regardless of age - draws on what Gonzalez, Moll, and Amanti (2005) call "funds of knowledge" [23] and Yosso (2005) call "community cultural wealth" [56]. These funds of knowledge may involve stories, traditions, family wisdom, values and dispositions towards learning and literacy. Each of these can be resources that AIED - and instructional systems more generally - can leverage to support parents' literacy learning. For instance, speech recognition systems have been developed to improve children's early reading skills [22, 36], or for children's speech-based vocabulary practice [29]. Such speech recognition systems may additionally be able to automatically transcribe oral traditions for family stories and sayings, and provide locally relevant content for parents to use to develop reading skills.

Additionally, school teachers and other representatives of formal learning can provide one method for parents to access literacy instructions, as in family learning coaches (Cf. [25]) or after-school family literacy classes [26]. However, families from historically marginalized communities may face additional barriers for accessing in-school instruction, either due to prior negative experiences with schools or differences in language [17], or, in the US, the very real fear of deportation due to engagement with apparatuses of the state. In prior work on low-literate Latino-American parents in the US, Wong-Villacres et al. found that school liaisons may be able to bridge between families and schools, allowing parents to access information they would not otherwise have been able to [52]. AIED systems may support this family-school learning ecology by identifying the literacy skills parents need most support with, and aligning those with curricular items they could engage with at home. Following the model of the family-school liaison, AIED systems might develop virtual literacy coaches to serve a similar role in providing educational opportunities across school and home contexts.

Finally, parents in other families may provide additional support for parents learning literacy, be that through explicitly teaching reading concepts, providing socio-emotional supports to help motivate parents to learn, or connecting low-literate parents to broader learning networks. Some prior work in connecting parents across families has studied parents' use of technology to develop and maintain social networks with other parents, suggesting that such networks provide a social ecology wherein parents can learn from more knowledgeable or experienced parents [50]. While this work focused on parents' knowledge of parenting, they are able to see other parents in these networks as a model for themselves, fostering motivation and self-efficacy, as well as providing learning opportunities [50]. AIED systems might thus support parents' use of social networks, be they extant networks such as Facebook, Twitter, or WhatsApp, or more dedicated networks just for parents, as in "Parentopia" [49]. Such AIED supports might include recommending particular clusters of parents to talk to for certain literacy topics, or recommending certain reading materials, parenting approaches, or parent-child literacy lessons based on a similar user profile, using a collaborative filtering approach.

3.2 Design directions for parent literacy AIED

To incorporate these design considerations for parents as learners of literacy, we suggest that the AIED field develop methods and advance theories in some critical ways.

First, we suggest that AIED researchers explore new methods, systems, and approaches for **parent-child complementary learner models**. Such approaches may model the literacy knowledge of both children and their parents and suggest content (e.g. particular words) or methods for parents to teach their children, or opportunities for mutual support and co-learning. As a precursor, it will be critical to understand how parents who have mastered a particular literacy knowledge component may be able to develop that knowledge component in their child's literacy practice. AIED researchers may thus also explore what types of scaffolds an AIED system might need to provide to parents to help them teach the concepts they already know, while also helping them develop concepts they have not yet mastered. This may also involve suggesting to parents opportunities for their children to teach them certain concepts in a

collaborative activity. A sufficiently robust AIED system may use the data on children's mastery development to suggest to parents to learn particular skills just before working with their child on that skill, using a "just-in-time" approach. Finally, AIED systems that incorporate these complementary learner models may share theirs and their child's learning progress with the parents, to help motivate them to continue learning themselves, if they can see that their co-learning is beneficial for their children. However, this may require sufficiently open and comprehensible learner models to communicate that learning progress to parents (Cf. [8]).

When and where should all this learning take place? To address this, we suggest research directions for AIED to develop methods, theories, and systems for **contextually-aware family literacy learning**. Given the "all-hours undertaking" of parenting [33], prior work has developed interventions for parents to support children's literacy learning in out-of-school contexts. Some have developed prompts for parents to discuss print in the environment, using foods at the grocery store as a way for children to learn new words [37]. AIED systems might take a similar approach and suggest activities or lessons to learn in a variety of contexts based on the learners' location or inferred activities. Similarly, prior work has developed an intervention to send parents SMS messages with tips or hints on how to help support their children's literacy [55]. AIED systems may build off of this work by adding intelligent recommendations for the preferred context (e.g. time, place, activity, etc) for these activities, suggesting appropriate tips or activities for different contexts. "Context" in this case may also involve more than just the time and place, but may involve the parents' use of other apps. For instance, the work of Wong-Villacres et al. suggests that everyday technologies could be augmented through intelligent support to track parents' learning (e.g. through their use of Google Translate) or suggest ways to augment their learning in apps they use on a regular basis [52]. This may require leveraging a parent learner model as described previously, to model their growth on certain concepts over time, or to suggest opportunities for parents to engage with children's literacy together on apps both use regularly.

Finally, mirroring the use of family literacy coaches, we also suggest that AIED develop designs for **virtual family literacy coaches**. These may take the form of spoken dialogue systems, pedagogical agents in intelligent storybooks, or virtual agents that can engage parents in learning literacy while supporting their children. As others have identified for family learning coaches [25] and family-school liaisons in bilingual communities [52], these mediators play crucial roles in framing the learning experience, motivating learners, and suggesting topics or methods to learn. Prior work on pedagogical agents suggests that such agents can play motivational roles [18] and may be able to provide learning recommendations over time and across contexts [46]. Analogously, a virtual family literacy coach may use the parent-child learning models described earlier, perhaps coupled with context-awareness to identify when, where, or how to scaffold learning.

For instance, joint media engagement between parents and children has been shown to be critical to fostering children's literacy development - specifically for the shared experience of reading together [31, 45]. However, low-literate parents may lack sufficient mastery to read to their children independently. Intelligent storybooks may thus adapt the reading level of the text to the parents' reading ability, or may incorporate a pedagogical agent as a character in the story or playing the role of a virtual literacy coach to support both parents' and children's reading. New theories and models for such virtual learning coaches are needed, however, to understand how to design these systems in ways that are supportive of, and not replacing, this critical parent-child joint engagement.

4 CONCLUSION

Global gaps in adult literacy present barriers for economic and personal development. AIED systems have been developed to support adult education, but this work has not yet developed theories, methods, or systems to explicitly support parents as learners, often viewing the family as an obstacle, rather than a unique opportunity for learning. In this paper, we synthesize prior work on AIED in adult education and parents as learners, and we suggest design considerations and design directions for AIED to support parents' literacy learning.

There remain some large open challenges for this research space not yet discussed. First, for AIED systems to be effective, they may require large corpora of training data - data which may be difficult to collect from families. Families may not want tech platforms collecting data on them or their children, often with good reason, as recent data scandals for in-home intelligent platforms like Alexa reveal. Or, in the absence of such corpora, AIED designers may explicitly knowledge engineer such systems, though this approach may be prohibitively expensive, and may not be robust to changes in learners' needs over time. Further, many parents developing literacy may be bilingual parents from nondominant linguistic groups, and may be literate in another language other than the dominant language. AIED researchers developing parent literacy tools should thus be sensitive to the political dimensions of language, and not unintentionally reinforce existing systems of oppression through their choice of language to teach (Cf. [34]). In fact, in such situations, AIED literacy systems may be able to support interlingual families where children may be literate in a language the parents are not (and vice versa). This may take inspiration from computer-assisted language learning (CALL) systems [47], and from prior work on bilingual children supporting ESOL parents in Latino families in the US [54]. Finally, in this paper we discuss AIED design directions for supporting parents' literacy, but parents are aspirational beings, like all people, with desires, dreams, and goals for other skills beyond literacy. Future AIED research may explore how to support parents learning other skills, such as fundamental math skills [12], learning sign language to communicate with their children with hearing impairments [51], or learning about parenting more broadly [33], among many other skills.

AIED researchers have the opportunity to develop new theories, methods, and systems to leverage parents' interactions with their children's learning as a fertile site for mutually beneficial co-learning to take place. This paper lays out a set of design considerations and design directions for AIED researchers to draw on for designing such systems. We hope that future AIED research views parents as agents of their own learning, with unique motivations, resources, and contexts for learning, and can contribute such systems to support lifelong learning for parents in ways that are appropriate and beneficial for them.

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