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The Science of Adult Literacy

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THE SCIENCE OF ADULT LITERACY

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ABSTRACT

This report considers the science of adult literacy acquisition, with the goal of identifying principles that may improve the effectiveness of adult literacy programs. We define literacy as a continuum, from emerging literacy, through improving literacy, to fluent literacy and we outline the factors that influence how far along that continuum an adult learner is likely to proceed. Four nested levels are identified at which obstacles to literacy progress operate, but to which adult learners may also bring strengths. We consider the evidence base for each of these levels: (1) *The Brain*, where the basic neuroscience of how learning changes over the lifespan gives us clues about processes that restrict adult learning, and hints about how teaching can be optimized for the adult brain; (2) *The Person*, where the roles of motivation, resilience and engagement can have a profound impact on outcomes; (3) *The Learning Environment*, where teaching approach, course structure, fellow learners and technology can all affect progress; and (4) *The Cultural Context*, where integrating expectations and local needs into literacy programs can allow learners to access materials in the most acceptable and appropriate ways. Principles derived from this evidence base are integrated and contextualized in an analysis of six case studies from the field. We indicate areas where further research is required (e.g., determining the degree of practice adults require to achieve fluency); and identify metrics that future literacy programs should collect in order to build an evidence base of properties that improve effectiveness. The evidence summarized in this report suggests that there is scope to improve outcomes in adult literacy programs around the world, and to realize more of the social and economic benefits that such gains provide.

EXECUTIVE SUMMARY

This report considers the science of adult literacy acquisition. Our goal is to identify principles that may improve the effectiveness of adult literacy programs. We define literacy as a continuum, divided into three phases: *emerging literacy* where learners develop symbolic understanding, metalinguistic awareness and basic decoding; *improving literacy*, where complex pattern recognition becomes more rapid; and *fluent literacy* where comprehension takes over from decoding.

The report is structured according to four nested levels: the brain, the person, the learning environment, and the cultural context. At each of these levels we identify both obstacles to progress and strengths specific to adult learners that may help overcome these obstacles.

Level #1: The Brain. The basic neuroscience of how learning changes over the course of a lifetime gives us clues about processes that may restrict adult learning, but also hints at how teaching can be optimized for the adult brain.

We must acknowledge that adults approach learning literacy with disadvantages compared to children. One such disadvantage is the gradual reduction of *brain plasticity* over a lifetime. Brain plasticity refers to the ability of the brain to change in response to the world around it, and its decline may have significant consequences for literacy acquisition in adulthood. Adult learners can compensate for reduced plasticity by using techniques to support learning; these may include learners repeatedly retrieving new information both inside and outside learning sessions; teachers supporting their students to actively engage during learning, rather than passively listening to instruction; and the use of learning materials that draw learners' attention to key features or distinctions. The good news is that nothing indicates severe or intrinsic brain-level limits on adult literacy acquisition.

Despite gradually decreasing plasticity, there are considerable and important skills that adults bring to the task of learning; indeed, many key skills for learning new material peak in adulthood. One important example is *executive function*: a set of cognitive skills that includes sustained attention, planning and meta-cognition (the skill of thinking about thinking). Literacy programs can exploit this suite of skills by making the rules and regularities of written language as explicit as possible, and by encouraging learners to reflect on their own learning progress.

Memory is another strength for adults, and over the course of a session adult learners can make considerable progress. However, in order to keep up momentum, adults need plenty of support to practice their new skills between sessions as well. Regular practice is crucial for adults because a key difference between learning in adulthood and learning in childhood is that adults struggle to maintain progress from session to session. Those cognitive

skills that peak in adulthood tend to do so between the ages of 18 and 30, suggesting that young adults are likely to be most responsive to literacy programs.

This report generally refers to evidence related to learning the Latin alphabet (as used when writing, for example, English). On the whole though, the principles we draw out are transferable: the scripts of the world may vary, but brains are the same the world over. However, some scripts are simpler to learn than others, with transparency (how consistent mappings are between written and spoken language) being a key factor; for example, British English has very poor transparency, while many North African languages such as Swahili are more consistent in their mappings. Under some circumstances, such considerations may factor into the decision about which language to teach literacy in.

Level #2: The Person. The learner is, naturally, the central focus of literacy programs: if those programs do not work for the learner, they simply do not work.

Learning in adulthood can be a slow and frustrating process, so maintaining motivation while minimizing frustration is key to success. A major issue for adult learners is prioritizing learning given the demands on their time, including employment and childcare. Literacy programs must therefore demonstrate their relevance so that learners are motivated to prioritize them.

At the level of The Person we see the vital role that teachers play in engaging and maintaining learners' motivation and momentum. Specific tips for teachers include:

- Teaching students in their mother tongue from the outset to support motivation and program relevance.
- Finding out *why* students want to become literate and helping them actively pursue their learning goals.
- Encouraging student autonomy by offering choice and giving simple rewards in the form of frequent positive verbal feedback.
- Considering the use of external practical rewards, such as family food vouchers, to encourage regular attendance.
- Harnessing the greater powers of adults' metacognitive skills with explicit encouragement to 'think about their thinking' and 'learn about their learning'.
- Encouraging the belief that effort and persistence will pay off, no matter what the learner's starting ability.
- Emphasizing the need for continued practice and working with existing social structures to facilitate it.
- Ensuring follow-up after the taught course is over, with meaningful opportunities to use newfound literacy skills in the real world to support the maintenance and development of proficiency.

Level #3: The Learning Environment. School classrooms in childhood are typically very carefully thought out, with teaching methods, teaching materials and the use of technology

being cornerstones of an environment conducive to learning. Naturally, these factors are equally important to the outcome of adult learning, but all too often are not prioritized or are under-funded.

Every learner knows that a good teacher can make a world of difference, but teachers of adult literacy are sometimes poorly trained in general teaching methods, or not trained for the highly specialist job of teaching adults. Teachers require training in adult-specific learning and where possible, qualified teachers should be drawn from the local community and properly remunerated. Co-learners can also play a pedagogical role in the classroom: actively encouraging peer discussion and providing opportunities for learners to practice and learn together outside of formal sessions supports both individual and group progress.

Presenting literacy not as a binary but as a continuum should reinforce the fact that a single short program will not transform 'illiterates' into 'literates', and learners should be encouraged to develop realistic expectations in this regard. A lack of robust evidence makes it difficult to give precise recommendations for course duration and intensity. Broadly speaking, the more successful programs have run for at least six hours per week for nine months in active learning environments, for each stage of literacy acquisition. In order to read effortlessly, children require around 2,000 hours of practice; we should not expect adults to require very much less. To have the desired effect, short courses must therefore be supported by extensive out-of-class practice.

Increasingly, technology is hailed as offering transformational benefits for adult education, and indeed there are many examples of the successful integration of technology into programs. For the moment however, the role of technology in teaching literacy is realistically quite limited. An option that does offer some benefit is mobile SMS texting, which can be used to encourage practice outside the classroom and is particularly beneficial in encouraging the use of new literacy skills once a taught course is over.

Level #4: The Cultural Context. The cultural context of a literacy program is perhaps the most important component of continuing progress after the end of a formal course, as well as attracting learners in the first place. Integrating expectations and local needs into literacy programs can allow learners to shape programs so that they take place at times and in places suitable to their needs, so that the content is relevant and meaningful and so learners can access materials in the most acceptable and appropriate ways. Understanding the needs of the local community, and working with it to develop courses and plans for post-course continued learning, will support engagement in both the long- and short-term.

Issues of motivation, engagement, and social support are even more crucial for women, who may experience additional obstacles to learning, and who are disproportionately affected by low literacy levels. Removing these obstacles and improving women's literacy has a 'force multiplier' effect, acting as a catalyst to much broader improvements to women as individuals, their families and to society as a whole. There is

sufficiently strong evidence of the knock-on social, economic and health benefits of educating women that working with women should be a priority for literacy programs.

Conclusion: The evidence summarized in this report makes it clear that challenges to adult literacy acquisition operate at many levels: from insufficient repetition of letter-sound matches that might prevent new knowledge from being sufficiently embedded in the brain, to social obstacles that may prevent women from attending classes. Importantly, neuroscience does not currently indicate severe and intrinsic limits for adults to learn education-relevant skills such as literacy. However, some uncertainty surrounds upper levels of proficiency attainable, and the amount of practice necessary to achieve a given degree of movement along the literacy continuum, at different ages. There may also be individual differences in rates and upper levels of learning. These outstanding questions suggest the need for further research. While there is much work to be done, in the lab and in the field, there are grounds for optimism, as the evidence suggests that adult literacy programs around the world can significantly improve adult literacy at all levels, and allow adult learners to access more of the social and economic benefits that such gains promise.

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1.0 AIMS AND OBJECTIVES

This paper is intended to act as a guide for policymakers and instructors to build programs that have the best chance of supporting learners based on what we know about adult literacy and the learning brain.

In 2016, 86% of the world's adult population was classified as being at least functionally literate[1], with functional literacy defined as the ability to read and write a short sentence about one's daily life[2]. Considering that this figure was just 75% in 1990[3], it is clear that progress has been made, reflecting substantial effort on the part of policymakers, teachers and learners the world over. However, even an 86% literacy rate leaves around 800 million individuals over 15 years of age with no, or very minimal, literacy skills, and progress made in the improvement of adult literacy levels this millennium has fallen short of global goals[4]. Importantly, there remain a number of countries, most notably in Southern Asia and sub-Saharan Africa, where literacy rates are still below 50%. Globally, relative educational inequality remains a barrier for women, with around 200 million more illiterate adult females than males in 2015[5], as well as for individuals from low socio-economic backgrounds[6]. Much of the progress that has been made in adult literacy rates results from the improving state of childhood education, rather than from developments in adult education outcomes[7]. Improvements in childhood education make for a promising future, but the relative failure of adult literacy initiatives leaves generations of adults at risk of political disenfranchisement[8], as well as economic and social disadvantage[9].

Literacy is a continuum, ranging from a basic understanding of the mapping between oral and written language, through to fluent, effortless reading and writing. Adult literacy programs often aim to support students in the acquisition of functional literacy, but there are numerous factors determining how far along the literacy continuum a learner will proceed. We should bear in mind when contemplating global literacy estimates that for every person classified as 'illiterate', there are four who have functional, but very low levels of literacy[10]. In the following sections, we map out the process of moving along the literacy continuum and pinpoint some of the impediments to progress that adults might face, as well as the strengths that adult learners bring. The vast majority of available evidence relates to reading, though we will also consider the production of written text where evidence exists.

Achieving any degree of literacy reflects the acquisition of a highly complex skill-set: the rapid recognition of letter and word forms, the retrieval and storage of the meaning of words before building those words into sentences and paragraphs. This is a daunting prospect for adults who may have been denied their right to childhood education. When thinking about an adult learner's journey, it is important to remember from the outset just how long fluent literacy acquisition takes in childhood. For example, brain-level changes reflecting the specialization of the brain for reading continue for at least eight years of formal schooling[11]. This lengthy period of change and improvement in reading is evident despite children spending a considerable portion of the working week, at least through the primary school years, practicing literacy skills. This time-course should be taken into consideration both when designing the structure of adult literacy programs and when managing the expectations of adult learners. That being said, any improvement in literacy skills represents an advance in personal opportunity and is a powerful tool.

Through this paper we consider four nested levels at which adults might face obstacles to learning and to which they bring strengths[12]: **The Brain**, where the basic neuroscience of how learning changes over the lifespan offers clues about processes that restrict adult learning, and hints about how teaching can be optimized for the adult brain; **The Person**, where the roles of motivation, resilience and engagement can have profound impact on outcomes; **The Learning Environment**, where teaching approach, course structure, fellow learners and technology can all affect progress; and **The Cultural Context**, where integrating expectations and local needs into literacy programs can allow learners to access materials in the most acceptable and appropriate ways. These nested levels are illustrated in Figure 1.

After considering each level, we give an in-depth analysis of a selection of case studies from the field. We describe features of these programs that are consistent with the science of learning, and highlight areas of potential improvement, at every nested level. These case studies have been selected to represent different geographical regions and highlight a diversity of approaches which can nonetheless all have a positive impact on learners and their communities. Examples are drawn from a variety of sources, including UNESCO's 'Effective literacy and numeracy practices database' and programs supported by other international agencies, national governments and NGOs.

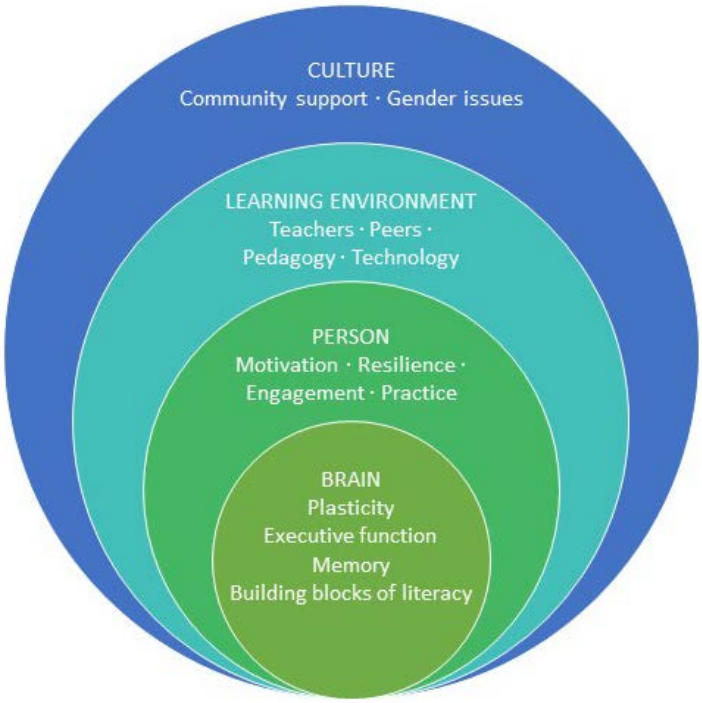
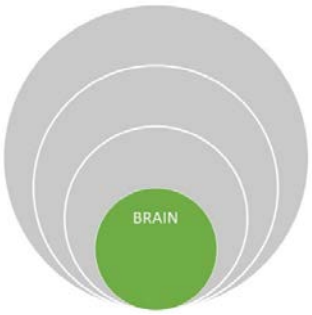


Figure 1. Four nested levels at which adult learning will be considered

2.0 THE BRAIN

Key questions: How might brain-level changes over the lifespan impact on literacy acquisition? What strengths do adult learners bring to the task of literacy acquisition? What are the stages of literacy acquisition in adulthood and what skills are necessary to progress through them?



Over our lifespan, the balance of key neurocognitive processes involved in learning changes. In this section we explore what changes, and how each change may have an impact on how adults learn new material. These changes hold clues as to how literacy development can best be facilitated in adulthood. While the majority of research into literacy acquisition has so far been conducted with learners of the English alphabetic script, most principles of learning will apply to all script types to a greater or lesser extent; throughout this section we point out any deviations from this assumption (see Box 1).

2.1 The plastic brain

Our brains are highly dynamic organs that change dramatically over our lifespan; these changes are normal, healthy and adaptive. One importance change is the degree of *plasticity,* the ease and speed at which the brain learns in response to the environment. Generally, plasticity is thought to decline very gradually through the lifespan[13]. In many animals there are sharp declines in plasticity at certain points in development, such that if specific behaviors aren't learned before that point then they become very difficult to learn at all; these periods of opportunity for learning are known as *sensitive periods*[14]. Importantly, in humans, sharply defined sensitive periods have only been found for very basic sensory processes such as binocular vision[15]; there is no evidence for sharp drop-offs in ability to learn when it comes to complex cognitive processes like literacy[16,17].

Extended plasticity through adolescence and into adulthood is important and reflects the adaptive nature of our gradual acquisition of cultural knowledge. Learning from others over an extended period allows us to acquire language, to use tools, and to read and write. The reduction in plasticity through adulthood is not indicative of cognitive decline. Rather it is reflective of the fact that as adults get older there is less new information in the environment to learn, and adults become adept at applying what they already know to cope

in new situations. The brain must constantly balance plasticity and stability, learning new things when it is necessary, but making sure that important knowledge is not overwritten or in need of re-learning. Over development, we learn two types of ability: those that are typical for our species (like binocular vision and walking) and those that are specific to us as individuals (like the languages spoken and the tools used by the people around us). Things that are typical for our species tend to be learned early and need to remain stable in our brains. When we learn to drive a car, we do not forget how to walk! Abilities that are specific to us can be more flexible, and here we see differences in our trajectories of learning over the lifespan, as demonstrated by people learning their specific native languages. Our native languages are always available to us and, assuming we continue to use them throughout our lives, stability gradually becomes much more important than plasticity: *using* language becomes more important than *acquiring* it.

Information, such as the sounds of our native language, gradually becomes stable in specialist areas of cortex; this is known as *entrenchment*. When learning a second language, we can be held back by decreasing plasticity and increasing entrenchment. We quickly become less sensitive to sounds that are not present in our own language, even over the first year of life[18]; this lower sensitivity can restrict our ability to learn to speak like a native in other languages. By contrast, to use grammar like a native speaker we only need to begin learning by 10-12 years of age[19], while verbal knowledge can be and is acquired over most of the lifespan[20]. Here we see a gradient from sensorimotor aspects of learning, which ideally should be tackled early, to higher-level cognitive aspects which can be easily achieved through adulthood. Crucially, even sensory learning can happen at any time, but brain-level changes are likely to make learning more difficult as we get older, and may negatively affect ultimate proficiency levels. Moreover, there can be differences between individuals in the extent to which reduced plasticity in sensory systems impacts their learning of new sensory skills, such as reading new scripts.

The challenge for adult education is that we are asking the adult brain to be flexible in response to something which may not have been relevant before. We can think about this quite concretely when it comes to literacy. The Visual Word Form Area (VWFA) is a brain region that in literate individuals is highly activated during letter recognition, regardless of the type

Box 1. Scripts of the world

There are five main groups of writing system (scripts) in common usage around the world today, which differ according to how much information is represented by a single written unit: *logographic* scripts such as Chinese, carry the most information in a single symbol, being comprised largely of characters, which represent words or morphemes (the smallest component of a word that carries meaning); *syllabaries* are scripts, such as Japanese kana, where graphemes (the smallest meaningful written unit) represent syllables; *alphasyllabaries* such as Hindi, are scripts where a single unit represents a consonant-vowel pair; *alphabetic* scripts are those where graphemes represent phonemes (speech sounds) or a combination of phonemes; and finally in *abjads* such as Arabic only consonants are represented.

Alphabetic scripts can vary in a number of ways including their complexity (sometimes called depth) which is determined by how regular the relationships are between phonemes and graphemes. In a shallow script such as Swahili, phonemes and graphemes correspond in a very regular predictable fashion. In a deep script such as English, the relationships are much less regular and often context dependent. (See Appendix Table A1 for more information).

of script[21]. Reading speed is strongly and directly correlated with level of activity in this region in response to a known script in literate adults[22]. As a species, we have not used written language for long enough for this area to have evolved specifically for reading; rather it represents an example of 'recycling' areas of cortex that are good at certain sorts of processing already[23]. In the case of the VWFA, this area is predisposed to process shapes with high-resolution seen in the center of our field of vision[24] as well as configurations of lines[25,26]. It is also connected to areas of the brain that process oral language[27]. Indeed, when humans do not learn to read in childhood, this brain region processes objects and faces, and developing literacy in adulthood then reduces the area's responses to faces[28]. This is an example of the brain working hard to undo entrenchment and represent something new with regions that have the appropriate processing attributes.

Reading is a particularly hard skill to learn as it requires adults to unlearn an important principle of object recognition known as *invariance*. Invariance is the phenomenon whereby when we see, for example, a cup, it does not matter which side we see it from or how it is rotated, we still recognize it as a cup. If we were to apply invariance when reading in English we would not be able to tell 'b' from 'd', or a 'p' from a 'q', or a '6' from a '9'. Indeed such 'mirror' or rotation mistakes are common among young children learning scripts that contain mirrored forms that correspond to different speech sounds. The VWFA is particularly good at invariance when presented with an object, but in skilled readers it learns to discriminate mirror images in letters[29, 30].

So, learning to read in adulthood means overcoming reduced plasticity, entrenchment and object invariance[31,32]. Despite all this, neural change does occur when adults learn literacy. Written words gradually come to activate the same brain circuits that children use for reading, demonstrating that plasticity is still present in the adult reading system[33]. As adults start on their literacy journey, the density of neural networks within the reading system increases (as measured in the brain's gray matter), and this change correlates with progress in reading[34].

2.1.1 Tackling plasticity

There are three complementary approaches that adult education programs can take to compensate for gradual reductions in plasticity and the effects of entrenchment in the adult brain; we will return to some of these ideas again throughout the report.

The first approach is to tailor the *schedule* and *type of learning* that adults are exposed to. An ideal learning schedule for adults provides plenty of opportunity for the retrieval of recently learnt information. Every time knowledge is retrieved, it is actively reconstructed and further consolidated, thereby making it easier to retrieve again in the future[35]. Two points are important here: first, to learn new things, adults need to retrieve them; second they need to re-visit the same material repeatedly. Retrieving information can be done with the support of a teacher, by oneself, or with co-learners during group or pair-based activities (the latter additionally working to improve motivation). New information is best learned when presented repeatedly over several sessions and days; this is known as *spaced learning*. For

the medium-to-long term retention of new information, spaced learning seems to be optimal when the same information is presented repeatedly with a day between repetitions[36].

The way that students and their learning materials interact is also extremely important. Learners need to actively engage in class rather than passively listen to a teacher; and there is some evidence that this is more true for adults than it is for children[37], as in adults attention drives plasticity in the brain[38]. In the classroom, attention can be supported and demonstrated by asking adults to respond to educational material. In return, materials presented in class should respond to the changing needs of the learner; this is referred to as *adaptive learning*. During adaptive learning, the material that learners engage with gets progressively more difficult, constantly challenging the learner[39], providing a sense of control as well as a boost to self-esteem as learners see themselves progressing.

The second approach to compensate for changes in plasticity over time is to optimize the nature of the materials presented to students. Presenting appropriate materials can improve the strength with which new information is encoded in the brain. Firstly, features to which learners should pay attention can be exaggerated. This might mean exaggerating the distinguishing features between graphemes, exaggerating distinctions between phonemes, or exaggerating the way that words can be broken down into morphemes and phonemes. These exaggerations can be reduced over time as learners gradually attend to the highlighted features or distinctions. Secondly, material can be presented in more than one modality wherever possible, allowing learners to make the most of their senses. Such multimodal learning might be as simple as making sure learners can both hear and see the teacher; or it might mean using the motor system to support learning the forms of graphemes by encouraging adults to write letter forms as they learn to recognize them. Thirdly, multiple different examples can be used to allow adults to extract the key features that define categories. The letter 'N' is a category of visual objects just as cats are, and just as we learn over time that we can tell a cat by its shape despite how much one cat can differ from another, so we must learn that N has certain consistent features despite being small or capital, print or cursive or typed.

Many of these approaches emphasize the need for learners to pay particular attention to certain things. A teacher or fellow students providing feedback on performance will considerably boost learners' ability to focus on the key defining features or distinctions between graphemes, phonemes or ideas. Many of these principles have been demonstrated with the teaching of non-native phonetic categories, such as native speakers of Japanese learning to hear the distinction between /r/ and /l/, which is not relevant in their mother tongue. Adults have been shown to learn non-native contrasts more effectively when given exaggerated perceptual features[39], multimodal exposure[40], external feedback[39], and multiple examples that slightly differ in their exact form as a result of being spoken by many different people[41].

The third approach which adult literacy programs can adopt to compensate for reductions in plasticity, and which we will consider in the next section, is to actively use the many strengths the adult brain possesses by virtue of skills and knowledge already in place.

In a nutshell, brain plasticity gradually decreases over the lifespan, which may have significant consequences for literacy development in adulthood. Learners can compensate for this by repeatedly retrieving new information, actively engaging in learning and being presented with material that draws their attention to key features or distinctions.

2.2 The many strengths of adult learners

Changes in plasticity represent a major hurdle for adult learners. By contrast, a plethora of cognitive skills crucial for learning peak in early adulthood, and these skills can be exploited by adult education programs to help adults progress more rapidly. The Seattle Longitudinal Study of Adult Cognitive Development[42] tracked the verbal, spatial, number and reasoning abilities of a large group of adults, starting when they were in their mid-twenties, for as long as 42 years. The study found that after fairly stable performance through adulthood, the first significant declines in ability were seen when comparing performance at 60 years-old with performance at 67 years-old, with all abilities tested showing significant decline by age 74. While these estimates are for performance on cognitive assessments, rather than capacity for change, the studies considered in this section all converge on approximately age 60 as the point when cognitive abilities begin to decline at the population level. Whenever the term 'older adults' is used in this paper, we therefore take 60 years of age to be an approximate transitional point. At the other end of adulthood, it is difficult to pin down exactly when the skills we discuss here peak, but between 20 and 30 years of age can be taken as a guide[43].

2.2.1 Executive function

Executive function refers to a set of abilities related to attention, control and abstract thought. These abilities develop very slowly through adolescence and into young adulthood[44] [45], a process supported by the gradual maturation of structures in the frontal lobes of the brain[46]. The slow development of executive function has positive implications for how adults approach learning in a formal setting. At the most basic level, the behavior of very young children is predominantly driven by what is happening around them; over time children, and then teenagers, learn to control their own attention[47] and thought processes. This means that adults can more easily select a task and focus on it, ignoring irrelevant distractors around them; to form and work towards goals and make choices that contribute to those goals; to act flexibly and adaptively. This is great news for adult learners who are learning in sub-optimal environments, for example classrooms with auditory noise or many fellow learners. Notably though, when adults are asked to hold a lot of information in working memory, for example when keeping track of what's happening in a passage of text, those noisy conditions become more distracting[48]. So, although noise should be less of a problem than it is for children in general, when working on material that is particularly challenging it is important for adults to be in an environment that is as quiet as possible.

One aspect of executive function that is particularly relevant to learning in the classroom is *meta-cognition*: the ability to think about thought. Meta-cognition allows individuals to plan, monitor and evaluate their own learning, and is a skill that many adults are likely to excel at. For example, children have to gradually learn to evaluate if they are comprehending a passage of text they are reading[49]; by contrast, adults find such judgments about their own learning much easier to make. Adult education programs can take advantage of learners' meta-cognitive skills by providing context and meaning for adults to hang their learning on. Giving adults ways to engage their higher-level skills supports the development of perceptual learning, which may be slow and frustrating. Ways to do this might include introducing the rules that govern spelling and morphology, or showing learners how words are related by their stem meanings. Strengths in meta-cognition also mean that younger adults can productively monitor their own performance level, and make judgments such as how long they will need to learn new material[50]. Involving adults with decision-making and engaging them in tracing their own learning progress may help to maintain motivation.

Generally speaking, executive function is a relative strength for adults, but performance in this area is also strongly related to years of education[51], suggesting that adult learners who have received little or no education in childhood may need support to develop their executive function skills, including meta-cognition[52]. Learning to learn is an important part of education for children, but may be overlooked in adult education; boosting learners' executive function abilities as part of literacy programs could therefore support key learning outcomes. Meta-cognitive skills can be taught in adulthood, and students who have been taught these skills are more motivated to learn[53], learn better, and learn better on their own, compared to those who have not been taught[54]. An example of training meta-cognition might be to encourage learners to reflect on their experience of learning a topic, and consider what they could do to boost their future progress. Another example is the use of error management strategies, where learners are taught a positive attitude towards making and learning from errors; this has been shown to support working-age adults to be confident learners[55]. Teachers of adult learners can model metacognitive processes themselves by talking about their own thought processes and how they monitor their own performance[56]. We will return to the question of how meta-cognition can be developed, and how it can support motivation in the section on The Person.

2.2.2 Memory

Broadly speaking, learning in the brain relies on two kinds of memory system: *explicit* (declarative) and *implicit* (procedural). 'Explicit memory' covers memory for new events or information. This type of memory is initially stored in an area of the brain called the hippocampus, from where new information is slowly transferred to the cortex with time and sleep. 'Implicit memory' refers to memory for skills and the unconscious learning of sequences or regularities, which are acquired gradually over days, weeks, months or years and are dependent on practice to become stably stored in the cortex. The hippocampus allows very quick learning, while the cortex is more stable over time but needs longer to learn.

The acquisition of literacy is reliant on both explicit and implicit memory. For example, explicit learning is needed to establish grapheme-phoneme mappings and spelling rules in alphabetic scripts, or the meaning of individual characters in logographic scripts. Implicit learning is important for establishing the motor movements of writing letter and word forms, typing and becoming familiar with the regularities within words to read and spell them. Becoming a fluent reader means gradually automatizing the recognition of words and minimizing explicit memory load so that learners can focus instead on the meaning of the text.

Children learn an astounding amount through implicit memory, needing little or no explicit instruction: they learn their native language, learn to walk and to throw a ball. Interestingly, though implicit learning is evident even in very young babies[57], the weight of evidence suggests that the ability to implicitly learn new information over the course of a single training session does not peak until around 18-30 years of age, then noticeably declines after around age 60[58]. Explicit memory, by contrast, is absent in infancy, and develops rapidly through childhood[59], before peaking around the same time as implicit learning. Children therefore rely more on implicit than explicit memory, while adults are strong at both but excel at explicit learning.

Unlike children, adults tend to default to the use of explicit strategies for learning[60], and are more likely to become explicitly aware of regularities in information and therefore generalize them to other examples more easily[61 62]. Learning sequences of items is often used as a test of implicit memory; for example, repeating a sequence of finger taps or listening to a sequence of speech sounds, where items follow a regular pattern, unbeknownst to the learner. Adult, but not child, performance on such tasks is positively related to how aware of the sequence structure learners become[61]. This indicates that supporting adults to explicitly extract regularities will help them more rapidly learn information that a child might learn implicitly over a longer period of time. An example of this might be explaining the rules that govern rhyming when learning phonological awareness, or explicitly stating how morphemes are represented in words or characters.

Despite their superior abilities in memory and executive function (relative to young children), adult learners struggle to acquire high ultimate proficiency in areas of complex cognition. In the case of literacy, we are not aware of any data that considers the rate of reading or fluency level that newly literate adults might expect to obtain. This poses an interesting problem for researchers and educators. One clue to explaining the gap between theory and practice comes from studies considering how individuals at different ages improve in performance over a single session compared to how they improve gradually over longer time frames. Improvement in performance over a single session follows an inverted u-shaped over the lifespan, peaking in early adulthood. However, progress in acquiring the same skills over a longer period of time follows a different trajectory. When learning sequences of stimuli over multiple sessions, adults show greater performance gains over single training sessions compared to children. Crucially though, adults also show a drop in performance between sessions, while children do not. This drop in performance has been found whether sessions are spaced an hour apart[63], or a year apart[61, 64], which means that children can end up with a higher level of ultimate proficiency because their performance progresses even when they

are not actively learning. The tendency for children to not lose skills between sessions has been described as demonstrating more 'developmental plasticity'[65]. The advantage that children have in developmental plasticity has been shown with respect to explicit memory[66], implicit sequence learning with words[61], repeating nonsense words[63], and implicit learning of grammatical structures[62].

Overall, adults show better performance when first introduced to a learning task; they can also be expected to make good progress within any given session, especially when they can use explicit strategies. Importantly, these skills in memory, as well as cognitive control peak just when the majority of adult literacy learning happens, between 18 and 30 years of age[67]. However, session-to-session and long-term progress is more difficult in adulthood, possibly illustrating underlying changes in brain plasticity. This means that adults will need more regular top-ups, more spread out practice (including retrieval) and to be given strategies and reminders to support them in their regular practice. This is where technology might be best used in literacy programs to help prompt adults to practice and give them plenty of opportunities to be exposed to even simple text (we return to the uses of technology in section 4.4).

2.2.3 Oral language

When we read and write, it is with reference to an oral language, so it makes sense that oral language skills influence the proficiency with which language can be translated to and from the page. The most obvious way in which oral language ability supports the development of literacy is through vocabulary knowledge. Both children[68,69] and adults[70] are better at reading and spelling words if they understand the meanings of those words, especially when spelling is unusual. Having good vocabulary also enables readers to accurately guess words which they have been able to partially decode[71], and to infer word meanings from context, thereby relying less on grapheme-phoneme rules and freeing up memory to focus on content. For healthy aging adults, unlike with memory and executive function, the quality and quantity of word knowledge increases gradually until around 60 and then only slightly declines[72]. Word knowledge remains a considerable strength for older adult learners. The use and judgment of grammar also seems to stay stable across adulthood, with little change in grammatical ability into older age[73]. Having a good grasp of grammatical structures in language means it is easier to predict upcoming words in text, supporting the extraction of meaning on the fly. In the following sections we refer back to these skills of word knowledge and grammar to illustrate the strengths that adults bring to different stages of literacy development. We also consider phonological abilities and higher-level aspects of adult language, including inferencing and summarizing.

In a nutshell, executive function peaks in adulthood, and literacy programs can exploit this suite of skills by making rules and regularities as explicit as possible. Memory is also a strength in adulthood, although in order to make progress between as well as within sessions, adults need plenty of support to maintain regular practice.

2.3 The building blocks of literacy

We can think of the literacy continuum as being divided into three broad stages: 1) *emerging literacy*, 2) *improving literacy* and 3) *fluent literacy* (see Figure 2). The term *Functional Literacy*, defined by UNESCO[74] as the ability to read and write a simple sentence about one's own life, can be considered as the dividing line between *emerging* and *improving* literacy. In this section we consider some of the building blocks for each of these stages of literacy development and ask what might constrain adults' path to progression. What is not yet understood is which of these building blocks rely on low-level sensorimotor skills and might therefore be more vulnerable to declines in brain plasticity, and which are supported by higher-level abilities such that learning should show a peak in adulthood.

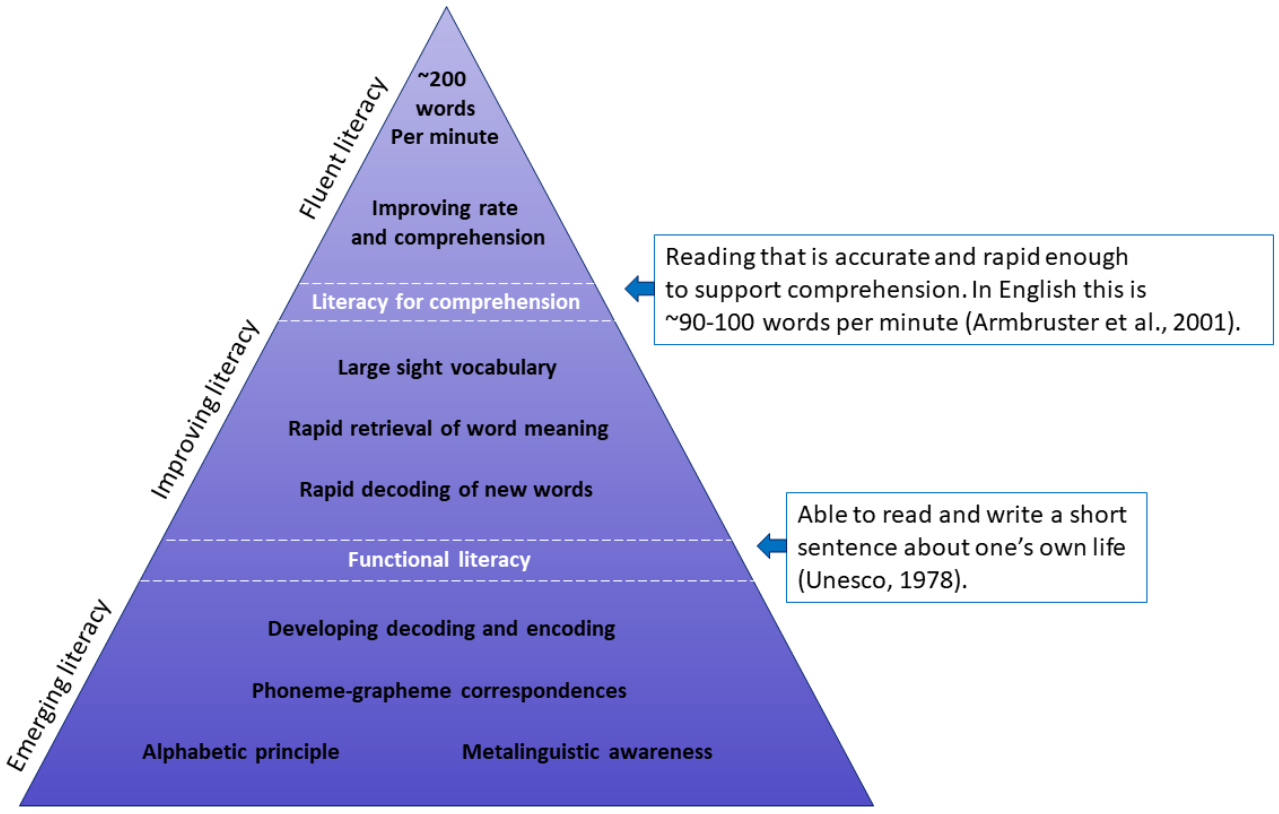


Figure 2. The continuum of literacy development: Emerging, Improving, Fluent literacy

2.3.1 Emerging literacy

The first key foundation stone for literacy is *metalinguistic awareness*. Metalinguistic awareness is the ability to consciously break language down into its constituent parts and manipulate or play with those parts; to know how language fits together. There are three components to metalinguistic awareness: *phonological awareness* relating to the individual sounds that make up words; *morphological awareness* relating to morphology, the smallest units of meaning that make up words; and *orthographic awareness*, relating to the visual nature of written words such as word forms and spelling patterns. Abilities in these three areas together explain the vast majority of reading comprehension performance for adults engaged in basic education[75], as well as early literacy development over childhood[76,77,78]. Overall, low-literate adults show relatively good orthographic awareness but very poor phonological and morphological awareness, with reading errors indicating that they rely more heavily on the visual patterns of words and world knowledge to extract meaning from context, and rely less on their weak phonological skills[79].

Phonological awareness has long been known to play a key role in literacy development over childhood[80] and is central to establishing phoneme-grapheme correspondences. Phonological awareness skills are also a strong predictor of spelling[81] and reading comprehension[82,83] in adults with low literacy, though this population shows very poor performance on phonological awareness tasks in comparison to children matched on reading level. Adults with low literacy have difficulty detecting rhyming words unless the words have similar spellings[84]; they struggle to add[85] or delete[86] phonemes from words, and they find repeating made-up, so-called 'non-words', challenging[87]. Although less fine-grained skills like syllable awareness are often good in adult learners, overall, children outperform adults on phonological tasks, while adults outperform children on visual word

Box 2. Visual attention span

The complexity of literacy means that there are a wide range of cognitive and perceptual processes that could constrain a learner's progress. Candidates include controlling rapid eye movements, pattern recognition, and visual attention span. Research considering the possibility that basic visual processes may constrain progress for illiterate adults is wholly lacking. Visual attention span (VAS) may be a fruitful place to start.

VAS refers to how big and clear the spotlight of visual attention is; it predicts how many letters children can process at a glance[1]. VAS has never been studied in illiterate adults, though in literate adults VAS can be trained, and training results in an improvement in maximum reading speed [2]. If there are low-level visual constraints on adult learning, then computer games might be the best way to remediate them; for example, the amount of time adults play action video games correlates with their VAS and non-word reading ability[3].

[1]Bosse, M-L., & Valdois, S. (2009). Influence of the visual attention span on child reading performance: A cross-sectional study. *Journal of Research in Reading, 32* (2): 230-253.

[2]Chung, S.T., Legge, G.E., & Cheung, S.H. (2004). Letter-recognition and reading speed in peripheral vision benefit from perceptual learning. *Vision Research, 44*:695-709.

[3]Antzaka, A., Lallier, M., Meyer, S., Diard, J., Carreiras, M., & Valdois, S. (2017). Enhancing reading performance through action video games: The role of visual attention span. *Scientific Reports, 7*: 14563.

recognition[84]. One study found that over a year-long German literacy course for adults with very low literacy (with an average of four years schooling in childhood), those with better phonological awareness at the start of the course tended to show greater improvement in literacy skills over the year; the ability to combine sounds to make words predicted around a third of the variance in literacy change[88].

Morphological awareness refers to the ability to reflect on how words are broken down into their smallest units of meaning, the *morphological structure* – for example, being able to segment the word 'unbreakable' into the prefix 'un-' meaning not, the root word 'break', and the suffix '-able' indicating an English adjective. Morphological awareness makes a distinct contribution to reading ability in adults with low literacy, independent of phonological awareness[89]. Morphology provides regularity in the relationships between written and spoken word forms[90], so teaching morphological awareness can be a powerful tool for adult literacy programs by allowing learners to chunk words when reading and writing. Breaking words down into smaller units tells you about meaning and spelling patterns; it also allows you to spot meaning in a text even if you do not know the root word. Morphological awareness is a good example of how explicit teaching can be used in adulthood, encouraging learners to analyze the structure of their spoken language, and making the most of their meta-cognitive strengths. Notably, in typically reading children this skill shows more protracted development than other varieties of metalinguistic awareness, continuing to develop until at least 11-to-12 years of age[91], though the time-course of learning is not known for adults with no or very little literacy.

The evidence from both the child and adult literature strongly suggests that phonological and morphological awareness should be considered key components of literacy programs, right from the start. Meta-linguistic awareness is not only important for alphabetic scripts, but for all script types. In English, orthography to phonology mapping is necessary for decoding newly encountered words, so naturally phonological awareness is highly predictive of decoding success. However, Chinese characters, and all logographic scripts, also have elements of phonemic notation, so, perhaps more surprisingly, phonological awareness also predicts reading comprehension in Chinese, though to a lesser extent. By contrast, morphological awareness is important in both languages[92], but is particularly important for logographic scripts as it gives clues to meaning when there are thousands of characters to learn.

The second key foundational stone for literacy is the ability to map oral language onto writing systems: the establishment of the appropriate symbolic principle of the script an individual is learning. For alphabetic scripts this principle is known as the *alphabetic principle*, and refers to the fact that written symbols are used to represent speech sounds. The more effectively speech sounds can be broken down and manipulated as units in their own right (phonological awareness), the more this principle will make sense and be applicable to both reading and writing. For other scripts the foundational principle will be a little different. For example, in syllabaries, the principle that groups of sounds can be represented by symbols must be established, while for logographic scripts a broader symbolic idea (more akin to the symbolic nature of pictures) is necessary. Although the idea of symbolic principles may seem

trivial for an adult learner, the extent to which adults have been exposed to any form of text in their lives will vary dramatically. For some adults an understanding that visual patterns can represent whole words may be understood, without the subtler understanding of symbol-sound associations.

The alphabetic principle directly relates to the most effective way to teach alphabetic scripts in adulthood. For many years, there has been disagreement about the best way to teach literacy to children, contrasting the relative benefits of phonological (sound-letter mapping) and whole word reading strategies[93]. In line with the dominant and most supported view of child literacy development, work with literate adults learning a novel alphabetic script suggests that teaching the relationships between printed symbols and their associated sounds, rather than the meanings of whole word patterns, results in better reading aloud, generalization to reading novel words, and comprehension of single words[94]. Teaching by whole-word instruction leads to greater brain-level effort[94] and an absence of improvement between sessions[95].

2.3.2 Improving literacy

Having established functional literacy, when students are able to decode and write a simple sentence, further improvement requires gradually recognizing more complex patterns (letters and words or characters) at a faster rate. Practicing complex pattern recognition makes up a substantial portion of literacy development as it requires that learners make very fine discriminations between highly specific visual stimuli. Visual learning of this sort is seen in adulthood, and shows concomitant changes at the level of the brain[96]. There is no research that we are aware of which compares trajectories of learning in adults and children for complex visual pattern recognition, so it is not clear theoretically how quickly adults could progress in comparison to their younger counterparts. What we do know is that visual discrimination of similar patterns is quite dramatically poorer in older adults (around 70 years of age) compared to younger adults (around 20) even with a year of matched practice[97].

Making progress at this stage will be supported by adopting those techniques presented above to address declining plasticity: making new representations of letters, characters and words as stable as possible in the brain. There are two distinct but related processes happening here: making fine *discriminations* between potentially very similar patterns, and being able to group subtly different forms together to form *categories* (letter or characters written in different ways). In order to make discriminations, practicing the hand movements required to create visual forms will support learners. Pre-literate five-year-olds only show activation in the reading circuit of the brain when shown letter forms they previously wrote, but not ones they typed or even traced[98]. Perceptual learning of similar forms has also been shown to improve using discrimination training, where learners are exposed to items where salient differences are slightly exaggerated to draw learners' attention[99]. When paired with feedback on how well learners are making appropriate discriminations, this technique can be particularly effective. In order to support categorization, learners should experience multiple different exemplars during practice. What learners need to do is not only recognize complex patterns but extract the invariant aspects

of those patterns when they encounter them in different fonts, as capitals or lower case, or in different hand writing. By exposing learners to multiple different examples of the same forms[100], they can extract the regularities more easily, allowing all those examples to be categorized as the same complex, meaningful pattern.

For alphabetic scripts, rate of skill development (and perhaps even ultimate proficiency level) is likely to be affected by the depth of the specific script being learnt. The depth of the script refers to the complexity and regularity of mappings between phonemes and graphemes and how easy it is to predict the pronunciation of words based on their orthography[101]. For example, British English has a very deep orthography, with multiple ways in which the same string of letters can be pronounced (compare *through*, *thorough*, *though*, *tough*), while Swahili has a much more shallow orthography, with pronunciation being quite predictable. A shallow orthography means that children learn to accurately read out loud after fewer years of schooling. Reading accuracy in English can lag up to four years behind reading accuracy in the very transparent orthography Hiragana (a syllabic Japanese script)[102]. The visual complexity of scripts also influences the rate at which learners can master the visual form of a written language. With alphabetic scripts, children learn grapheme-phoneme correspondences after a year of schooling[103]; in syllabic scripts it takes 3-4 years of formal schooling[104]; while for logographic scripts learning visual forms continues for more than six years[105]. There is a strong association between how difficult it is to learn the written form of a language and how visually complex the smallest units of that script are[106]. Of course, when deciding which script to learn any consideration about orthographic depth or complexity must be balanced with the many other needs of the learner. Most notably given the importance of oral language skill for literacy development, and motivation, the learner's mother tongue. Orthographic considerations might come into play, for example, when choosing between two native alphabetic African scripts, or between the relatively shallower American English orthography and deeper British English.

Two strengths that adults bring to literacy acquisition will be particularly beneficial at the stage of improving literacy. The first strength is verbal working memory, which refers to the ability to hold information about words actively in mind. Being able to do this as you read through a sentence is critical for understanding, and in children working memory is a good predictor of reading comprehension skill[107]. If you have forgotten how the sentence started by the time you get to the end, then the meaning of the whole will not be recoverable: verbal working memory is therefore particularly important when reading is still relatively slow. The good news is that verbal working memory, like other sorts of memory we have looked at, is at its peak in early adulthood. This gives adults at earlier stages of literacy development an advantage over children at the same point. However, working memory of this sort in adults is also related to years of formal schooling during childhood[108], possibly because students learn effective strategies such as chunking[109] (grouping bits of information together to reduce memory load). This suggests that adults might benefit from being taught verbal working memory strategies to support their developing text comprehension skills as complex pattern recognition becomes gradually more rapid. The second strength of particular note that adults bring to the improving literacy stage is oral language. Adults have a larger vocabulary and a greater ability to bring their world knowledge to bear. This means that when an adult is unsure how a word should be decoded, or cannot remember the exact meaning of a complex

character, they will be more able than a child at a similar level of literacy attainment to use context to deduce the meaning.

2.3.3 Fluent literacy

We can talk about automaticity in reading as moving from effortful decoding to effortless, rapid word recognition. Reading fluency was neatly described by Harris and Hodges in 1995[110] as 'freedom from word identification problems that might hinder comprehension'. Fluent reading requires rapid, accurate word reading, but also, when reading out loud, appropriate prosody (patterns of intonation, stress and rhythm) to reflect the syntax and content of the text. The development of fluency is a critical consideration in adult literacy acquisition as the need to decode individual words in a text places heavy demands on the working memory of the reader. Heavy working memory demands will considerably reduce the amount of information about meaning which can be held in mind, as well as increasing the mental effort required to read. As comprehension is the goal of reading, fluency level is a major constraint on reading skill. Despite this, fluency is an almost entirely un-researched area of adult literacy acquisition. As far as we are aware, no studies of adult literacy have considered reading speed or ultimate proficiency levels, focusing instead on improvements in accuracy. Exactly when fluent reading can be said to emerge has not been formally defined; two estimates are given in the literature, one suggesting that an individual reading an alphabetic Latin script needs to read around 60 words per minute to show comprehension[111], and the other that around 90-100 words per minute are required[112].

Establishing automaticity for even basic motor skills has not been studied from the perspective of lifelong learning, making it very difficult to judge whether adults can expect to enjoy a level of ultimate proficiency equivalent to a child learner. It is important that we remind ourselves here just how long the literacy journey is. Although children make great progress in learning to map the smallest units of script to phonology or meaning over the first year of formal schooling, it takes many years to become really fluent in reading even with hours of daily practice at school. Such substantially long learning trajectories are likely to be frustrating for adults. What is really needed (in terms of research) is data on whether the strengths that adults bring to the table allow them to make progress more quickly, given sufficient practice, or whether changes in low-level brain plasticity practically constrain learning trajectories for adults. No work, of which we are aware, has compared reading progress in adult and child readers practicing for the same amount of time, and without such data it is not possible to draw clear conclusions about how long adults might need to move along the literacy continuum. It is likely that progress in fluency will depend both on frequent, regular rehearsal, and the emergent literacy skills that adults already possess when they begin a literacy program. Level of emergent literacy before embarking on an adult literacy program might depend on how much schooling individuals received in childhood and whether they have been exposed to text such as street signs and brand names, in everyday life.

As at other stages of the literacy continuum, adults bring strong oral language skills to the development of fluent literacy. While vocabulary is particularly important for the stage of improving literacy, here, having a good grasp of the grammatical structures in language is

beneficial. Grammatical skill makes it easier to predict upcoming words, supporting the extraction of meaning as readers work through a sentence. Other aspects of higher-level language which are necessary for reading comprehension[113] are the ability to summarize and the ability to make inferences about ideas which though not directly in a text, contribute to the overall comprehension of a passage. Adults will bring many of these skills into the classroom, and should be encouraged to actively summarize text and talk about the inferences they make, with text comprehension questions focusing on inference and the more abstract aspects of a piece of writing.

What does this mean for adult education programs? Even though there are ways to support the establishment of automaticity in adulthood, trajectories of learning may be slow and consequently frustrating. It is important for learners to have realistic expectations about how long it takes to establish automaticity. Slow progress in sensorimotor tasks can be teamed with the more rapid development of explicit knowledge such that learners do not feel demotivated. One way to support the development of fluency with adults is through the use of a repeated reading program. During repeated reading, learners read the same short passage of text out loud repeatedly, until they reach a pre-specified goal of rate and accuracy. This can be done in conjunction with other learners or, ideally, one-to-one with a tutor. Repeated reading has been shown in learners enrolled on an adult education program in the USA[114] to result in fluency gains on standardized tests, but also more basic reading skills including word reading accuracy.

In a nutshell, the literacy continuum can be divided into three phases: *emerging literacy* where learners develop symbolic understanding, metalinguistic awareness and basic decoding; *improving literacy*, where complex pattern recognition becomes more rapid; and *fluent literacy* where comprehension takes over from decoding.

What are the conclusions from the level of The Brain? We have seen that brain-level reductions in plasticity over the lifespan might have an impact on the ease with which adult learners can acquire new literacy skills. However, by drawing attention to relevant new information and by engaging learners in frequent, regular practice, educators can ameliorate the effects of this change. Optimizing teaching programs for the adult brain requires consideration of both the limitations of learning later in life but also the many strengths that adults bring to the classroom. We have seen that these strengths include executive function, memory and oral language skills. Encouraging the use of these skills, and developing them where necessary will help adult learners progress gradually over time. Figure 3 shows approximate trajectories of some of the aspects of learning discussed in this section: brain plasticity, executive function and word knowledge. These feed through to an understanding

of the building blocks of literacy as they relate to the literacy continuum, from emerging, through improving, and on to fluent literacy.

As we will see next, even though one can identify key principles at the brain level, actual adult literacy programs have multiple features, some which accord to those principles and some which do not. Moreover, practical factors may limit a given program's effectiveness even when principles from an understanding of the learning brain are evident.

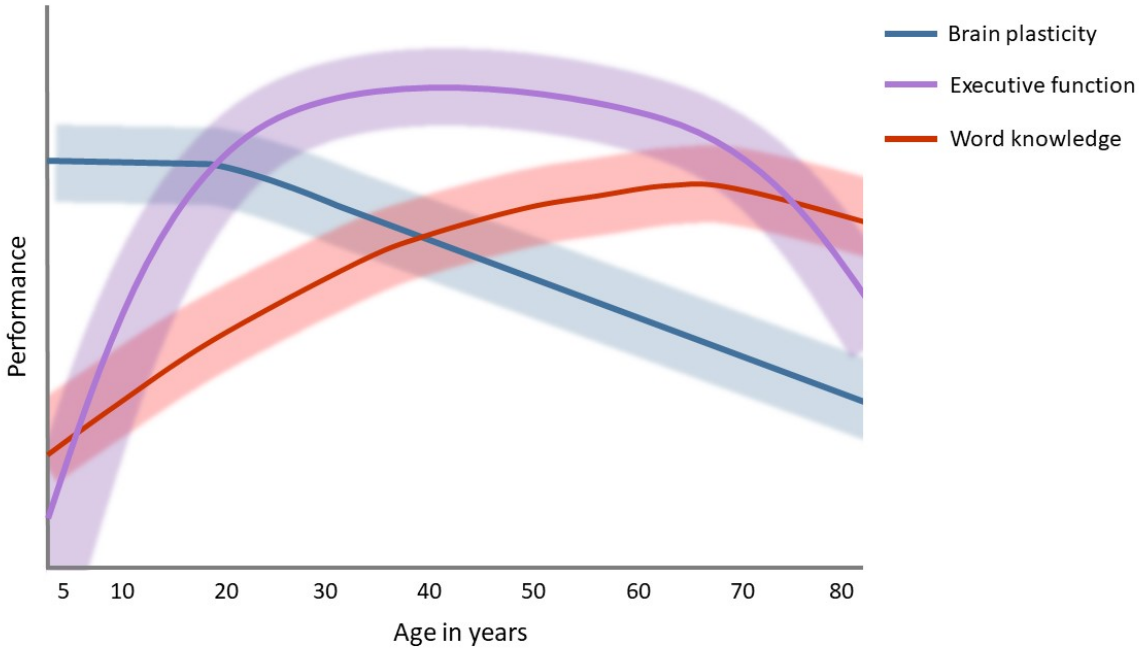
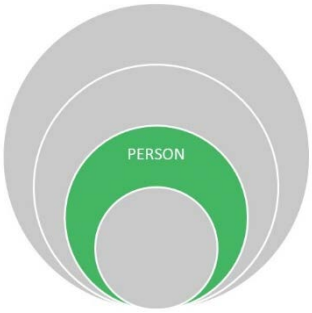


Figure 3. Approximate trajectories of change in brain plasticity, executive function and word knowledge over the lifespan.

3.0 THE PERSON



How can intrinsic motivation be maintained when learning is slow and difficult? What kinds of rewards are beneficial? What are the most effective ways to minimize learner frustration? How can programs be made relevant enough for learners to engage? And how best to encourage the consistent, regular practice needed to bring about long-term success?

We now move beyond the cognitive neuroscience of learning to read and write, to consider factors operating at the level of the individual, the learning environment and the wider cultural context, all of which can profoundly affect success.

While there are important differences in how the adult brain learns compared to the child's, at the level of the person, there are also important similarities, including our basic physiological needs. People who are hungry, tired, over-stressed or unwell will not learn effectively and interventions can target these basic needs; for example, breakfast clubs have proven effective for improving learning in primary school children in the UK[115]. Beyond these basic needs, some key principles derived from decades of science of learning research show that children "learn best when they are cognitively active and engaged, when learning experiences are meaningful and socially interactive, and when learning is guided by a specific goal." [116] (See also[117] & [118]). There is no reason to believe adults are different[111]. In this section, we consider how to maximize motivation, resilience, meaningfulness, and engagement, and encourage the considerable and enduring practice needed for the long-term mastery of written language.

3.1 Motivation and rewards

Many factors can lead to low motivation and potential drop out. Learning to read is demanding. We saw previously that the brain must work hard to undo entrenchment, and difficulties persist at every level: learning takes a long time, it can be physically difficult (e.g. seeing the board, cramped classroom conditions, noise), morale can be lost through slow progress, teaching might be poor, peer relations might be uneasy, there could be conflict with the family or the wider community[111], learning itself might carry a financial burden if attending a course means foregoing paid work and disengagement is easier since learning for adults is not mandatory. Dealing with the consequences of loss of engagement through frustration, boredom and apathy is difficult; it is much better to try to design programs to minimize the chance of these consequences happening in the first place.

Motivation is composed of two aspects: *intrinsic motivation*, driven by an individual's internal rewards and sense of satisfaction, and *extrinsic motivation* which is driven by external

rewards such as money, praise or prizes. While intrinsic motivation appears to be an incontestable positive for learning, extrinsic motivation is more complex[119]. A classic piece of research on children[120] showed that extrinsic rewards can undermine intrinsic motivation putatively by over-emphasizing the quest for goals over pleasure in process. This contributed to a prevailing view that extrinsic rewards should be avoided. However, the more recent view is that this is an over-simplification[121]. A recent meta-analysis[122] testing the effects of extrinsic reward on intrinsic motivation found that while tangible rewards can indeed undermine intrinsic motivation, this might not be true for all kinds of learning and all kinds of learners. Notably, the study found that the adverse effect of extrinsic reward was greater in children[123] and additionally that reward in the form of positive feedback substantially improved self-reported interest, particularly for adults. When motivation is required over extended periods and when a learning situation might be difficult and boring, external rewards, such as food vouchers, might also help[124].

Recent work has also looked at the concept of 'situational interest'[125]. This typically refers to a one-off external trigger which, although extrinsic, can sometimes provide the impetus for a learner to become engrossed and so boost intrinsic motivation. The introduction of simple choice (e.g. which book would you like to read?) has been shown to improve learning[126], a finding consistent with the idea that an enhanced sense of control over learning improves persistence and motivation. In children, reward solely in the form of access to richer information has been shown to enhance engagement and motivation[127]. Several researchers[128,129] have also shown that teaching style is an important factor in motivation; the students of teachers who support students' autonomy have higher intrinsic motivation and greater self-esteem (and better educational outcomes) than those with controlling teachers.

Rewards can influence learning not only indirectly through their effect on motivation, but also directly through their influence on memory[130]. Extrinsic rewards can promote memory consolidation through activating the brain's reward system[131] and this 'reward network' circuit appears to be engaged by feedback alone[132]. Some recent work[133] suggests that expectancy and anticipation of reward can be as important as the reward itself in improving learning. This has led to current investigations of the efficacy of applying this finding in the classroom by introducing a game-like environment, where rewards are uncertain[134].

In a nutshell, teachers can encourage student autonomy by offering choice and giving simple rewards in the form of frequent positive verbal feedback. Access to richer information enhances engagement and motivation. Consider the use of external practical rewards, such as regular food vouchers, to encourage regular attendance.

3.2 Resilience and frustration

Even in perfect conditions (and most adult learners lack those, instead dealing with poverty, hard physical work, care of young children and more), learning to read and write takes a great deal of mental effort over an extended period of time. We sometimes characterize children as learning 'effortlessly' but in reality, as we have seen, they are engaged in literacy acquisition on an almost full-time basis for many years. There are no miracle short-cuts to literacy. How then can the considerable commitment and resilience required be nurtured?

The 'first stop' in minimizing frustration is designing programs that are meaningful, engaging, social and relevant[117]. Otherwise even the most resilient learner will struggle. Beyond this, some specific skills of adult learners can be harnessed to encourage them to continue even when they experience frustration or boredom. As we have seen in part one, adult learners benefit from *explicit* learning and teaching approaches - and that is highly relevant here, where metacognitive strategies, making explicit not just learning but 'learning to learn', reflecting on learning and goal-setting are all important[135].

Growth mindset[136] (in which students are taught that their abilities are not pre-determined but can be improved with effort and persistence) and its putative influence on academic achievement have proved a hugely popular concept in recent years. A large-scale meta-analysis[137], however, showed very weak overall effects of growth mindset interventions, although the results did 'support claims that academically high-risk students and socioeconomically disadvantaged students may benefit from growth-mind-set interventions', a proviso which could be highly relevant for adult literacy. And it has the benefit of being a cheap, easily deliverable intervention with a positive message.

Another technique similar to mindset is called metacognitive training. This strategy to think about one's thinking has also been tested in young adults[138]. Researchers asked participants to rate their use of self-reflective statements such as 'I asked myself questions to make sure I understood' or 'I thought about which areas needed the most practice' and found that metacognitive activity was a strong predictor of cognitive, affective and skill-based learning outcomes. They did, however, find that this was only true for learners who were less concerned about demonstrating incompetence; by contrast, those who were more self-conscious of failure engaged in *less* metacognitive activity after training and subsequently performed worse. This raises the difficult problem faced by all educators that one size is not guaranteed to fit all.

One metacognitive approach which has been used is the unwieldy sounding 'Mental Contrasting with Implementation Intentions' (MCII) which is essentially concerned with encouraging learners to plan how they will reach a specified goal by considering obstacles

In a nutshell, teachers can harness the greater powers of adults' metacognitive skills with explicit encouragement to 'think about their thinking' and 'learn about their learning'; and encouraging the belief that effort and persistence will pay off, no matter what the learner's starting ability.

which really exist and working out how to overcome them. As such it can be contrasted with the less grounded ('if you can dream it, you can achieve it') positive thinking school[139,140]. The approach has been shown to improve academic performance in disadvantaged children,[141] suggesting that a realistic, pragmatic consideration of how to achieve goals might help actually achieve them; an approach constitutionally suited to an adult population.

3.3 Relevance and engagement

Why learn to read and write? There are the 'big ticket' reasons for improving literacy, propounded by governments and agencies: the reduction of poverty and hunger, promoting gender equality, health promotion, improving income generation, ensuring environmental sustainability and much more[111]. Such motivations are likely to be crucial for committing the necessary funding. However, what are the *personal reasons for learners*? These reasons are likely to be critical in determining success. "Partly to blame for the unsatisfactory literacy situation in Africa is the fact that… many adults fail to perceive the relevance of literacy in their everyday lives"[142].

One stark example of failure at the first hurdle of relevance is teaching literacy in the wrong language. This sounds improbable but in fact, the 'right' language for literacy programs is not always obvious. In addition to consideration of script types (as discussed in Section 2), there are many countries where the local language is not the national language, which in turn is not the official language. So, which is the right one to learn? From a relevance and engagement standpoint, the answer is 'the language the student wants to learn', very often their mother tongue. Some argue[10] that the low incidence of mother tongue as a medium of instruction is one of the key causes of failure to meet literacy targets.

As with many questions, systematic comparisons of mother tongue and other language instruction in adults has not been undertaken. However, there is strong theoretical reason, backed by experience in the field and evidence from children, to believe that mother tongue instruction has a positive impact on many measures of learning[143,144]. Instruction in mother tongue language: facilitates an understanding of sound-symbol or meaning-symbol correspondence; allows teachers and students to interact naturally; allows students to learn through communication rather than memorization; makes it easier for teachers to assess what has been learned; and in the affective domain, confidence, self-esteem and identity are strengthened, increasing intrinsic motivation[145]. In situations where both parents and children are learning to read in their mother tongue, there is great potential for practice at home and knock on benefits for children's literacy, through increased engagement of parents in the home[146] and the creation of a literacy-conducive environment. There remain, however, many situations which lack this congruence of child and adult language learning, particularly for immigrant families where language choices for low literate adults are complicated by many factors.

Teaching in the mother tongue is not always straightforward. In Africa, for example, there is a huge diversity of languages, with many Africans speaking multiple languages, some of which lack a written form. In such cases, a good deal of initial groundwork needs to be done to develop and achieve agreement on orthographies before literacy work per se can be

undertaken[147]. In many cases, there is not the time, money or expertise for this groundwork, so programs revert to teaching in the most easily available language.

There are occasionally situations in which learners themselves might want to learn a non-mother language if it is seen as a more effective way of increasing their earning potential[148]. There are many examples from the field in which mother tongue learning is a first step to access learning another script. In other cases (notably in South America) bilingual instruction is given, though these programs may take longer[149]. And even bilingual instruction may be insufficient in countries, for example in West Africa, where multilingualism is the norm and choices about language have to be made, importantly in consort with local communities.

The choice of language is not the sole determiner of the relevance of a literacy program[150]. The broader notion that learning and knowledge are constructed by individuals from their own experience lies at the heart of many literacy program philosophies. Rich Environments for Active Learning (REALs[151]) embody this constructivist approach, with their emphasis on promoting study and investigation in authentic contexts, encouraging learner responsibility and decision making, cultivating collaboration between learners and teachers and assessing progress using realistic tasks. Evidence that yoking learning to real life brings benefits comes from a study[152] which found that in numeracy assessments, US adults scored 59% in shopping calculations in decontextualized tests but 98% when actually in a supermarket, a reminder of the importance of situating learning in the real world of the learner.

What many effective programs have in common for the individual is their emphasis on literacy as a *means* rather than an end in itself. Many programs (perhaps even the majority) see literacy as part of a bigger learning project – to improve health, primary school attendance, conflict resolution, earning and more. 'Learn to earn' is the tagline for the Kala program in Kenya[153], whilst others see *family* literacy (discussed later) as the key to relevance.

In a nutshell, it is important to understand why students want to learn to read and write, teach them in their mother tongue from the outset and keep them actively pursuing their ultimate learning goals.

3.4 Practice and long-term success

It has been said that education is not filling a bucket but lighting a fire. In maximizing literacy proficiency, it is crucial to think not only about the period in which learners are enrolled in a program of study, but about what happens to them when that program ends. Because literacy/illiteracy is not a binary condition but a continuum, attending a 6-month literacy program does not transform 'illiterates' into 'literates'; rather, it equips those who do not read and write with the tools of learning and enough basics to continue more independently. How best to consolidate short-term gains?

Continued practice is absolutely key. A 9-year longitudinal study of adult literacy graduates[154] found that it was the engagement with literacy practice *after* schooling that was crucial for improving literacy proficiency in the long term. Persisting with the necessary practice can be helped in many ways and technology can be of potential assistance. Several programs aim to instantiate new literacy knowhow with the aid of mobile phones and SMS; texting is cheap, easy to roll-out even to remote populations, and can potentially create self-sufficient groups of learners.

People are more likely to persist in the long term if they have strong social support[155], so making practice meaningful and relevant is key. Functional literacy programs also help here as the heavy-lifting of literacy learning is rewarded with practical application to real life environments, whether that is writing a job application, understanding a vaccine leaflet or practicing within the family, perhaps alongside children who are also learning to read.

Many of these approaches will be considered in more detail in Sections 4 and 5, but the important message here, in the context of engaging the individual, is that false expectations should not be raised in learners. They need to understand that becoming literate is not something that happens overnight and that only by putting in the requisite practice consistently and over a long period will they approach or achieve fluency.

In a nutshell, programs should emphasize the need for continued practice and work with existing social structures to facilitate it. Ensuring follow-up after the taught course is over, with meaningful opportunities to use newfound literacy skills in the real world of the learner will support the maintenance and development of proficiency.

4.0 THE LEARNING ENVIRONMENT

What are the active ingredients of literacy teaching? How important is the teacher and their pedagogical approach? What is an appropriate rate and duration of learning? What role do other learners in the classroom play? Can technology help with learning and if so, how, which technologies and for which learners?

We now move beyond the individual to consider the learning environment itself. We will begin with teachers and their pivotal role in the learning process, considering both their approach and their relationship with learners. Next, we will look at classroom factors including the rate and volume of classroom learning, pedagogical approach and class size, before moving on to consider the very important role *other learners* play in each individual's learning. A key consideration of long-term success is how social learning can best be harnessed in the classroom and outside it. We will end this section with a discussion on the inclusion of various forms of technology in literacy programs, looking at the degree to which different technologies have and have not proved effective for learners at different stages of literacy development.

4.1 Teachers and their relations with learners

The quality of teaching is deemed the single biggest factor determining success of programs[156,157]; teaching and teachers lying at the heart of student engagement[158,129]. Unfortunately, many teachers of adult literacy programs are volunteers with no specialist knowledge of teaching adults and in most countries, conditions and salaries for those in adult literacy is below those in other education sectors[156]. Even school teachers (who usually teach children), often persuaded of their civic duty to engage with adult literacy programs in their spare time (particularly during national campaigns), might lack knowledge specific to adult learning. Proper remuneration and training of teachers, although a costly aspect of program implementation, may well prove a worthwhile investment. See Appendix table A2 'Ingredients for teacher training'.

The teaching approach can sometimes be problematic. "A pervasive and persistent observation in large-scale literacy programs is that most facilitators tend to revert to teacher-centered, didactic forms of teaching. Most appear unwilling or unable to sustain the learner-centered and participatory methods that are widely advocated"[111]. Training teachers takes time, expertise and money, all the more so to teach them how to teach in the learner-centered, active and contextually adapted ways that we have seen are desirable for learner engagement[159]. Instead, trainers themselves are often taught in didactic lectures, an approach they then pass on. It takes a minimum of 2-3 weeks to train even professionally qualified primary or secondary teachers how to teach adults[111].

How teachers are perceived and accepted by the local community is also of great importance, with several programs training community members as teachers to promote engagement and to help ensure the relevance of program materials. Many programs adhere to an emancipatory Freirean approach (based on the work of Brazilian philosopher and educationist Paolo Freire[160]) which enacts community-up program design at all levels. Community-up design means that programs are created, programmed and enacted under the guidance of local community representatives who decide for themselves what is important for the community, rather than being told by external agencies. In some cases, the approach

extends to a whole different way of teaching literacy, doing away with standard primers and alphabets in favor of maps, charts, matrices and other symbols to represent the community. Learners and facilitators then co-create, from this newly realized symbolic base, a functional curriculum[111]. The approach raises bigger questions about the relative importance of literacy versus empowerment, questions important to consider from the outset.


In a nutshell, teachers require training in adult-specific learning so they have the confidence to teach in learner-centered ways. Where possible qualified teachers should be drawn from the local community and properly remunerated.

4.2 Classroom environment and context

From kindergarten to 12th grade, literacy teaching takes the equivalent of about 2,000 hours[161]. In adults, it is estimated that 300-400 hours of instruction is needed to attain levels roughly equivalent to levels of 2nd/3rd year pupils in local primary schools[111]. Crucially, this level will be lost again over 2-3 years if not practiced (and ideally, used) in everyday life.

There is a lack of solid meta-analytic data on the optimal or necessary numbers of teaching and learning hours for literacy programs. What can be seen is a great deal of variation, from 3 months to 3 years[162] and even some unusual 'crash courses' of as little as 10 days[153]. Shorter programs are often part of mass literacy campaigns while longer ones are often a part of broader learning projects, for example to improve health outcomes, primary school attendance, income generation and more. There is sometimes a trade-off between achieving small gains for many versus larger gains for fewer people. Several programs operate a staged approach whereby successful completers of an initial stage (typically around 9 months) move on to more advanced, often more functional, levels. An ideal program will optimize both rate and duration of learning; this means frequent, regular rehearsal to develop automaticity and sufficient course duration to consolidate progressive learning[163]. A tentative suggestion of an appropriate schedule, finding a compromise between the intensity of learning typical for children and logistical feasibility for adults, would be a course offering classes 3 times a week for 2-3 hours a session (a minimum of 6 hours a week) over a period of 9 months, with as much practice as possible outside of the classroom.

It should be reiterated, however, that there is a real problem in the lack of rigorous data on outcomes[164]. Even programs billed as 'successful' often present no concrete outcome measures, even at the most basic level such as numbers starting and completing courses, never mind detailed data on start and end literacy levels. Box 3 outlines the data all programs should ideally capture in order to properly evaluate effectiveness. Further, the 'known unknowns' of adult literacy are outlined in Table A3 of the appendix.

Evidence from the field does provide some useful pointers on the practicalities of course scheduling[165]. Course drop-out increases when there are breaks in the course, so these should be avoided if at all possible. Drop-out tends also to be highest early on in courses, so building in incentives, rewards, social engagement and setting goals early on is very important. These could cover a wide range of activities as disparate as offering childcare support to creating individually staged learning goals. Where relevant, courses should also try to fit around seasonality and other changing needs of learners.

Class sizes typically seem to be 20-30 students per teacher, but there is little adult specific evidence to suggest what class size might be optimal. The message from research on class size in children suggests that reducing class size does have some learning benefits, but the cost is usually very high[115] compared to other effective interventions. There will be differences both in starting ability and knowledge as well as in the desired end point for each individual learner; courses need to be flexible enough to cater to individual needs but stable enough to allow teachers to plan effective classes. There are possible benefits, discussed later, to grouping learners according to ability.

	Preferred metrics to optimize accumulation of evidence to improve future programs
Brain	Pre- *and* post-course assessment (using the same measures) of: Phonological awareness (e.g. add or remove a phoneme from a known word to produce an unknown word) * Word or character reading speed (words per minute) * Reading comprehension of a short, unfamiliar passage*
Person	Attendance (% of classes attended) Language of instruction, language being taught, native language of learner* Educational level (number of years of school attended) Age
Learning environment	Course duration and frequency (hours per week; number of weeks) * Teacher qualification level Teacher training (number of hours) Pedagogical approach (active/passive) Rates of drop out* Class size Long-term follow up Information about post-course practice
Culture	Source of funding Cost* Community involvement Target population

Box 3. Data that would ideally be acquired from all adult literacy programs
*Those marked * are those we would consider essential*

What are the best classroom techniques? Again, with a lack of data specific to adults, the best available evidence comes from well-established principles from the science of learning in children[166]. Some of the more important are: adapt materials to the level of the learner such that they are not too easy, not too hard; present material in a clear and organized format; use multiple and varied formats and examples (trigger memory in different ways to improve retention and transfer); space presentation of new material across time; test on multiple occasions, ideally spaced out; and ground concepts in the concrete experience of the learner[167,168,169].

Many adult readers are simultaneously learning to read and learning to learn, which is why active learning is so crucial[170] and the evidence from research in children is strong on this point[115]. Learners should be encouraged to produce their own material, invent their own tests, choose their own topics to study, seek explanations and solve problems they set themselves and each other. "The passive lecture format where faculty do most of the talking and students listen is contrary to almost every principle of an optimal learning environment"[171].


In a nutshell, literacy courses should be staged, so that learners can see their progress, and run for a minimum of 6 hours per week for 9 months per stage in active learning environments.

4.3 Social/peer learning

There are many ways in which acting socially can enhance learning, with effects being both direct and indirect[172]. Indirect effects include those on motivation and reward, such as using peer pressure. Examples might include sending SMS reminders between the group to encourage attendance or rewarding the group or the community rather than the individual for regular attendance. Direct effects operate through our metacognitive abilities[173] and the reflective discussions which allow us to compare our views with others and so arrive at better understanding. Perhaps surprisingly, this effect even seems to work at quite a basic sensory level. One study[174] grouped pairs of people and asked them to detect whether a subtle visual signal was present. If the pair disagreed, they had to discuss it and come to a joint decision. As long as the pair had similar perceptual abilities, the group performance significantly outstripped the performance of the better performing individual. The key here is discussion,

as it forces each member to reflect, communicate and compare their experience (in other words to think about their thinking). Notably, if participant abilities were not well matched, the group performance was *worse* than the better individual, which suggests a potential benefit from organizing learners in groups of similar starting ability.

Active learning in groups and peer relationships are a key part of initiating and maintaining engagement[129] and peer learning inside and outside the classroom can improve learning outcomes[175]. Mazur's 'Peer instruction' technique[176], originally developed for undergraduates, encourages students to discuss their thinking and answers with their peers and has been shown to improve conceptual understanding[177] and reduce drop-out. As such, peers constitute conducive partners to encourage the retrieval and elaboration of newly acquired knowledge which we know helps the brain to learn.

Social learning need not necessarily refer only to fellow learners; it can also include co-workers, community contacts or family. The desire to help children with their learning can be a strong motivation for parents to (re-) engage with learning themselves[149] and learning in a workplace setting can offer both immediate functional application and the benefit of seeing the potential rewards of learning in the form of improved outcomes or a better job (see, for example, the Workplace Literacy program, Jamaica[153]).

In a nutshell, actively encouraging peer discussion in the classroom and providing opportunities for learners to practice and learn together outside of it supports both individual and group progress.

4.4 Technology

Information and communication technology (ICT) can potentially enhance the effectiveness of literacy programs through direct means, for example, using mobiles to encourage and structure long-term practice and follow up once the taught program is over. It can also be used indirectly, for example, charging mobile phones is a resource that could potentially be offered as an incentive for course attendance. There is also the broader question of whether defining literacy for the 21st century should include some acknowledgement of technological literacy; some suggest that the consequences of illiteracy will become increasingly severe as technology becomes ever more widespread[178].

It is important to distinguish between many different kinds of technology which have been deployed in the quest to improve literacy – from the wholesale adoption of computer-based learning (in extremis, fully replacing teachers with computers[179]) through to the addition of simple mobile phones to promote long-term practice outside the classroom[180]. There are also several one-off examples of innovative uses of technology, from the talking

pen that speaks as it is written with, to the provision of pink mobile phones to encourage women to practice literacy (and deter men from using the phones), to the harnessing of mass media (radio / television) to create a literacy-conducive environment[181].

Some potential practical advantages of computer-based programs are their requirement for fewer instructors (a potentially large saving to cost since training and paying instructors often accounts for half of program costs), their ability to teach more learners at a time across wide geographical areas, the constant availability of course materials and consistency of quality across multiple locations. Adaptive computer technologies in particular can construct learning environments very much aligned with the science of learning: learners can work at their own pace, task difficulty can be made adaptive, learners are not told they are wrong but correct themselves (and do so privately) and, if materials are well-constructed, they can be very fun and engaging for learners[182]. For these reasons, there are some impassioned advocates of ICT-based solutions. Among them is TATA, Asia's biggest software group, who claim that their stripped-down functional literacy program can teach people a basic vocabulary of 300-500 words in about 30-45 hours over 10-12 weeks[183]. They say that their approach, which focuses not on alphabets but on just enough words to fulfill everyday requirements such as reading a street sign or a newspaper, has the potential to be a 'single-shot solution' to India's illiteracy problem. Tens of thousands have completed their courses.

Most would be more circumspect. A more typical view would be that computer-based approaches are best seen as an adjunct to teacher-taught programs, most suited to those who already have some basic literacy[184]. And there are several difficulties with computer-based solutions: even if computers can be bought or acquired for courses, very few learners have access to computers at home to practice, creating problems for longer term literacy instantiation. The lack of a social dimension to learning – in terms of teacher/learner relationship and peer learning - is also not ideal.

Moving from computers to mobile phones, however, the picture is brighter. In South Africa, 51% of households have no books, only 7% of public schools have libraries but about 90% of young adults have mobiles, of which about 70% are internet-enabled and usage costs are low[180]. Other countries are not far behind. These 'book-poor, mobile-rich' environments present a real opportunity for literacy programs[185]. Although some urge caution in the introduction of new technology[186], mobiles are relatively easy even for new users to learn to use and they have the obvious advantage of their portability, meaning structured literacy practice can be extended beyond the class to times and places suited to the learner[187]. To maximize the benefits of mobiles, content should be delivered in its simplest possible format, using cloud computing (since most people have low storage) with frequent small chunks of content such as SMS messages for practice and testing[188]. There are several examples of programs which have used SMS technology to good effect alongside more traditional programs[189,181]; they encourage learners to read and write beyond the classroom, responding to quizzes, reading community news and events and even jokes. Regular daily practice of

newfound literacy can be maintained over a long period of time and at low cost, with content geared to learners at different levels of literacy.

One final issue raised by technology is an important difference between reading and writing: whilst reading is not very different in physical or digital form, there is a substantial difference between the cognitive and motor demands of recognizing and pressing letters on a keyboard or touchscreen versus learning to produce letters by hand. Handwriting carries advantages, in that it generates motor codes which aid the perception of symbols – but it is unclear whether the increased time and effort required to gain this additional motor skill is merited, given that the primary aim is learning to decode symbols. There is also a cultural question here about whether it is socially and psychologically important for people to be able to write by hand. Whilst some speak of the undoubted thrill that comes with being able to write your own name for the first time[190], others might argue that in the long-term, it is digital literacy that is more likely to change the material circumstances of your life[191].

Despite some programs with interesting approaches and some successes, we have not seen evidence that computer technology is currently revolutionizing adult literacy. Given the complexity of literacy learning outlined in this report, we think it unlikely that there is a single technological 'magic bullet' which will remediate all the difficulties adults face in learning to read and write. However, there is evidence that informed use of appropriate technologies could be of great benefit to learners who have acquired a basic level of literacy which they need to cement, practice and build on.

In a nutshell, mobile SMS texting can be used frequently to complement classroom teaching, with content relevant to learners, to encourage practice outside the classroom. This is particularly beneficial when the taught course is over.

5.0 THE CULTURAL CONTEXT

What role does the local community play in literacy learning? How can local communities help to promote, maintain and develop literacy? How might particular issues affecting women learners be addressed?

5.1 Involvement and support of the local community

Why are some interventions successful and others, despite great hopes, not? What can we do to improve the translation of good research into effective and lasting behavioral change?

One of the most common reflections on the causes of success or failure of literacy projects[153] is the degree of engagement of the local community. The consensus is that, no matter how much else might be in place in terms of instruction methods, course frequency and timing, if there is not buy-in from the community then the program is highly unlikely to succeed. The good news is that countries seem to be getting better at achieving this buy-in. The most recent GRALE (Global Report on Adult Learning and Education) report[192] asked countries whether they involved local communities in the planning implementation and evaluation of adult literacy: 97% of African countries, 74% in Asia and 65% in Latin America said that they did.

Again, there is a lack of any systematic evidence on the effect that community involvement has on the ultimate level of learner success. Indeed, it is hard to envisage quite what form such data might take. Instead, there is only really the experience of program-implementers and their reflections on why programs were more or less successful[193,153]. Community-level engagement impacts directly on many factors already discussed: personal motivation and engagement are enhanced if they are scaffolded by the local community's support; relevance will be maximized if teaching is culturally appropriate (e.g. mother tongue, familiar materials) and yoked to tangible goals (e.g. improving family income); long-term practice and consolidation will be more achievable and enjoyable if done with other learners in the community.

From a practical standpoint, there are different routes to achieving buy-in. Some programs come about through national-level implementation, with big campaigns harnessing the sort of resources only governments can muster, and which attempt to give citizens a personal stake in a mission to improve the literacy of the whole country. Teachers are sometimes persuaded to play a role (frequently poorly remunerated) in these national missions, so these programs often see primary and secondary school teachers taking on adult-teaching roles. Learner engagement is encouraged through promised benefits, occasionally in direct rewards offered for attendance, or, more commonly, through promised indirect, long-term rewards of improved employment opportunities, health promotion, crime reduction and other socially desirable outcomes[194,195].

Other programs (e.g. Freirean approaches) take the opposite approach: they are small scale, grass roots initiated and take as their starting point the wishes and needs of local communities. This might mean working around agricultural calendars, finding teachers prepared to teach peripatetically alongside nomadic communities or accepting that literacy is a second tier goal for the community, after empowerment, improving citizen's rights or social inclusion.

In a nutshell, understanding the needs of the local community and working with them to develop both courses themselves (materials, teacher and learner recruitment, class environments) and plans for post-course continued learning will support engagement in both short term (enrolment, attendance) and long term (practice, application).

5.2 Gender

Gender equality is a key principle of the 2030 Agenda for Sustainable Development[196] and a central United Nations development goal. Gender equality matters intrinsically, as a basic human right[197] and it is also 'smart economics', as it contributes to economic efficiency and key development outcomes. The central role of education in bringing about the economic gains of gender equality is now universally recognized, with an abundance of persuasive evidence[198]. Gender differences in education make a significant contribution to the productivity gap between men and women[199] and when investment *is* forthcoming, women see higher returns (9.8% on average for women, 8.7% for men) on their schooling investment[200]. In short, there is broad consensus that "Gender inequality in education is bad for economic growth" [201].

Investing in female literacy makes economic sense for its own sake. What is more, improvements in female literacy act as 'force multipliers' - catalysts for a country's social development[202]. This is because investments in women's education are special: as mothers, women pass on their own educational improvements to their children in multiple ways – in reduced infant mortality, better childhood school attendance, improved family income, higher vaccination rates and more. Improving women's literacy also has significant knock-on benefits for their own reproductive health, reducing the often high rates of mortality and morbidity related to childbirth, reducing fertility rates and increasing life expectancy.[203,204,205]

Despite these positive economic benefits, gender differences in literacy persist for cultural and historical reasons. And despite great strides in improving equal gender access to primary education in recent decades, one in five girls still do not complete primary schooling[180]. Two-thirds of the non-literate adults around the world are women[196] and in many cases, the institutional impediments which prevented these women learning as girls still exist[206]. Women who are most likely to be affected by the lowest literacy rates are those in the poorest populations, in remote rural areas, employed in low skilled manual and sometimes seasonal jobs which are tiring and inflexible. In most communities, expectations persist that, even when women contribute equal hours of work outside the home, they should still do the vast majority of work within it – housework, childcare, care of elderly relatives and so on. Patriarchal attitudes remain dominant and can make studying practically and socially difficult for women. Undoubtedly, women experience significant additional practical and emotional barriers to their learning[207].

For this reason, encouraging and maintaining motivation and engagement is even more essential. And key to this is involving women and their communities in every aspect of the literacy program – what is taught, when, where and by whom. To maintain attendance and encourage practice outside the classroom and after formal teaching, maximizing social connections, is also crucial. There are several examples of programs – from community radio listening clubs in the DRC[208], to peer support groups in Timor-Leste, community forums in Mozambique and tutoring networks in Mexico which all make the most of women's wishes to strengthen social connections – and through doing so, improve their literacy.

There are some even more serious impediments to women's learning. Social and civil disruption and conflict cause numerous severe social problems, including reduced access to learning environments and disconnection from fellow native language speakers. Women, as explicit targets of violence and with fewer economic opportunities, are particularly at risk[209]. As part of their rehabilitation, low literate refugees are likely to benefit from native language instruction, before attempting to acquire new languages[210].

A substantial minority of women experience violence in the home, a situation that can have a massive impact on learning at many levels. At the practical level are fundamental logistics such as whether women are able to leave home to attend a class; at the emotional and physiological level, the stress they are under is likely to be highly counterproductive for learning. Though a small amount of stress can have positive effects on learning (through hormonal enhancement of synaptic activity boosting memory formation), chronic stress has the opposite effect, impairing memory formation[211]. Some have gone so far as to propose a new type of functional literacy which brings literacy and therapy together for women experiencing domestic violence[212]. In contrast with stress, fatigue (experienced by many women already juggling work, childcare and housework) is never a positive influence on thinking, learning and retention[213].

Stereotypes about women and technology (that men are more predisposed to use technology) persist. The evidence however[214], suggests that any technological advantage that men have is a matter of access and economics and that, given the opportunity, women are actually *more* inclined to use digital tools than men. This presents a real potential opportunity for literacy programs to engage women socially through digital means, to achieve social goals and thereby embed and extend their newfound literacy skills.

In a nutshell, investment in women's literacy acts as a 'force multiplier', improving health, wealth and social outcomes for women, their families and their communities. Social support is particularly crucial for women, who are disproportionately affected by low literacy levels and experience additional obstacles to their learning.

6.0 EXAMPLES FROM THE FIELD

In this section, we present an in-depth analysis of case studies from the field. These serve to contextualize the principles we have identified in real-life program examples. The case studies have been selected to represent different geographical regions and highlight a diversity of approaches that can nonetheless all have a positive impact on learners and their communities. Examples come from a variety of sources, including UNESCO's 'Effective literacy and numeracy practices database' and programs supported by other international agencies, national governments and NGOs[215,153]. Table 1 describes each program and highlights those features of programs that are consistent with the science of learning, as well as suggesting areas where programs could have been more effective. The numbers in *blue italics* refer to the relevant section of this report explaining the principles.

We should stress that it cannot necessarily be deduced from a given program which were the most important factors in its success, as each program represents a unique and contextualized combination. To analyze the key factors (e.g. of dose, duration, frequency of instruction and so forth) would require more systematically designed studies and randomized control trials.

Table 1. Case studies of adult literacy programs and their relation to the science of adult learning

Program	Brief description	Features of the program consistent with the science of adult learning	Additional features which would have been desirable
Aagahi, Pakistan	A well established program which has enrolled nearly 50,000 learners in 43 areas of Pakistan. Evolving out of a children's school program, the adult program primarily targeted women and especially mothers, to help foster a positive learning environment for the whole family. Learners were all from very poor areas, both rural and urban.	Clear building blocks began with improving metalinguistic awareness, particularly phonological training, *2.3.1* which progressed to mapping oral language to writing systems *2.3.2*	Main language of instruction was Urdu, rather than Sindhi, Pashto or Punjabi which are the native languages of most participants. It is important to ensure learners' views are considered in choice of language instruction *3.3*
		Classes were held six days a week, two hours per day, over 15 weeks (a total of 180 learning hours) – an appropriate learning schedule for repetition and practice *2.1.2*	Courses were geared to achieving basic level literacy. Effectiveness could be improved with systems for long-term practice, further learning and functional use *3.4* possibly with the help of technology such as simple mobile phones *4.4*
		Relatively small class size of 15 learners to one teacher *4.2*	High dropout (25%) could be addressed by better understanding learner motivation and goals *3.1*, working with local interest groups to gear programs to learner's functional needs *5.2* and encouraging social learning *4.3*

		English language was introduced in response to learner demand *3.3*	Although cycle allowed 3 weeks for training teachers, each teacher received only 16 hours training. Given disparity of teacher qualification level, this might need to be increased *4.1*
		To better suit community needs, most (83%) programs were geographically shifted to learning centers in a community setting *5.1*	Primary goal of improving family literacy could be made more relevant and engaging *3.3* through functional emphasis (e.g. making links between adult learners and local primary schools) *3.4*
		3 weeks built in to program cycle to train teachers *4.1*	
		Teachers were properly paid, drawn from local community wherever possible and a reasonable minimum education level set *4.1*	
		All students were assessed at the start and grouped according to ability *4.3*	
ABC, Niger	A program run in collaboration with Tufts University and Catholic Relief services. Target group was rural population, people with lowest literacy levels (no reading or writing in any language). The program, involving around 6000 learners, tested the impact of mobile phone use on adult learning in a randomized control study. Control villages followed a regular adult education program; ABC villages also learned how to send and receive SMS messages on a mobile phone given to them.	All classes were taught in the native language of the community, either Zarma or Hausa *3.3*	In oversubscribed villages, selection was made by public lottery, which might have threatened local community buy-in *5.1* and also did not ensure inclusion of the most highly motivated learners 3.1
		Classes extended over a long period (8 months of instruction over 2 years) to emphasize long-term practical usage over short term success *3.4*	The problem of significant early drop out could be addressed by offering appropriate incentives *3.1*, goal-setting *3.2* and an emphasis on functional ends *3.3*
		An incentive, in the form of a monthly food aid ration, was given to those maintaining 80% attendance. This helped ensure good attendance (74% on average) *3.1*	Move towards greater consistency in teacher qualification level, especially since organizers recognize that 'better-educated teachers are better able to harness mobile technology' *4.1*
		Students were enabled and encouraged to practice their newly acquired literacy skills outside the classroom using mobile phones *4.4*	Pedagogical approach was not specified but 'traditional adult literacy course' does not suggest emphasis on either active learning approach *4.2* or on establishing literacy building blocks *2.3*

		Functional literacy, including teaching about agricultural, environmental and health issues, helped to keep learning relevant *3.3*	
		Dosage (3 hours a class, five times a week) was sufficiently high *2.1.2* to enhance and maintain learning both within and between classes *4.2*	
		Classroom schedule was arranged around seasonal work demands *5.1* in collaboration between teachers and local community *4.1, 4.2*	
		Teachers were properly remunerated *4.1*	
		The large-scale randomized controlled trial carried out represented an unusual, and laudable, case of a rigorous approach to evaluation *4.0*	
		Clear benchmarks for levels and evaluation, with assessment at every level. Writing test scores of ABC villages were 20% - 25% higher than non-ABC villages in the short-term, and 20% higher in longer term (7 months after end of program) *4.2*	
		Mobile phones were given 1 among 5 learners (i.e. not to each individual), obliging learners to work in social groups *4.3*. SMS messaging allowed for practice outside the classroom *4.4* and for learners to communicate about local events in ways which reinforced relevance and engagement *3.4*	
Alfalit Adult Youth and Literacy Program, Liberia	Alfalit Liberia's stated mission was to "educate, empower and enable economic independence among the marginalized, disadvantaged, distressed and poorest of Liberia's population." Their literacy program was designed to improve social mobility and earning potential for those in these	Three terms each lasted for 9 months with clear goals for each term (term 1 to reach equivalent of 3rd grade, term 2 beyond 4th grade and term 3 6th grade) and teaching over a long enough timeframe to maximize chances of long term success *3.4*	Course materials started with sound-letter correspondence. Would be preferable to begin with metalinguistic training, first breaking down the structures of oral language before progressing to written language *2.3.1*
		Usual dosage was three 2 hour classes per week, sufficient for practice and repetition *2.1.2*	All teaching was in English, from initial assessment on. There is no indication of whether this was what learners desired *3.3*

	communities. The program has been run at 76 locations all over the country, engaging over 8,000 learners each year.	A profile was made of each learner at the program outset, including their reasons for wanting to read and write *3.1, 3.2, 3.3*	Whilst systems for evaluating real world outcomes were in place, there were not systems to encourage continued learning. Consider the use of functionally connected social groups *4.3* and technology *4.4* to address this
		Courses emphasized content meaningful to learners and used novelty to enhance situational interest *3.1*	
		Teachers were properly paid, fully trained and members of the local community so that they understood local needs and concerns *4.1*	
		Learners were encouraged to learn independently rather than relying on didactic instruction *4.2*	
		All facilitators were required to do pre and post testing of students *4.0*. Post testing included longer-term impact assessment, to establish whether new reading and writing skills had impacted the life of the individual learner and community in a meaningful way *3.4, 4.4*	
		Class size was not excessive, at around 25 learners per class *4.2*	
		Facilitators received an intensive five-day training program of seven hours per day *4.1*	
		Emphasis was put on the real-world use of literacy, with programs such as 'Sew to sell' (teaching literacy for business) and 'Literacy in the marketplace' (facilitators bringing training to women at their market stalls) *3.4*, *5.0*	
		Alfalit worked very closely with local communities and their leaders, putting empowerment at the heart of their mission *5.1*	
Community Learning	National-level government-backed pro-literacy campaign.	Pre-course assessment of reading and writing levels as well as aspirations of learners were carried out *2.3*	To increase take up in rural areas, where communities can lack motivation to enroll, consider use of

Centers, Vietnam	Programs particularly targeted women and ethnic minority groups. Between 2009 and 2013 almost a quarter of a million people participated in literacy and 'post-literacy' classes.		contextually appropriate incentives and rewards at start of course *3.1*
		There was flexibility in the language of instruction. Whilst the majority were taught Vietnamese (Kinh), programs were also developed in a number of minority languages spoken by ethnic minority groups *3.3*	Teaching materials were primary school textbooks; ideally, adult-specific materials i.e. with content relevant to adult learners' lives, would be used *3.4*
		Clear goals were set at each level of the program *3.3*	To ensure long-term stability of literacy gains, establish systems for longer-term practice and use *3.4* – through use of literacy in work, in the community *4.3* or with the help of SMS technology *4.4*
		Literacy instruction evolved from basic, introductory levels up to functional literacy (teaching life skills) *3.4*	Move further to train teachers to use active rather than a traditional (passive) teaching approach *4.1*
		Several features relating to teachers were consistent with best practice: they were mainly qualified primary school teachers, were trained in adult teaching methods and properly remunerated *4.1*	A greater emphasis on summative evaluations of what learners have learned by the end of each stage (rather than evaluations of what centers have taught) would be helpful *4.2*
		An active learning approach was advocated *4.1* (although in practice proved difficult to implement, since traditionally Vietnamese teaching is passive)	
		There were several stages of learning with sufficient time (3 months) per stage, emphasizing the long-term nature of literacy learning *4.2*	
		Learning needs of local community were established through discussion with local interest groups – from before the start and throughout program *5.1*	
Neuroalfa, Mexico	A small-scale (n=60) intervention which aimed 'to apply neuropsychological principles to social problems'. The study, whose participants were all described as 'illiterates' living in a	Course was designed to enhance skills often lacking in adults who cannot read and write. Course trained phonological abstraction, semantic categorization, similarity-finding, visuoperceptual abilities, verbal memory and abstracting abilities *2.1.2*, *2.3*	Dosage and spacing: course comprised 3.5-hour sessions 3 times per week for 3 months. While this level and frequency of teaching might be sufficient to acquire basic skills *2.1.2*, longer-term practice and follow up is needed to make them meaningful and useful *3.4*

	poor urban environment, compared the Neuroalfa approach with two existing literacy methods, with approximately 20 participants per group.	Strong emphasis was put on metalinguistic training. Learners had to complete tasks such as combining sounds to make new words, finding phonological and semantic similarities between words *2.3.1*, analyzing proverbs for multiple levels of meaning and visually discriminating letters e.g. upper case vs. lower case *2.3.2*	The single teacher involved was an unpaid volunteer *4.1*
		Specific exercises emphasized verbal memory *2.2.2*	There is a lack of information about the approach to social learning, use of technology and other classroom factors *4.2, 4.3, 4.4*
		Teaching was in Spanish, a phonologically transparent language *2.1.2*	There is no information provided about the native language of the participants, bilingualism or language of choice *3.3*
		Concrete and personal examples, relevant to learners' lives, were used whenever possible *3.3*	Unclear that there was any involvement of local community in any aspect of the program's implementation, recruitment or follow up *5.1*
		Detailed assessments of neuropsychological, linguistic, motor and memory abilities were made pre and post intervention *4.0*	
		Emphasis put on functional importance of literacy through application to real world situations such as reading a medical prescription *3.4*	
REFLECT Literacy and Livelihood Program, Sudan	REFLECT targeted socially disadvantaged women particularly refugees. Its philosophy saw empowerment as the primary goal and literacy as a means to achieve it. Teaching started with training symbolic understanding, using objects which are meaningful to learners, to demonstrate how symbols represent realities. This then extended to showing how written letters and	The functional nature of literacy was constantly reinforced by stating aims in terms of concrete goals to improve health, reduce poverty and increase women's engagement *3.4*, *5.2*	Courses were taught mainly in Arabic and English, raising two problems: many local teachers in remote areas were not highly literate in these languages and conducting lessons in a language not spoken by learners can be counterproductive to comprehension, relevance and engagement. Moving to local languages would help both problems. *3.3*
		Study units were developed in collaboration with involved communities so motivation to enroll was often based on the program	All facilitators were engaged on a voluntary basis, receiving only a modest monthly stipend *4.1*

	words symbolize the realities of speech and ideas. The program served over 2,000 learners annually.	covering issues which the women themselves prioritized *5.0*, *3.1*, *3.4*	
		Learning groups or 'circles' put social learning at the heart of the pedagogical approach *4.3*. The 'circles', with assistance from a facilitator, met almost on a daily basis, ensuring regular practice *3.4* and conducted their learning activities using a range of active, participatory methods *4.2*	In some remote areas, it was difficult to engage qualified facilitators as many had been deprived of educational opportunities. Consider paying qualified teachers from further afield or taking longer to train teachers *4.1*
		In addition to pre-course training, teachers took part in monthly training workshops 4.1	Consider formalizing method of instruction to established 'building blocks' of literacy *2.3* without compromising engagement *3.4* and active learning approach *4.2*
		The program was developed and promoted in communities with assistance from the local leaders and existing women's groups *5.1*, *5.2*	
		Very active learning approach with activities such as drama, story-telling and songs *4.2*	
		Learning progress was assessed through quarterly tests. At the end of the first year, from a baseline of 100% illiteracy, 67% of women could write a short paragraph *4.0*	
		Assessment included broader functional gains (e.g. organizing health, nutrition, education initiatives); functional relevance was seen as central to success *3.3*	
		Established learning circles went on to implement similar activities in their community with little or no external assistance, contributing to a more literacy-conducive environment *5.0*, *3.4*	

 In a nutshell, previous and existing programs exhibit promising features consistent with the principles outlined in this report, but in many cases there are areas that can be improved. The diverse contextual factors apparent from the examples highlight the difficulty of proposing any single program design that will ideally suit every situation.

7.0 CONCLUSION

We have outlined a guide for policymakers and instructors to build adult literacy programs that have the best chance of supporting learners, based on what we know about the science of adult literacy and the learning brain. We considered four nested levels at which adults might face obstacles to learning and at which they bring strengths: The Brain, The Person, The Learning Environment, and The Cultural Context. In each case, constraining factors on literacy outcomes were identified and recommendations offered to optimize outcomes.

In some cases, we identified where relevant evidence was missing. Further, we indicated the metrics programs should include going forward, to enable the accumulation of evidence for design factors that support the most effective programs. Finally, we analyzed a selection of case studies from the field, describing features of these programs consistent with the science of learning, and highlighting areas of potential improvement at each nested level. These case studies served as contextualization of the identified principles in real-life situations.

Even though we identified the wider principles that programs should embody, we recognize that there is also room for innovation and creative local changes that may enhance outcomes. To give a sense of what such locally effective innovations might look like, we provide some examples of highly diverse approaches drawn from a wide range of programs in Table 2.

Lastly, we recognize that there is a tension between identifying *what works* and *getting it to work*. To identify *what works*, factors must be systematically varied in randomized control trials, and in some cases, the optimal design would have ethical limitations (for example, employing control groups who do not immediately receive the intervention judged to offer best outcomes). *Getting it to work* should involve combining all factors at once to maximize the chance of a good outcome, that is to 'throw everything at the problem'. This may sometimes involve compromising principles where local contextual factors are more important. Moreover, due to the nested nature of the factors that constrain the success of adult literacy programs, each inner layer may be optimized but outer layers may still limit effectiveness. The body of evidence summarized in this report suggests that there is scope to improve outcomes in adult literacy programs around the world and realize the social and economic benefits that such gains provide.

Table 2. Examples of innovative approaches to adult literacy interventions

Name of program	*Description of innovation*	*Why is it of interest?*
Literacy in Local Language, Mozambique	Working with local communities to agree orthographies on local languages previously lacking written forms	Significant commitment to enabling mother tongue literacy, engaging and empowering local communities
Pink phones, Cambodia	Giving pink phones (with paid credit) to women community leaders who had attended a literacy program	Frequent SMS text messaging with functional, relevant content extends literacy use beyond the classroom. The pink-colored phones empowered women (and deterred men) from using them.
Reading for a billion, India	Same language subtitling added to public access TV shows, including Bollywood musicals and other popular programs	Creating an environment mindful to print exposure through motivating millions in their own homes to sing along to popular music
El Maestro en Casa, Panama	Broadcasting free weekly literacy classes on national radio stations	Enabling literacy learning even for those unable to attend taught courses, or as a supplement for those who are
Jokko Initiative, Senegal	Providing a free text-based platform for mobile phone messaging alongside literacy program	Channeling community engagement by encouraging written communication of local news and events
Ten day crash course, India	Developing a very intensive literacy course for highly motivated community leaders	Attempting to spur and 'spread' literacy through communities by empowering and energizing influential community members
Family Literacy program, S Africa	Gearing literacy program to training adults to support their school-age children with their learning	Putting motivation and emotion at the heart of literacy learning, by 'transforming literacy into a shared pleasure'.

APPENDIX: Table A1. Scripts of the world

'Write what you mean'

'Write what you say' (Ellis et al., 2004)

Group	Size of written units (largest to smallest)	Scripts	Languages	Depth (+ = deeper)	Notes on learning
Logographic	Words/morphemes	Hànzi 汉字	Chinese	Not applicable	Learning basic characters takes more than six years of schooling (Shu et al., 2003), with over 2,000 characters taught in elementary school.
Syllabary	Syllables	Kana 仮名	Japanese		Syllables are more obviously accessible in spoken language than phonemes. Kana is learnt alongside logograms (Kanji script), and used in parallel with them.
Alphasyllabary	Vowel-consonant pair	Devanagari देवनागरी	Hindi		Devanagari is a very shallow script, but the use of vowel-consonant pairs mean there are many symbols to learn.
			Sanskrit		
Abjads	Consonants only	Arabic العربية	Arabic		The transparency of Arabic and Hebrew orthography is increased by the use of stress markings to indicate pronunciation of written forms. Word meaning is heavily dependent on context.
			Urdu		
		Hebrew עברית	Hebrew		
Alphabetic	Phonemes/combination of phonemes	Cyrillic кириллица	Russian	+++	Cyrilic has close ties to the Greek script.
		Greek ελληνικά	Greek	++	Orthographic transparency and a simple syllabic structure makes Greek very accessible to learners (Seymour et al., 2003).
		Latin Latin	English	++++	Learning basic phoneme-grapheme correspondences happens in first year of school, but depth of orthography largely determines mastery. English is known to have the deepest orthography, and Serbo-Croatian the most shallow.
			French	+++	
			Italian	++	
			Swahili	++	
			Serbo-croatian	+	

There are thought to be around 4,000 written languages in the world; Table A1 shows a very small sample to illustrate how script types are grouped and how features of those scripts might relate to learning. The most examples are given for Latin scripts as there are more users of this script type around the world than any other (around 2.6 billion). Script groups are ordered by size of graphemic units, from the largest (logograms), to the smallest (phonemes). 'Depth' is given as a rough approximation of the orthographic depth of each script, with scripts denoted + being the most shallow and scripts denoted ++++ being the most deep. The notion of depth is particularly relevant to Latin scripts as it relates to how consistent symbol-sound mappings are (See Schmalz, Marinus, Coltheart & Castles, 2015, for a thorough review of the idea of orthographic depth). Generally speaking, the deeper the orthography the longer it takes children to master basic principles, affecting progress in accuracy and speed of reading (Ellis et al., 2004; see the Orthographic Depth Hypothesis- Katz & Frost, 1992). Depth also interacts with other key variables; for example, phonological awareness (sensitivity to the speech sounds making up words) is an excellent predictor of the rate of reading acquisition in alphabetic Latin scripts, however it is modulated by orthographic depth (Ziegler et al., 2010). Depth ratings have not been given for non-alphabetic scripts as the idea is not really meaningful for logographic scripts (although Hanzi does include some clues as to pronunciation), and in syllabaries, alphasyllabaries and abjads, orthographic depth is meaningful, but is highly modified by other factors such as the use of diacritics (stress or accent markings added to the written form).

Orthographic depth is not the only factor to influence the speed of learning to read Latin scripts. Other factors include: the availability of units relevant to orthography in spoken language (e.g., syllables vs phonemes), and granularity (when orthographic units represent a larger unit in speech, there are more combinations to learn) (Ziegler & Goswami, 2005). The *visual complexity* of graphemes, as well as the *syllabic complexity* of the language being represented (Seymour et al., 2003) will also influence learning speed.

The majority of African languages use either an Arabic-derived Ajami script or the Latin script, with Latin being used across sub-saharan Africa and Arabic in North Africa. The Latin script was introduced to Africa around the turn of 20th century. Generally speaking, orthographies using Latin are shallow, although not all sounds used in African languages are represented with Latin letter forms, making pronunciation inconsistent. In some countries, such as Niger, both script types are used, Ajami to write the Hausa language and Latin to write the Zarma language. Some languages can be written in multiple scripts. For example, Swahili is generally now written in Latin, but was once written in Arabic, while other languages actively use multiple scripts to this day, such as the Shilha language of West Morocco, which is written in Latin, Arabic and the ancient African abjad script of Tifinagh. Only a handful of languages are written in a script other than Ajami or Latin, most notably Ethiopian languages tend to use the ancient African alphasyllabary, Ge'ez.

References for Table A1

Ellis, N. C., Natsume, M., Stavropoulou, K., Hoxhallari, L., van Daal, V. H. P., Polyzoe, N., Tsipa, M-L., & Petalas, M. The effects of orthographic depth on learning to read alphabetic, syllabic, and logographic scripts. *Reading Research Quarterly, 39* (4): 438–468.

Katz, L., & Frost, R. (1992). Reading is different in different orthographies: the orthographic depth hypothesis. *Advances in Psychology, 94*: 67-84.

Seymour, P. H. K., Aro, M., Erskine, J. M., & COST Action A8 network. (2003). Foundation literacy acquisition in European orthographies. *British Journal of Psychology, 94* (2): 143-174.

Schmalz, X., Marinus, E., Coltheart, M., & Castles, A. (2015). Getting to the bottom of orthographic depth. *Psychonomic Bulletin & Review, 22* (6): 1614-1629.

Shu, H., Chen, X., Anderson, R., Wu, N., & Xuan, Y. (2003). Properties of school Chinese: Implications for learning to read. *Child Development, 74:* 27–47.

Ziegler, J., Bertrand, D., Tóth, D., Csépe, V., Reis, A., Faísca, L., Saine, N., Lyytinen, H., Vaessen, A., & Blomert, L. (2010). Orthographic depth and its impact on universal predictors of reading: a cross-language investigation. *Psychological Science, 21* (4): 551-559.

Ziegler, J., & Goswami, U. (2005). Reading acquisition, developmental dyslexia, and skilled reading across languages: a psycholinguistic grain size theory. *Psychological Bulletin, 131* (1): 3-29.

Table A2. Ingredients of teacher training: key knowledge regarding adult learners

Level	
Brain	Important differences and similarities between adult and child learners
	Decline in plasticity – need frequent retrieval practice, multiple examples, active learning, exaggerated exemplars
	Emphasis on metacognition – rules of spelling and grammar, showing how words are related to stem meanings
	Phonological awareness
	Morphological awareness
	Orthographic awareness
Person	Motivation is key and can be improved using simple rewards such as positive feedback, increased autonomy and offering choices to learners
	Programs must be meaningful, engaging, social and relevant to minimize frustration
	Be clear about expectations of progress and attainment and emphasize need for long term practice
	Metacognitive training: reflect on learning – what has worked, what hasn't, best strategies. Say it out loud
Learning environment	Importance of active rather than passive learning – create own materials, invent own tests, solve problems learners set each other
	Frequent practice over a long period of time, assisted by technology or functional goal-setting
	Frequent testing (retrieval learning), desirable difficulties, spaced learning, ground concepts in real experiences, multiple and varied formats and examples
	Access to high-quality materials, relevant to learner, with graduated difficulty, supporting both exploration and practice
	Encourage social learning wherever possible – in groups in the classroom and outside it; with fellow learners, children, colleagues
	SMS technology training to encourage practice, set homework, quizzes and puzzles
Culture	Importance of local community in facilitating, scaffolding, and supporting learning. They must be meaningfully involved throughout

Table A3. Known unknowns of adult literacy learning

Level	
Brain	What is the effect of lack of prior education on executive function capabilities?
	How similar is forgetting in adults vs children (to what extent do adults lose new skills between learning sessions more than children)?
	What is the final rate of reading or fluency level potential for adult learners?
	To what extent is visual attention span different in adults and children, and differently trainable?
	Are there differences in how quickly complex visual patterns can be recognized in children and adults, and what level of expertise can be achieved?
	What is the effect of different script type on rate of learning in adults?
	What is the relationship between working memory capacity and rate of progress in reading speed?
	How similar is the reading progress of children and adults given the same amount of practice?
Person	What is the rate of progress with mother tongue versus non mother tongue teaching and learning?
	What is the effect of frequency / dose / duration of long-term, post course practice on literacy outcomes?
Learning environment	What is the optimal frequency, dose and duration of teaching?
	What is the effectiveness of different external rewards such as food vouchers/ payments?
	What is the optimal class size?
	How are outcomes influenced if learners are banded according to ability?
	How effective are computer-based interventions, either as a complement to or a subst for teacher-based learning?
	How effective are mobile-phone-based interventions?
Culture	What is the respective impact of 'top-down' vs 'bottom-up' approaches on end outcomes?
	How is the speed of writing acquisition influenced by digital versus manual approaches?

REFERENCES

[1] United Nations Educational, Scientific and Cultural Organization; UNESCO. (2017). *FactSheet No 45: Literacy Rates Continue to Rise from One Generation to the Next*. UNESCO Institute for Statistics, Paris, France.

[2] United Nations Educational, Scientific and Cultural Organization; UNESCO. (1978). *Resolution 15.1'1 adopted by the General Conference at its twentieth session*. UNESCO, Paris, France.

[3] Roser, M., & Ortiz-Ospina, E. (2018) - "Literacy". *Published online at OurWorldInData.org.* Retrieved from: 'https://ourworldindata.org/literacy' [Online Resource]

[4] UNESCO. (2015). *Education for all 2000-2015: Achievements and Challenges*. Paris: UNESCO.

[5] United Nations Educational, Scientific and Cultural Organization; UNESCO. (2017). *FactSheet No 45: Literacy Rates Continue to Rise from One Generation to the Next*. UNESCO Institute for Statistics, Paris, France.

[6] Ma, X. (2009). Background paper prepared for the Education for All Global Monitoring Report 2009 Overcoming Inequality: why governance matters A Global Perspective on Socioeconomic Differences in Learning Outcomes. Paper commissioned for the EFA Global Monitoring Report 2009, Overcoming Inequality: why governance matters.

[7] United Nations Educational, Scientific and Cultural Organization, UNESCO (2013). *Adult and Youth Literacy: National, regional and global trends, 1985-2015*. UNESCO Institute for Statistics, Paris, France.

[8] See Post, D. (2016). Adult literacy benefits? New opportunities for research into sustainable development. *International Review of Education, 62*:751–770.

[9] Kutner, M., Greenberg, E., & Baer, J. (2005). *National Assessment of Adult Literacy (NAAL): A first look at the literacy of America's adults in the 21st century (NCES 2006-470).* Washington, DC: National Center for Educational Statistics.

[10] Tuckett, A., & Popović, K. (2015). Plus ça change, plus c'est la même chose: Adult literacy since 2000—a civil society perspective. *Andragoške Studije*, *1*(2015), 25–40.

[11] Centanni, T. M., King, L. W., Eddy, M., Whitfield-Gabrieli, S., & Gabrieli, J. D. E. (2017). Development of sensitivity versus specificity for print in the visual word form area**.** *Brain and Language, 170*.

[12] Thomas, M. S. C., Ansari, D., & Knowland, V. C. P. (2018). Annual Research Review: Educational Neuroscience: Progress and Prospective. *Journal of Child Psychology and Psychiatry,* 2018 https://doi.org/10.1111/jcpp.12973

[13] Freitas, C., Farzan F., & Pascual-Leone, A. (2013). Assessing brain plasticity across the lifespan with transcranial magnetic stimulation: why, how, and what is the ultimate goal? *Frontiers in Neuroscience, 7*: 42.

[14] Knudsen, E.I. (2004). Sensitive periods in the development of the brain and behavior. *Journal of Cognitive Neuroscience, 16,* 1412–1425.

[15] Daw, N. W. (1998). Critical periods and amblyopia. *JAMA Ophthalmology, 116*(4): 502-505.

[16] Fox, N. (2014). What do we know about sensitive periods in human development and how do we know it? *Human Development, 57*:173–175.

[17] Knowland, V. C. P., & Thomas, M. S. C. (2014). Educating the adult brain: How the neuroscience of learning can inform educational policy. *International Review of Education*, *60*, 99-122.

[18] Kuhl, P.K., Conboy, B. T., Coffey-Corina, S., Padden, D., Rivera-Gaxiola, M., & Nelson, T. (2007). Phonetic learning as a pathway to language: new data and native language magnet theory expanded (NLM-e) *Philosophical Transactions of the Royal Society B: Biological Sciences, 363:* http://doi.org/10.1098/rstb.2007.2154

[19] Hartshorne, J. K., Tenenbaum, J. B., & Pinker, S (2018). A critical period for second language acquisition: Evidence from 2/3 million English speakers. *Cognition, 177*: 263–277.

[20] Park, D. C., Lautenschlager, G., Hedden, T., Davidson, N. S., Smith, A. D., & Smith, P. K. (2002). Models of visuospatial and verbal memory across the adult life span. *Psychology of Aging,17*(2): 299-320.

[21] Bolger, D. J., Perfetti, C. A. & Schneider, W. (2005). Cross-cultural effect on the brain revisited: universal structures plus writing system variation. *Human Brain Mapping,* 25 92–104.

[22] Dehaene, S., Pegado, F., Braga, L. W., Ventura, P., Nunes Filho, G., Jobert, A., Dehaene-Lambertz, G., Kolinsky, R., Morais, J., & Cohen, L. (2010). How learning to read changes the cortical networks for vision and language. *Science, 330* (6009): 1359-1364.

[23] Deheane, S., & Cohen, L. (2007). Cultural recycling of cortical maps. *Neuron, 52* (2): 384-398.

[24] Hasson, U., Levy, I., Behrmann, M., Hendler, T., & Malach, T. (2002). Eccentricity bias as an organizing principle for human high-order object areas. *Neuron, 34*: 479–490.

[25] Szwed, M., Cohen, L., Qiao, E., & Deheane, S. (2009). The role of invariant line junctions in object and visual word recognition. *Vision Research, 49*, 718–725.

[26] Szwed, M., Deheane, S., Kleinschmidt, A., Eger, E., Valabrèque, R., Amadon, A., & Cohen, L. (2011). Specialization for written words over objects in the visual cortex. *Neuroimage 56,* 330–344.

[27] Stevens, W. D., Kravitz, D. J., Peng, C. S., Tessler, M. H., & Martin, A. (2017). Privileged functional connectivity between the visual word from area and the language system. *Journal of Neuroscience, 37* (21): 5288-5297.

[28] Dehaene, S., Pegado, F., Braga, L. W., Ventura, P., Nunes Filho, G., Jobert, A., Dehaene-Lambertz, G., Kolinsky, R., Morais, J., & Cohen, L. (2010). How learning to read changes the cortical networks for vision and language. *Science, 330* (6009): 1359-1364.

[29] Dehaene, S., Nakamura, K., Jobert, A., Kuroki, C., Ogawa, S., & Cohen, L. (2010). Why do children make mirror errors in reading? Neural correlates of mirror invariance in the visual word form area. *Neuroimage, 49* (2): 1837-1848.

[30] Pegado, F., Nakamura, K., Cohen, L., & Deheane, S. (2011). Breaking the symmetry: Mirror discrimination for single letters but not for pictures in the visual word form area. *Neuroimage, 55*(2): 742-749.

[31] Kolinski, R., Verhaeghe, A., Fernandes, T., Mengarda, E. J., Grimm-Cabral, L., & Morais, J. (2011). Enantiomorphy through the looking glass: literacy effects on mirror image discrimination. *Journal of Experimental Psychology, General, 140* (2): 210-238.

[32] Pegado, F., Comerlato, E., Ventura, F, Jobert, A., Nakamura, K., Buiatti, M., Ventura, P., Dehaene-Lambertz, G., Kolinsky, R., Morais, J., Braga, L. W., Cohen, L., & Dehaene, S. (2014). Timing the impact of literacy on visual processing. *Proceedings of the National Academy of Science, U.S.A, 111* (49): E5233-5242.

[33] Braga, L. W., Amemiya, E., Tauil, A., Suguieda, D., Lacerda, C., Klein, E., Dehaene-Lambertz, G., & Dehaene, S. (2017). Tracking adult literacy acquisition with functional MRI: A single case study. *Mind, Brain & Education, 11* (3).

[34] Boltzmann, M., Mohammad, B., Samij, A., Münte, T. F, & Rüsseler. (2017). Structural changes in functionally illiterate adults after intensive training. *Neuroscience, 344*: 229-242.

[35] See Chan, J. C. K., Meissner, C. A., & Davis, S. D. (2018). Retrieval potentiates new learning: a theoretical and meta-analytic review. *Psychological Bulletin, 144* (11): 1111-1146.

[36] Cepeda, N. J., Pashler, H., Vul, E., Wixted, J. T., & Rohrer, D. (2006). Distributed practice in verbal recall tasks: a review and quantitative synthesis. *Psychological Bulletin, 132* (3): 354-380.

[37] Keuroghlian, A. S., & Knudsen, E. I. (2007). Adaptive auditory plasticity in developing and adult animals. *Progress in Neurobiology, 82*(3), 109–121.

[38] Lillard, A. S., & Erisir, A. (2011). Old dogs learning new tricks: neuroplasticity beyond the juvenile period. *Developmental Reviews, 31* (4): 207-239.

[39] McCandliss, B., Fiez, J. A., Protopapas, A., Conway, M., & McClelland, J. L. (2002). Success and failure in teaching the [r]-[l] contrast to Japanese adults: Tests of a Hebbian model of plasticity and stabilization in spoken language perception. *Cognitive, Affective & Behavioural Neuroscience, 2* (2): 89-108.

[40] Hazan, V., Sennema, A., Iba, M., & Faulkner, A. (2005). Effect of audiovisual perceptual training on the perception and production of consonants by Japanese learners of English. *Speech Communication, 47* (3): 360-378.

[41] Zang, Y., Kuhl, P. K., Imada, T., Iverson, P., Pruitt, J., Stevens, E., Kawakatsu, M., Tohkura, Y., & Nemotoc, I. (2009). Neural signatures of phonetic learning in adulthood: a magnetoencephalagraphy study. *Neuroimage, 46* (1): 226-240.

[42] Schaie, K. W. (2005). *Developmental Influences on Adult Intelligence: The Seattle Longitudinal Study*. Oxford University Press: Oxford, UK.

[43] De Luca, C.R., Wood, S.J., Anderson, V., Buchanan, J-A., Proffitt, T. M., Mahony, K., & Pantelis, C. (2003). Normative data from the cantab. I: Development of executive function over the lifespan. *Journal of Clinical and Experimental Neuropsychology, 25* (2): 242-254.

[44] Best, J. R., & Miller, P. H. (2010). A developmental perspective on executive function. *Child Development, 81* (6): 1641-1660.

[45] Zelazo, P. D., & Carlson, S. M. (2012). Hot and cool executive function in childhood and adolescence: development and plasticity. *Child Development Perspectives, 6* (4): 354-360.

[46] See Burnett, S., Sebastian, C., Cohen Kadosh, K., & Blakemore, S-J. (2011). The social brain in adolescence: Evidence from functional magnetic resonance imaging and behavioural studies. *Neuroscience & Biobehavioral Reviews, 35* (8): 1654-1664.

[47] Craik, F. I., & Bialystock, E. (2006). Cognition through the lifespan: mechanisms of change. *Trends in Cognitive Science, 10* (3): 131- 138.

[48] See Murphy, G., Groeger, J. A., & Greene, C. M. (2016). Twenty years of load theory - Where are we now, and where should we go? *Psychonomic Bulletin & Review, 23* (5): 1316-1340.

[49] See Kuhn, D. (2000). Metacognitive development. *Current Directions in Psychological Science, 9* (5): 178-181.

[50] Souchay, C., & Isingiri, M. (2004). Age related differences in metacognitive control: Role of executive functioning. *Brain and Cognition, 56* (1): 89-99.

[51] Gómez-Pérez, E., & Ostrosky-Solís, F. (2006). Attention and memory evaluation across the life span: heterogeneous effects of age and education. *Journal of Clinical and Experimental Neuropsychology, 28* (4): 477-494.

[52] Gómez-Pérez, E., & Ostrosky-Solís, F. (2006). Attention and memory evaluation across the life span: heterogeneous effects of age and education. *Journal of Clinical and Experimental Neuropsychology, 28* (4): 477-494.

[53] Sperling, R. A., Howard, B. C., Staley, R., & DuBois, N. (2004). Metacognition and self-regulated learning constructs. *Education Research and Evaluation, 10* (2): 117-139.

[54] See Zimmermann, B. J. (2010). Becoming a self-regulated learner: an overview. *Theory into Practice, 41* (2): 64-70.

[55] Carter, M., & Beier, M. E. (2010). The effectiveness of error management training with working-aged adults. *Personnel Psychology, 63* (3): 641-675.

[56] Schraw, G. (1998). Promoting general metacognitive awareness. *Instructional Science 26*: 113–125.

[57] Vöhringer, I. A., Kolling, T., Graf, F., Poloczek, S., Fassbender, I., Freitag, C., Lamm, B., Suhrke, J., Teiser, J., Teubert, M., Keller, H., Lohaus, A., Schwarzer, G., & Knopf, M. (2017). The development of implicit memory from infancy to childhood: on average performance levels and interindividual differences. *Child Development, 89* (2): 370-382.

[58] Lukács, Á., & Kemény, F. (2015). Development of different forms of skill learning throughout the lifespan.

Cognitive Science, 39 (2): 383-404.

[59] Ghetti, S., & Bunge, S. A. (2012). Neural changes underlying the development of episodic memory during middle childhood. *Developmental Cognitive Neuroscience, 2* (4): 381-395.

[60] Rabi, R., Miles, S. J., & Minda, J. P. (2015). Learning categories via rules and similarity: Comparing adults and children. *Journal of Experimental Child Psychology, 131*: 149-169.

[61] Smalle, E. H. M., Page, M. P. A., Duyck, W., Edwards, M., Szmalec, A. (2018). Children retain implicitly learned phonological sequences better than adults: a longitudinal study. *Developmental Science, 21* (5): e12634.

[62] Ferman, S., & Karni, A. (2010). No childhood advantage in the acquisition of skill in using an artificial language rule. *PLOS one, 5* (10): e13648

[63] Bishop, D. V., Barry, J. G., & Hardiman, M. J. (2012). Delayed retention of new word-forms is better in children than adults regardless of language ability: a factorial two-way study. *PLoS One, 7* (5): e37326.

[64] Brehmer, Y., Li, S. C., Muüller, V., von Oertzen, T., & Lindenberger, U. (2007). Memory plasticity across the life span: uncovering children's latent potential. *Developmental Psychology, 43* (2): 465-478.

[65] Baltes, P.B. (1987). Theoretical propositions of life-span developmental psychology: On the dynamics between growth and decline*. Developmental Psychology, 23*:611–626.

[66] See Shing, Y. L., & Lindenberger, U. (2011). The development of episodic memory: lifespan lessons. *Child Development Perspectives, 5*(2): 148-155.

[67] United Nations Educational, Scientific and Cultural Organization; UNESCO. (2008). *Effective Literacy Programmes: options for policy makers.* UNESCO International Institute for Education Planning, Paris, France.

[68] Duff, F. J., & Hulme, C. (2012). The role of children's phonological and semantic knowledge in learning to read words. *Scientific Studies of Reading, 16*: 504–525.

[69] Wang, H. C., Nickels, L., Nation, K., & Castles, A. (2013). Predictors of orthographic learning of regular and irregular words. *Scientific Studies of Reading, 17*: 369–384.

[70] Taylor, J. S. H., Plunkett, K., & Nation, K. (2011). The influence of consistency, frequency, and semantics on learning to read: An artificial orthography paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37*: 60–76.

[71] Tunmer, W. E., & Chapman, J. W. (2012). Does set for variability mediate the influence of vocabulary knowledge on the development of word recognition skills? *Scientific Studies of Reading, 16,* 122–140.

[72] Salthouse, T. A. (2014). Quantity and structure of word knowledge across adulthood. *Intelligence, 46*: 122-130.

[73] Hartshorne, J. K., Tenenbaum, J. B., & Pinker, S. (2018). A critical period for second language acquisition: Evidence from 2/3 million English speakers. *Cognition, 177*: 263-277.

[74] United Nations Educational, Scientific and Cultural Organization; UNESCO. (1978). *Resolution 15.1'1 adopted by the General Conference at its twentieth session*. UNESCO, Paris, France.

[75] Tighe, E. L., Little, C. W., Arrastia-Chisholm, M. C., Schatschneider, C., Diehm, E., Quinn, J. M., & Edwards, A. A. (2018). Assessing the direct and indirect effects of metalinguistic awareness to the reading comprehension skills of struggling adult readers. Reading and Writing, doi.org/10.1007/s11145-018-9881-2.

[76] Melby-Lervåg, M., Halaas Lyster, S-A., & Hulme, C. (2012). Phonological skills and their role in learning to read: a meta-analytic review. *Psychological Bulletin, 138* (2): 322–352.

[77] Lonigan, C. J., & Burgess, S. R. (2000). Development of emergent literacy and early reading skills in preschool children: evidence from a latent-variable longitudinal study. *Developmental Psychology, 36* (5): 596-613.

[78] Caravolas, M., Hulme, C., & Snowling, M. J. (2000). The foundation of spelling ability: evidence from a 3-year longitudinal study. *Journal of Memory and Language, 45* (4): 751-774.

[79] Thompkins, A. C., & Binder, K. S. (2003). A comparison of the factors affecting reading performance of functionally illiterate adults and children matched by reading level. *Reading Research Quarterly, 38*(2), 236-258.

[80] See Goswami, U., & Bryant, P. (2016). *Phonological Skills and Learning to Read*. Routledge: Oxford, UK.

[81] Talwar, A., Cote, N. G., & Binder, K. S. (2014). Investigating predictors of spelling ability for adults with low literacy skills. *Journal of Research and Practice for Adult Literacy, Secondary and Basic Education, 3* (2): 35-50.

[82] Eme, E., Lambert, E., & Alamargot, D. (2014). Word reading and word spelling in French adult literacy students: the relationship with oral language skills. *Journal of Research in Reading, 37* (3): 268-296.

[83] Tighe, E. L., & Scatschneider, C. (2016). Examining the relationships of component reading skills to reading comprehension in struggling adult readers: A meta-analysis. *Journal of Learning Disabilities, 49* (4): 395-409.

[84] Greenberg, D., Ehri, L. C., & Perin, D. (2002). Do adult literacy students make the same word-reading and spelling errors as children matched for word-reading age? *Scientific Studies of Reading, 6* (3): 221-243.

[85] Morais J., Cary, L., Alegria, J., & Bertelson, P. (1979). Does awareness of speech as a sequence of phones arise spontaneously? Cognition, 7,323-331.

[86] Jiménez, J. E., García, E., & Venegas, E. (2010). Are phonological processes the same or different in low literacy adults and children with or without reading disabilities? *Reading and Writing, 23* (1): 1-18.

[87] Petersson, K. M., Reis, A., Askelöf, S., Castro-Caldas, A., & Ingvar, M. (2000). Language processing modulated by literacy: a network analysis of verbal repetition in literate and illiterate subjects. *Journal of Cognitive Neuroscience, 12* (3): 364-382.

[88] Landgraf, S., Beyer, R., Hild, I., Schneider, N., Horn, E., Schaadt, G., Foth, M., Pannekamp, A., der Meer, E. (2012). Impact of phonological processing skills on written language acquisition in illiterate adults*. Developmental Cognitive Neuroscience, 2*: S129-S138.

[89] To, N. L., Tighe, E. L., & Binder, K. S. (2016). Investigating morphological awareness and the processing of transparent and opaque words in adults with low literacy skills and in skilled readers. *Journal of Research in Reading, 39* (2): 171–188.

[90] Rastle, K. (2018). The place of morphology in learning to read in English. *Cortex*, pii: S0010-9452(18)30057-1.

[91] Berninger, V. W., Abott, R. D., Nagy, W., & Carlisle, J. (2010). Growth in phonological, orthographic, and morphological awareness in Grades 1 to 6. *Journal Psycholinguistic Research, 39*:141–163.

[92] Ruan, Y., Georgiou, G. K., Li, Y., & Shu, H. Does writing system influence associations between phonological awareness, morphological awareness, and reading? A meta-analysis. *Journal of Educational Psychology, 110*(2): 180-202.

[93] See Castles, A., Rastle, K., & Nation, K. (2018). Ending the reading wars: reading acquisition from novice to expert. *Psychological Science in the Public Interest*, *19*(1), 5–51.

[94] Taylor, J. S. H., Davis, M. H., & Rastle, K. (2017). Comparing and validating methods of reading instruction using behavioural and neural findings in an artificial orthography. *Journal of Experimental Psychology, General, 146* (6): 826-858.

[95] Bitan, T., & Booth, J. R. (2012). Offline improvement in learning to read a novel orthography depends on direct letter instruction. *Cognitive Science, 36* (5): 896-918.

[96] Gilbert, C. D., & Li, W. (2012). Adult visual cortical plasticity. *Neuron, 75* (2): 250-264.

[97] Salthouse, T. A., & Somberg, B. L. (1982). Skilled performance: Effects of adult age and experience on elementary processes. *Journal of Experimental Psychology: General, 3* (2): 176-207.

[98] James, K. H., & Engelhardt, L. (2012). The effects of handwriting experience on functional brain development in pre-literate children. *Trends in Neuroscience and Education, 1*(1): 32-42.

[99] McIntyre, A. H., Hancock, P. J. B., Kittler, J., & Langton, S. R. H. Improving discrimination and face matching with caricature. *Applied Cognitive Psychology, 27* (6): 725-734.

[100] Li, J. X., & James, K. H. Handwriting generate variable visual input to facilitate symbol learning. *Journal of Experimental Psychology: General, 145* (3): 298-313.

[101] Schmalz, X., Marinus, E., Coltheart, M., & Castles, A. (2015). Getting to the bottom of orthographic depth. *Psychonomic Bulletin Review, 22*: 1614-1629.

[102] van Daal, V. (2002). The effects of orthographic depth on learning to read alphabetic, syllabic and logographic scripts. *Reading Research Quarterly, 39* (4), 438-468.

[103] Seymour, P. H. K., Aro, M., & Erskine, J. M. (2003). Foundation literacy acquisition in European orthographies. *British Journal of Psychology, 94*: 143–174.

[104] Nag, S. (2007). Early reading in Kannada: The pace of acquisition of orthographic knowledge and phonemic awareness. *Journal of Research in Reading, 30*: 7–22.

[105] Shu, H., Chen, X., Anderson, R., Wu, N., & Xuan, Y. (2003). Properties of school Chinese: Implications for learning to read. *Child Development, 74:* 27–47.

[106] Chang, L-Y., Plaut, D. C., & Perfetti, C. A. (2016). Visual complexity in orthographic learning: Modelling learning across writing system variations. *Scientific Studies of Reading, 20* (1).

[107] Cain, K., Oakhill, J., & Bryant, P. (2004). Children's reading comprehension ability: concurrent prediction by working memory, verbal ability, and component skills. *Journal of Educational Psychology, 96*(1), 31-42.

[108] Reis, A., Guerreiro, M., & Petersson, K. M. (2003) A sociodemographic and neuropsychological characterization of an illiterate population. *Applied Neuropsychology, 10* (4): 191-204.

[109] Petersson, K. M., & Reis, A. (2006). Characteristics of illiterate and literate cognitive processing: Implications of brain- behavior co-constructivism. In P. B. Baltes, P. Reuter-Lorenz, & F. Rösler (Eds.), *Lifespan development and the brain: The perspective of biocultural co-constructivism* (pp. 279-305). Cambridge: Cambridge University Press.

[110] Harris, T.L., & Hodges, R.E. (1995). *The literacy dictionary: The vocabulary of reading and writing*. Newark, DE: International Reading Association.

[111] Oxenham, J., & International Institute for Educational Planning. (2008). *Effective literacy programmes: options for policymakers*. Paris: UNESCO : IIEP - International Institute for Educational Planning.

[112] Armbruster, B.B., Lehr, F., & Osborn, J. (2001). *Put reading first: The research building blocks for teaching children to read*. Jessup, MD: National Institute for Literacy.

[113] Cain, K., Oakhill, J., & Bryant, P. (2004). Children's Reading Comprehension Ability: Concurrent Prediction by Working Memory, Verbal Ability, and Component Skills. *Journal of Educational Psychology, 96*(1), 31-42.

[114] Shore, J., Sabatini, J., Lentini, J., Holtzman, S., & McNeil, A. (2015). Development of an evidence-based reading fluency program for adult literacy learners. *Reading Psychology, 36* (1): 86-104.

[115] Education Endowment Foundation. (2018). Teaching and Learning Toolkit. Retrieved 3 December 2018, from https://educationendowmentfoundation.org.uk/evidence-summaries/teaching-learning-toolkit

[116] Hirsh-Pasek, K., Zosh, J. M., Michnick, R., Gray, J. H., Robb, M. B., & Kaufman, J. (n.d.). Putting Education in "Educational" Apps: Lessons From the Science of Learning, 32.

[117] Ambrose, S., Bridges, M., Lovett, M., DiPietro, M., & Norman, M. (2010). How Learning Works: 7 Research-Based Principles for Smart Teaching. *Centers for Teaching and Technology - Book Library*. Retrieved from https://digitalcommons.georgiasouthern.edu/ct2-library/16

[118] Benassi, V., Overson, C., & Hakala, C. (2014). Applying science of learning in education: Infusing psychological science into the curriculum. *Psychology Scholarship*. Retrieved from https://scholars.unh.edu/psych_facpub/287

[119] Cameron, J., & Pierce, W. D. (2002). *Rewards and intrinsic motivation: Resolving the controversy*. Westport, CT, US: Bergin & Garvey.

[120] Lepper, M. R., Greene, D., & Nisbett, R. E. (1973). Undermining children's intrinsic interest with extrinsic reward: A test of the 'overjustification' hypothesis. *Journal of Personality and Social Psychology*, *28*(1), 129–137. https://doi.org/10.1037/h0035519

[121] Deci, E. L., Vallerand, R. J., Pelletier, L. G., & Ryan, R. M. (1991). Motivation and Education: The Self-Determination Perspective. *Educational Psychologist*, *26*(3–4), 325–346. https://doi.org/10.1080/00461520.1991.9653137

[122] Deci, E. L., Koestner, R., & Ryan, R. M. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychological Bulletin*, *125*(6), 627–668. https://doi.org/10.1037/0033-2909.125.6.627

[123] Hidi, S. (2016). Revisiting the Role of Rewards in Motivation and Learning: Implications of Neuroscientific Research. *Educational Psychology Review*, *28*(1), 61–93. https://doi.org/10.1007/s10648-015-9307-5

[124] Hidi, S., & Harackiewicz, J. M. (2000). Motivating the Academically Unmotivated: A Critical Issue for the 21st Century. *Review of Educational Research*, *70*(2), 151–179. https://doi.org/10.3102/00346543070002151

[125] Abadiano, H. R. (2010). The New England Reading Association Journal, *46*(1), 120.

[126] Fridkin, L., & Hurry, J. (2018). Motivation to read: Effects of choice in a children's reading comprehension task. *(In Submission)*.

[127] Alvarez, A. L., & Booth, A. E. (2014). Motivated by Meaning: Testing the Effect of Knowledge-Infused Rewards on Preschoolers' Persistence. *Child Development*, *85*(2), 783–791. https://doi.org/10.1111/cdev.12151

[128]Deci, E. L., Schwartz, A. J., Sheinman, L., & Ryan, R. M. (1981). An instrument to assess adults' orientations toward control versus autonomy with children: Reflections on intrinsic motivation and perceived competence. *Journal of Educational Psychology*, *73*(5), 642–650. https://doi.org/10.1037/0022-0663.73.5.642

[129] Zepke, N., & Leach, L. (2010). Improving student engagement: Ten proposals for action. *Active Learning in Higher Education*, *11*(3), 167–177. https://doi.org/10.1177/1469787410379680

[130] Adcock, R. A., Thangavel, A., Whitfield-Gabrieli, S., Knutson, B., & Gabrieli, J. D. E. (2006). Reward-Motivated Learning: Mesolimbic Activation Precedes Memory Formation. *Neuron*, *50*(3), 507–517. https://doi.org/10.1016/j.neuron.2006.03.036

[131] Murayama, K., & Kitagami, S. (2014). Consolidation power of extrinsic rewards: Reward cues enhance long-term memory for irrelevant past events. *Journal of Experimental Psychology: General*, *143*(1), 15–20. https://doi.org/10.1037/a0031992

[132] Tricomi, E., & DePasque, S. (2016). The Role of Feedback in Learning and Motivation. In *Recent Developments in Neuroscience Research on Human Motivation* (Vol. 19, pp. 175–202). Emerald Group Publishing Limited. https://doi.org/10.1108/S0749-742320160000019015

[133] Howard-Jones, P. A., & Jay, T. (2016). Reward, learning and games. *Current Opinion in Behavioral Sciences*, *10*, 65–72. https://doi.org/10.1016/j.cobeha.2016.04.015

[134] Howard-Jones, P. A., Jay, T., Mason, A., & Jones, H. (2016). Gamification of Learning Deactivates the Default Mode Network. *Frontiers in Psychology*, *6*. https://doi.org/10.3389/fpsyg.2015.01891

[135] Schunk, D. H., & Zimmerman, B. J. (2008). *Motivation and Self-regulated Learning: Theory, Research, and Applications*. Routledge.

[136] Dweck, C. S. (2006). Mindset: How we can learn to fulfill our potential. *New York, NY: Random*.

[137] Sisk, V. F., Burgoyne, A. P., Sun, J., Butler, J. L., & Macnamara, B. N. (2018). To What Extent and Under Which Circumstances Are Growth Mind-Sets Important to Academic Achievement? Two Meta-Analyses. *Psychological Science*, *29*(4), 549–571. https://doi.org/10.1177/0956797617739704

[138] Schmidt, A. M., & Ford, J. K. (n.d.). Learning Within a Learner Control Training Environment: The Interactive Effects of Goal Orientation and Metacognitive Instruction on Learning Outcomes. *Personnel Psychology*, *56*(2), 405–429. https://doi.org/10.1111/j.1744-6570.2003.tb00156.x

[139] Peale, N. V. (n.d.). *The Power of Positive Thinking*. Om Books International.

[140] Masters, B. (2016). *Positive Thinking: Easy self help guide: How to stop negative thoughts, negative self-talk, and reduce stress using the power of positive thinking, happiness, affirmations, and positive psychology*. CreateSpace Independent Publishing Platform.

[141] Duckworth, A. L., Kirby, T. A., Gollwitzer, A., & Oettingen, G. (2013). From Fantasy to Action: Mental Contrasting With Implementation Intentions (MCII) Improves Academic Performance in Children. *Social Psychological and Personality Science*, *4*(6), 745–753. https://doi.org/10.1177/1948550613476307

[142] Omolewa, M. (2008). Adult Literacy in Africa: The Push and Pull Factors. *International Review of Education*, *54*(5), 697–711. https://doi.org/10.1007/s11159-008-9091-2

[143] Ouane, A., & Glanz, C. (2010). *Why and how Africa should invest in African languages and multilingual education*. UNESCO Institute for Lifelong Learning. Retrieved from http://uil.unesco.org/literacy/multilingual-research/why-and-how-africa-should-invest-african-languages-and-multilingual

[144] Ouane, A., & Glanz, C. (2011). *Optimising Learning, Education and Publishing in Africa: The Language Factor–A Review and Analysis of Theory and Practice in Mother-Tongue and Bilingual Education in Sub-Saharan Africa.* ERIC.

[145] Benson, C. (2004). The importance of mother tongue-based schooling for educational quality.

[146] Baker, S. J. (2002). *Language Policy: Lessons from Global Models (1st, Monterey, California, September 2001)*. Monterey Institute of International Studies, 460 Pierce Street, Monterey, CA.

[147] Brock-Utne, B., & Skattum, I. (2009). *Languages and Education in Africa: a comparative and transdisciplinary analysis*. Symposium Books Ltd.

[148] Pinon, R., & Haydon, J. (n.d.). A custom report compiled by Euromonitor International for the British Council, 71.

[149] Hanemann, U., & Institute for Lifelong Learning (Eds.). (2015). *Transforming our world: literacy for sustainable development: selected case studies from http://unesco.org/uil/litbase*. Hamburg: UNESCO Institute for Lifelong Learning.

[150] Diekhoff, G. M., & Wigginton, P. K. (1989). Factors of success in a volunteer adult literacy program. *Reading and Writing*, *1*(2), 153–162. https://doi.org/10.1007/BF00377468

[151] Grabinger, R. S., & Dunlap, J. C. (1995). Rich environments for active learning: a definition. *ALT-J*, *3*(2), 5–34. https://doi.org/10.1080/0968776950030202

[152] Rogoff, B., & Lave, J. (1984). *Everyday cognition: Its development in social context*. Cambridge, MA, US: Harvard University Press.

[153] UNESCO Institute for Lifelong Learning. (2017, September 8). Effective Literacy Programmes. Retrieved 5 June 2018, from http://litbase.uil.unesco.org/

[154] Reder, S. (2012). *The longitudinal study of adult learning: Challenging assumptions*. Centre for Literacy Montreal, Quebec, Canada.

[155] National Research Council. (2012). *Read 'Improving Adult Literacy Instruction: Developing Reading and Writing' at NAP.edu*. https://doi.org/10.17226/13468

[156] Medel-Añonuevo, C. (2013). *2nd Global Report on Adult Learning and Education: Rethinking Literacy*. UNESCO Institute for Lifelong Learning. Retrieved from https://eric.ed.gov/?id=ED560502

[157] Benseman, J., Sutton, A., & Lander, J. (2005). Working in the light of evidence, as well as commitment. A literature review of the best available evidence about effective adult literacy, numeracy and language teaching. Retrieved from https://unitec.researchbank.ac.nz/handle/10652/2051

[158] Nora, H., & Irene, S. (2010). *Teaching Adult Literacy: A Teacher Education Handbook: principles and practice*. McGraw-Hill Education (UK).

[159] Mazur, E. (2009). Education: Farewell, Lecture? *Science*, *323*(5910), 50–51. https://doi.org/10.1126/science.1168927

[160] Freire, P. (2000). *Pedagogy of the Oppressed: 30th Anniversary Edition*. Bloomsbury Publishing.

[161] Council, N. R. (2012). *Improving adult literacy instruction: Supporting learning and motivation*. National Academies Press.

[162] Hanemann, U., & Institute for Lifelong Learning (Eds.). (2015). *Transforming our world: literacy for sustainable development: selected case studies from http://unesco.org/uil/litbase*. Hamburg: UNESCO Institute for Lifelong Learning.

[163] Sawyer, R. K. (Ed.). (2006). *The Cambridge Handbook of the Learning Sciences* (1 edition). Cambridge ; New York: Cambridge University Press.

[164] Torgerson, C. J., Porthouse, J., & Brooks, G. (2003). A systematic review and meta-analysis of randomised controlled trials evaluating interventions in adult literacy and numeracy. *Journal of Research in Reading*, *26*(3), 234–255. https://doi.org/10.1111/1467-9817.00200

[165] Paul. Fordham. (1995). *Adult literacy: a handbook for development workers / Paul Fordham, Deryn Holland, Juliet Millican.* Oxford: Oxfam in association with Voluntary Service Overseas.

[166] Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). What Works, What Doesn't. *Scientific American Mind*, *24*(4), 46–53. https://doi.org/10.1038/scientificamericanmind0913-46

[167] Brown, P. C., Roediger (III), H. L., & McDaniel, M. A. (2014). *Make It Stick*. Harvard University Press.

[168] Ambrose, S., Bridges, M., Lovett, M., DiPietro, M., & Norman, M. (2010). How Learning Works: 7 Research-Based Principles for Smart Teaching. *Centers for Teaching and Technology - Book Library*. Retrieved from https://digitalcommons.georgiasouthern.edu/ct2-library/16

[169] Cromley, J. (2000). Learning to Think, Learning to Learn: What the Science of Thinking and Learning Has to Offer Adult Education. National Institute for Literacy

[170] Bolton, L. (2017). Effective adult education. Retrieved from https://opendocs.ids.ac.uk/opendocs/handle/123456789/13092

[171] Kuh, G. D., Kinzie, J. L., Buckley, J. A., Bridges, B. K., & Hayek, J. C. (2006). *What matters to student success: A review of the literature* (Vol. 8). National Postsecondary Education Cooperative Washington, DC.

[172] National Research and Development Centre for Adult Literacy and Numeracy. (2013). The study of effective practice in the teaching of reading to adult learners, 2003-06.

[173] Frith, C. D., & Frith, U. (2012). Mechanisms of Social Cognition. *Annual Review of Psychology*, *63*(1), 287–313. https://doi.org/10.1146/annurev-psych-120710-100449

[174] Bahrami, B., Olsen, K., Latham, P. E., Roepstorff, A., Rees, G., & Frith, C. D. (2010). Optimally Interacting Minds. *Science*, *329*(5995), 1081–1085. https://doi.org/10.1126/science.1185718

[175] Boud, D., Cohen, R., & Australia), S., Jane (all of the University of Technology, Sydney. (2014). *Peer Learning in Higher Education: Learning from and with Each Other*. Routledge.

[176] Mazur, E. (1996). *Peer Instruction: A User's Manual* (Pap/Cdr edition). Upper Saddle River, N.J: Pearson.

[177] Lasry, N., Mazur, E., & Watkins, J. (2008). Peer instruction: From Harvard to the two-year college. *American Journal of Physics*, *76*(11), 1066–1069. https://doi.org/10.1119/1.2978182

[178] UIL. (2013). 2nd global report on adult learning and education: rethinking literacy; summary and recommendations UNESCO Digital Library. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000223449

[179] Graesser, A., & McNamara, D. (2010). Self-Regulated Learning in Learning Environments With Pedagogical Agents That Interact in Natural Language. *Educational Psychologist*, *45*(4), 234–244. https://doi.org/10.1080/00461520.2010.515933

[180] Latchem, C. (2018). *Open and Distance Non-Formal Education in Developing Countries*. Singapore, SINGAPORE: Springer. Retrieved from http://ebookcentral.proquest.com/lib/ucl/detail.action?docID=5255534

[181] Hanemann, U., & Scarpino, C. (2016). *Harnessing the Potential of ICTs: Literacy and Numeracy Programmes Using Radio, TV, Mobile Phones, Tablets and Computers. 2nd Edition*. UNESCO Institute for Lifelong Learning. Retrieved from https://eric.ed.gov/?id=ED573633

[182] Laurillard, D. (2012). *Teaching as a Design Science* (1 edition). New York, NY: Routledge.

[183] TATA group. (n.d.). Tata Computer-based Functional Literacy Programme -- The challenge. Retrieved 6 December 2018, from http://www.tataliteracy.com/challenge_overview.htm

[184] Deshpande, A., Desrochers, A., Ksoll, C., & Shonchoy, A. S. (2017). The Impact of a Computer-based Adult Literacy Program on Literacy and Numeracy: Evidence from India. *World Development*, *96*, 451–473. https://doi.org/10.1016/j.worlddev.2017.03.029

[185] Aker, J. C., Ksoll, C., & Lybbert, T. J. (2012). Can Mobile Phones Improve Learning? Evidence from a Field Experiment in Niger. *American Economic Journal: Applied Economics*, *4*(4), 94–120. https://doi.org/10.1257/app.4.4.94

[186] Traxler, J. M. (2018). Learning With Mobiles in Developing Countries: Technology, Language, and Literacy. *Information and Technology Literacy: Concepts, Methodologies, Tools, and Applications*, 774–790. https://doi.org/10.4018/978-1-5225-3417-4.ch041

[187] Aker, J. C., & Mbiti, I. M. (2010). Mobile Phones and Economic Development in Africa. *Journal of Economic Perspectives*, *24*(3), 207–232. https://doi.org/10.1257/jep.24.3.207

[188] Elias, T. (2011). Universal instructional design principles for mobile learning. *The International Review of Research in Open and Distributed Learning*, *12*(2), 143–156.

[189] Mojaddidi. (n.d.). Afghan women learn literacy through mobile phones. Retrieved 18 June 2018, from https://phys.org/news/2012-11-afghan-women-literacy-mobile.html

[190] Ardila, A., Ostrosky-Solis, F., & Mendoza, V. U. (2000). Learning to read is much more than learning to read: A neuropsychologically based reading program. *Journal of the International Neuropsychological Society*, *6*(7), 789–801.

[191] Mbah, B. A. (2016). Functional Adult Literacy through the Integration of Information and Communication Technology (ICT) for Human Resource Development in Nigeria. *Journal of Law, Policy and Globalization*, *55*, 213.

[192] Walters, S., & Watters, K. (2018). 3rd Global Report on Adult Learning and Education (GRALE 111). *Studies in the Education of Adults* https://doi.org/10.1080/02660830.2018.1432113

[193] Birch, C., Pahl, K., Bird, V., Taylor, C., & Hannon, P. (2003). *Community - focused provision in adult literacy, numeracy and language: an exploratory study.* London: National Research and Development Centre for adult literacy and numeracy.

[194] Blunch, N.-H. (2017). Adult literacy programs in developing countries. *IZA World of Labor*. https://doi.org/10.15185/izawol.374

[195] Blunch, N.-H. (2013). Staying Alive: Adult Literacy Programs and Child Mortality in Rural Ghana. *World Development*, *42*, 114–126. https://doi.org/10.1016/j.worlddev.2012.06.021

[196] Hanemann, U., & Institute for Lifelong Learning (Eds.). (2015). *Narrowing the gender gap: empowering women through literacy programs: case studies from the UNESCO Effective Literacy and Numeracy Practices Database (LitBase): http://unesco.org/uil/litbase*. Hamburg: UNESCO Institute for Lifelong Learning.

[197] Razavi, S. (2012). World Development Report 2012: Gender Equality and Development - A Commentary: Assessment: World Development Report 2012. Development and Change, 43(1), 423–437. https://doi.org/10.1111/j.1467-7660.2012.01743.x

[198] Tembon, M., & Fort, L. (2008). Girls' Education in the Twenty-first Century. World Bank Publications. Chapter 4.

[199] Weltbank (Ed.). (2011). Gender equality and development. Washington, DC: World Bank. World Development Report 2012.

[200] Psacharopoulos, G., & Patrinos, H. (2018). Returns to Investment in Education. A Decennial Review of the Global Literature. World Bank.

[201] Dollar, D., & Gatti, R. (1999). Gender Inequality, Income, and Growth: Are Good Times Good for Women? [Policy Reseach Report on Gender and development]. World Bank.

[202] Katiyar, S. P. (2016). Gender Disparity in Literacy in India. Social Change, 46(1), 46–69. https://doi.org/10.1177/0049085715618558

[203] Knowles, S. (2002). Are educational gender gaps a brake on economic development? Some cross-country empirical evidence. Oxford Economic Papers, 54(1), 118–149. https://doi.org/10.1093/oep/54.1.118

[204] Qian, Nancy. 2008. "Missing Women and the Price of Tea in China: The Effect of Sex-Specifi c Earnings on Sex Imbalance." Quarterly Journal of Economics123 (3): 1251–85.

[205] Patrinos, Harry. "Returns to Education: The Gender Perspective." In Girls' Education in the 21st Century: gender equality, empowerment, and economic growth. Washington DC: World Bank, 2008. 53-66.

[206] World Economic Forum. (2017). The Global Gender Gap Report 2017. Retrieved 6 December 2018, from https://www.weforum.org/reports/the-global-gender-gap-report-2017/

[207] Stromquist, N. (2016). Adult literacy and women: A present account. Dialogues in Social Justice: An Adult Education Journal, 1(1).

[208] Food and Agriculture Organization of the United Nations. (n.d.). Community listeners' clubs empower rural women and men. Retrieved 10 September 2019, from Food and Agriculture Organization of the United Nations website: http://www.fao.org/in-action/community-listeners-clubs-empower-rural-women-and-men/en/

[209] UN Office for the Coordination of Humanitarian Affairs (2015): World Humanitarian Data and Trends

[210] Bigelow, M., Vanek, J., King, K., & Abdi, N. (2017). Literacy as social (media) practice: Refugee youth and native language literacy at school. International Journal of Intercultural Relations, 60, 183–197. https://doi.org/10.1016/j.ijintrel.2017.04.002

[211] Whiting, S., Green, S., & Thomas, M. S. C. (2018). Stress and learning in children: neuroscience evidence and its relevance for teachers. *In Prep*.

[212] Horsman, J. (2013). *Too Scared To Learn : Women, Violence, and Education*. Routledge. https://doi.org/10.4324/9781410604965

[213] Mahan, J. D., & Stein, D. S. (2014). Teaching Adults—Best Practices That Leverage the Emerging Understanding of the Neurobiology of Learning. *Current Problems in Pediatric and Adolescent Health Care*, *44*(6), 141–149. https://doi.org/10.1016/j.cppeds.2014.01.003

[214] Hilbert, M. (2011). Digital gender divide or technologically empowered women in developing countries? A typical case of lies, damned lies, and statistics. *Women's Studies International Forum*, *34*(6), 479–489. https://doi.org/10.1016/j.wsif.2011.07.001

[215] Ardila, A., Ostrosky-Solis, F., & Mendoza, V. U. (2000). Learning to read is much more than learning to read: A neuropsychologically based reading program. *Journal of the International Neuropsychological Society*, *6*(7), 789–801.

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ABSTRACT

This report considers the science of adult literacy acquisition, with the goal of identifying principles that may improve the effectiveness of adult literacy programs. We define literacy as a continuum, from emerging literacy, through improving literacy, to fluent literacy and we outline the factors that influence how far along that continuum an adult learner is likely to proceed. Four nested levels are identified at which obstacles to literacy progress operate, but to which adult learners may also bring strengths. We consider the evidence base for each of these levels: (1) The Brain, where the basic neuroscience of how learning changes over the lifespan gives us clues about processes that restrict adult learning, and hints about how teaching can be optimized for the adult brain; (2) The Person, where the roles of motivation, resilience and engagement can have a profound impact on outcomes; (3) The Learning Environment, where teaching approach, course structure, fellow learners and technology can all affect progress; and (4) The Cultural Context, where integrating expectations and local needs into literacy programs can allow learners to access materials in the most acceptable and appropriate ways. Principles derived from this evidence base are integrated and contextualized in an analysis of six case studies from the field. We indicate areas where further research is required (e.g., determining the degree of practice adults require to achieve fluency); and identify metrics that future literacy programs should collect in order to build an evidence base of properties that improve effectiveness. The evidence summarized in this report suggests that there is scope to improve outcomes in adult literacy programs around the world, and to realize more of the social and economic benefits that such gains provide.

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