Department for Education

Numeracy skills interventions for adults (19+): A systematic review of the evidence

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Contents

List of Figures

Introduction

This systematic evidence review seeks to synthesise the evidence base for interventions to improve numeracy skills among adults with below Level 2 qualifications in Maths (*What Qualification Levels Mean*)[1]. This research will primarily be used to inform the future development of policy in this area as part of the UK government's Multiply programme (*Multiply*)[2]. It will also inform the decisions of adult numeracy practitioners and the delivery of adult numeracy provision.

This systematic evidence review combines evidence identified in earlier reviews of the literature with new or more recent research, while it focuses specifically on the Multiply target learner base (i.e. adults aged 19+ with below Level 2 qualifications in Maths). Consequently, it summarises all available evidence that is relevant to the Multiply programme in one place and facilitates the evidence-based development of the overall programme as well as a series of Randomised Controlled Trials (RCTs) and quasi-experimental trials to test promising interventions. It should be noted that the results of individuals aged 16-19 are not examined in this systematic review. Young people aged 16-19 may experience different outcomes than adults aged 19+ for similar interventions and thus the results of this research should be extrapolated to other age groups with caution.

Multiply will offer adults who do not already have a GCSE grade C/4 or higher in Maths or equivalent, and who need to improve their numeracy, free flexible courses that fit into their lives. Courses are expected to be available this autumn in person, at work or at home, on either a part time or intensive basis. These courses will equip adults across the UK with the numeracy skills they need to fulfil their potential (*Multiply*).

The primary aim of this project was to present evidence on the following questions:

i) What lessons can be learnt from adult skills policy in this area over the past 20 years?
ii) What is known about adults (19+) in the UK who have limited numeracy skills (below Level 2)?
iii) Which approaches appear to be the most and least successful in supporting different groups of adults to improve their numeracy skills, up to and including Level 2 (GCSE Grade 4+ or equivalent)?

In total, 198 studies were reviewed in full. Most of these studies were identified through a keyword-based search of relevant academic databases. Additional evidence was added to the review through the identification of additional sources, data analysis and engagement with experts. This review divides the evidence into five sections:

[1] https://www.gov.uk/what-different-qualification-levels-mean/list-of-qualification-levels
[2] https://www.gov.uk/government/news/multiplying-maths-skills-for-adults

(i) What survey data tells us about adults who have low levels of numeracy qualifications

(ii) What motivates adult learners and encourages them to engage and persist in learning

(iii) Which delivery channels are best suited to adult numeracy learners

(iv) Which teaching practices are most effective for this group of learners

(v) What additional support can be provided to support adult numeracy learners with specific needs

Methodology

To address the research questions, we carried out a systematic search of the literature, data analysis of publicly available data and interviews and roundtable discussions with sector experts. This report presents our findings from the literature review and data analysis and has been shaped by engagement with sector experts.

Literature Review

For the systematic literature review, we developed a search protocol drawing on a desk-based review of existing evidence, which was agreed upon by the Department for Education prior to the commencement of the literature search. The protocol included search terms, inclusion and exclusion criteria for screening results, and a quality assessment framework to guide our review of evidence. The results of the literature searches were supplemented by materials collected through a call for evidence to relevant UK and international organisations and through tracing forward and backward references in the literature at the discretion of the researchers. The complete protocol can be found in Appendix A.

The evidence base

As a result of keyword searches, we initially identified 865 potential sources, which were screened for relevance based on their title. Of these, 303 studies were included in the long list, which was assessed based on inclusion criteria, and duplicates were removed. The short list contained 198 studies which were reviewed in full, and 149 were found to be relevant and cited in this report. We added a further 60 studies from our call for evidence and reference tracing for a total of 209 studies[3]. Of these:

- 93 were relevant to engagement
- 70 were relevant to delivery channels
- 98 were relevant to teaching practices

[3] For the interactive evidence map, see: https://multiply.evidencemap.com/

- 30 were relevant to additional support for adult learners

Many studies were relevant to more than one section. The quality and coverage of evidence is discussed in more detail in each section. The evidence base for adult numeracy is part of a larger literature on adult basic skills education which often also includes literacy education and language learning (particularly for adults learning a new language after migration). In the literature, adult numeracy courses are often evaluated alongside other types of basic skills provision. Depending on how results are reported, it can be difficult to identify when adult numeracy practice should diverge from general adult basic skills approaches or adult literacy practices, as literacy has historically often been the primary focus of basic skills programmes. We have highlighted areas where evidence specifically relates to adult numeracy. There are a few areas, such as learner motivations, where the evidence diverges for adult numeracy courses and other adult skills training.

Most research in this area is in the form of small case studies, often based on small samples of teachers and learners. Assessments of impact are frequently drawn from surveys and interviews with participants and data on completion of courses and attainment of qualifications. These studies are useful for understanding the issues faced by teachers and learners and potential strategies to overcome them, but they can rarely be compared to a counterfactual to understand what would have happened without the intervention, and they may not be widely applicable.

There are a small number of studies which use an experimental design to try to isolate the impact of adult numeracy interventions (see e.g. Allan et al., 2012; Hume et al., 2018; Torgerson et al., 2004). These studies highlight interventions which are likely to have a causal impact on adult numeracy levels, but are very specific in nature and, in most cases, the studies have not been replicated. There are also studies which evaluate larger initiatives, follow groups of learners over time, or consider national data (e.g. Bathmaker & Pilling, 2008; Cara & de Coulon, 2008; Reder et al., 2020). These tend to cover much larger samples of learners and permit a wider range of analysis of learning provision and its impact.

As a result, the evidence discussed in this review is of mixed quality. In many cases, context is important in understanding how strong findings are and where and to what extent we would expect results to generalise. Where appropriate, the review contains methodological detail of the studies to help highlight these factors. In general, a larger range of studies applying experimental or quasi-experimental approaches to establish the impact of interventions would be welcome, as such studies were limited within the literature reviewed.

In some areas, there was a gap in the evidence base or we found only a small amount of evidence. In each of the following sections, the strength of the relevant literature is discussed in detail. Some areas where key gaps were identified include support for adults with dyscalculia; family support for adult learners; home learning; and dual

teaching[4]. In these areas, the evidence base is small with regards to adult basic skills provision. More research in these areas would be welcome, and ideas and evidence from other parts of the education and training academic literature may support the design of provision and research.

Data analysis

Data scoping

At the start of the project, we conducted a review of data sources which provided insight into the UK's adult population with low numeracy skills. We screened databases to determine how we could identify the target population for the Multiply programme (i.e. where the level of numerical attainment of respondents is identifiable). We also searched for potential data sources by (i) using CLOSER Discovery to search for relevant questions in UK longitudinal studies, and (ii) reviewing data dictionaries for datasets with variables of interest.

The data scoping identified only a limited number of datasets which facilitated the identification and analysis of adults with low numeracy skills. These included Understanding Society (UKHLS), The Skills for Life Survey (last carried out in 2011) and the PIAAC Survey of Adult Skills (last carried out in 2011).[5,6,7] Of the datasets we explored during the scoping exercise, Wave 11 of Understanding Society (UKHLS) was identified as the most current and informative dataset for facilitating the analysis of Multiply's target population.

About Understanding Society

Understanding Society is a longitudinal household panel study of the UK population (with 40,000 households sampled at Wave 1), covering a wide range of subjects such as health, work, education, income, family, and social life. Multiply's target population is specifically identifiable in Wave 11 of Understanding Society (2020). Respondents were asked if they had an O Level or GCSE grade A*-C or equivalent qualification in English, Maths, both or neither (recorded in variable qmegcse).

Understanding Society therefore established respondents' numeracy attainment through self-reporting of their numeracy qualification level. This approach differs to the Skills for Life Survey and Survey of Adult Skills which both relied on testing of participants to establish their current level of numeracy skills. As a result, the findings cited below are not directly comparable with the results of those surveys.

[4] Where a teacher is teaching a mix of remote and physically present learners
[5] The UK Household Longitudinal Study. See: https://www.understandingsociety.ac.uk
[6] 2011 Skills for Life Survey. See: https://www.gov.uk/government/publications/2011-skills-for-life-survey
[7] OECD Survey of Adult Skills. See: https://www.oecd.org/skills/piaac/

Assumptions and limitations

The analysis summarised in this report is subject to a number of assumptions and limitations, and care should be taken when interpreting our findings.

The trends and patterns presented in the analysis display associations between a series of demographic, socio-economic, and behavioural indicators, and the likelihood of having low numeracy attainment. It is important to note that any associations do not imply causation in either direction.

Understanding Society is a household survey with a sample which has been constructed to be representative of UK households. The survey has a large sample size and we have adjusted the base sample of Understanding Society Wave 11 using an appropriate weight to adjust for any over- or under-sampling and other constructional issues. Nonetheless, there was a degree of missingness and non-response within the Understanding Society dataset, with some respondents choosing not to answer certain questions or being unable to offer a response to the question. The share of missing or non-responses was generally small but they could still have introduced an element of bias to the results.

We also suspect that there is some potential for measurement error within the construction of the underlying variable used in our analysis for measuring numeracy attainment given the reliance on self-reported data. The accuracy of findings is therefore partly reliant on respondents' understanding of what information was being asked of them and their ability to accurately recall their prior achievement in maths. It is also possible that respondents' prior numeracy attainment does not reflect their current skill levels due to any gains made through informal learning opportunities, such as workplace training.

More detail on the regression analysis performed is included in the research protocol in Appendix A.

Expert engagement

As part of this project, we carried out four semi-structured individual interviews and one focus group with nine attendees. The interviews and focus group covered the same areas of engagement, delivery channels, teaching practices and additional support, with a specific focus on learning from the last 20 years of policy. Attendees included researchers, representative bodies, think tanks and individuals who had been involved in the delivery of previous interventions. Participants took part anonymously and consented to insights from these events being used in this report without identification. The insights from this phase of work have been included throughout the report and have been particularly useful in exploring the areas where the literature review did not produce much evidence.

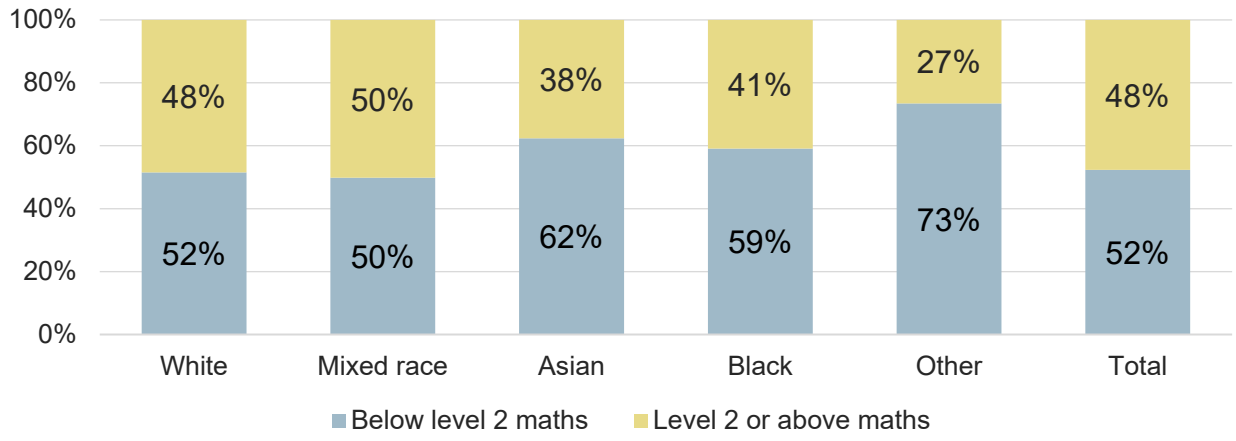
Analysis of Secondary Data

We present below our findings for numeracy attainment across different segments of the adult population, based on an analysis of responses to Understanding Society (2020). 52% of the full sample had low numeracy attainment (defined here as not having a Level 2 qualification in numeracy). The raw survey responses have been adjusted so that they are representative of the UK population.

Ethnicity

Our analysis of Understanding Society (2020) indicated that there is variation in reported numeracy attainment across different ethnic groups. Asian and black ethnic groups were found to be overrepresented amongst adults with low numeracy attainment, with 62% and 59% of adults in these groups respectively reporting numeracy attainment below Level 2. In contrast, individuals with white and mixed-race ethnicity were broadly in line with the population average, at 52% and 50% respectively.[8]

Figure 1: Numeracy attainment level by ethnicity



Base: Unweighted n = 22,891. Adults aged 19-65 responding to Understanding Society (2020).

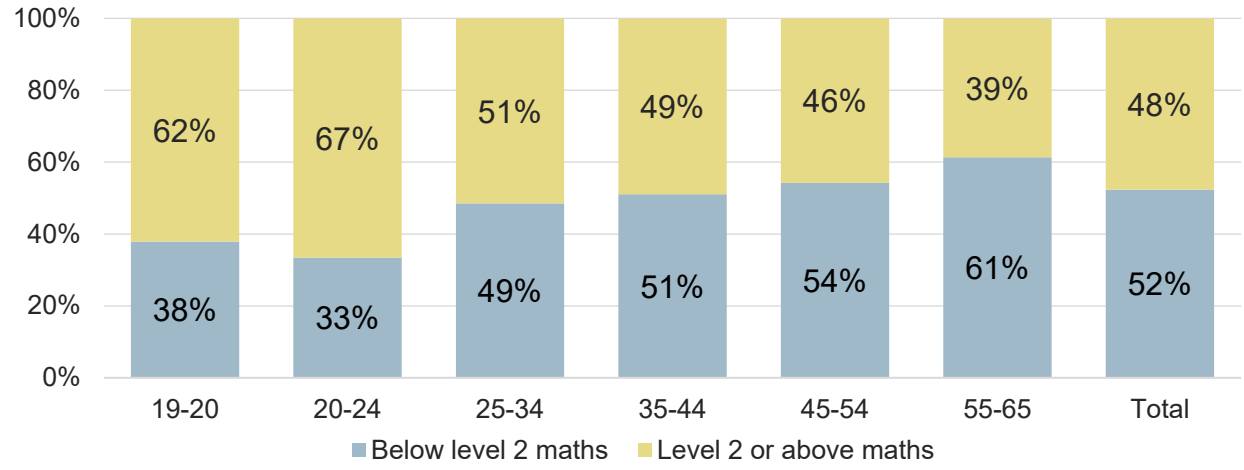
Age

Our analysis of Understanding Society (2020) indicated that there was a higher likelihood of low reported numeracy attainment amongst older age groups within society, with the proportion of adults with numeracy attainment below Level 2 increasing with every age group between the 20-24 age group, where 33% of adults had low numeracy attainment, and the 55-65 age group, where 61% of adults had low numeracy attainment.[9]

[8] These findings were broadly echoed by the results from Skills for Life (2012) which similarly found that Asian and black ethnic groups were overrepresented in the segment of the adult population with low numeracy skills.

[9] In contrast, the findings from the Skills for Life survey (2012), which tested adults' skills as opposed to using self-reported skill levels, did not exhibit a clear correlation between age and numeracy skills.

Figure 2: Numeracy attainment level by age group

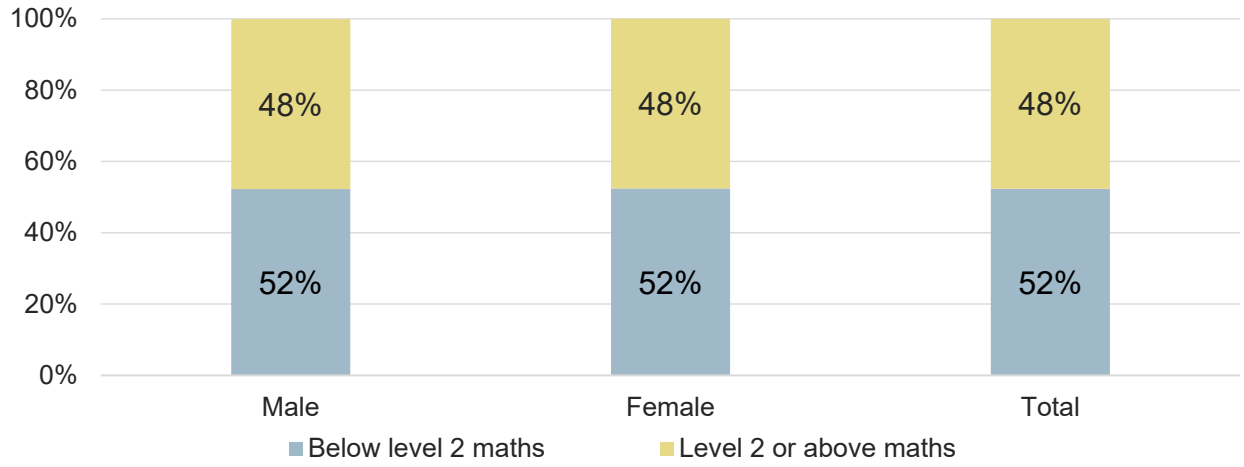


Base: Unweighted n = 22,983. Adults aged 19-65 responding to Understanding Society (2020).

Sex

Our analysis of Understanding Society (2020) indicated that there is little variation in the likelihood of low numeracy attainment based on the sex of the respondent, with 52% of both male and female respondents reporting numeracy attainment below Level 2.[10]

Figure 3: Numeracy attainment level by sex

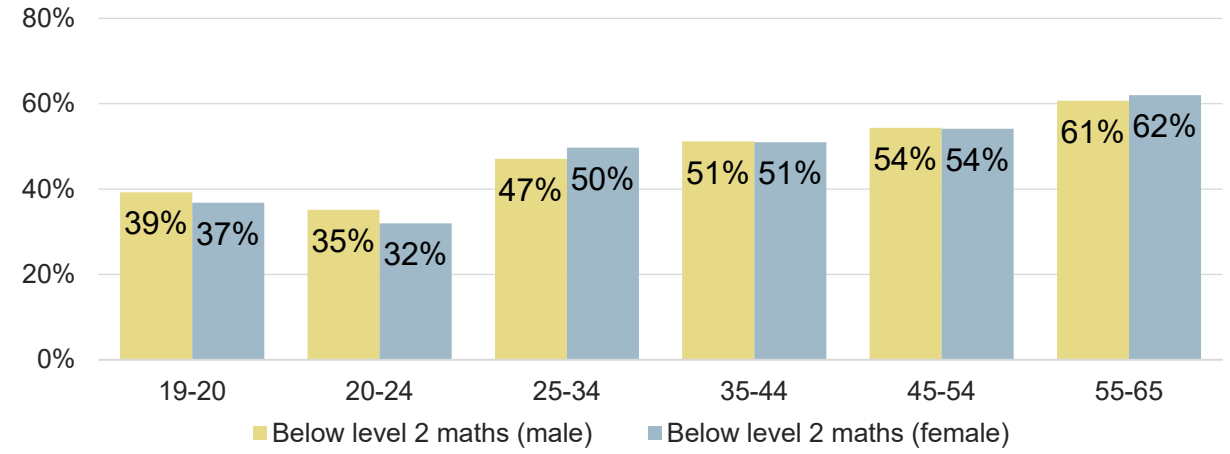


Base: Unweighted n = 22,980. Adults aged 19-65 responding to Understanding Society (2020).

Whilst there was very little overall difference in the likelihood of low numeracy attainment between males and females, more granular analysis of population segments indicated that there are differences within certain age groups. In particular, males aged 19-24 are slightly more likely to have reported numeracy attainment below Level 2 than females.

[10] Skills for Life (2012), in contrast, found that men had higher numeracy skills than women in every age group analysed.

Figure 4: Adults with low numeracy attainment by sex and age group

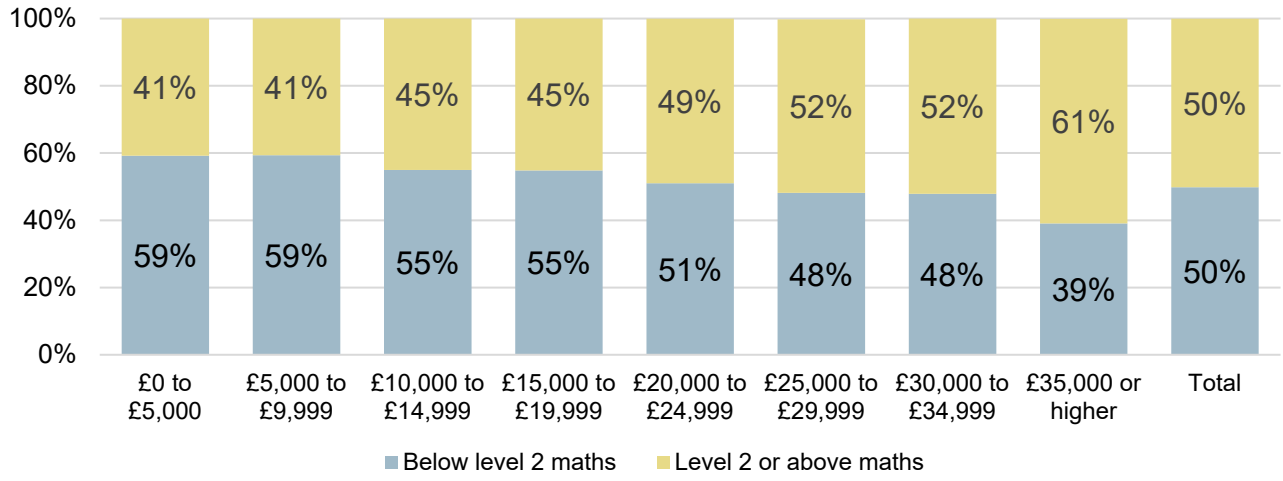


Base: Unweighted n = 22,980. Adults aged 19-65 responding to Understanding Society (2020).

Income

Our analysis of Understanding Society (2020) indicated a strong association between gross labour income and numeracy attainment, with lower income levels associated with a higher likelihood of having low numeracy attainment.[11] Around 59% of individuals with gross labour earnings below £10,000 reported having numeracy attainment below Level 2 compared with just 39% of the population for those earning £35,000 or higher.[12]

Figure 5: Numeracy attainment level by gross annual labour income band



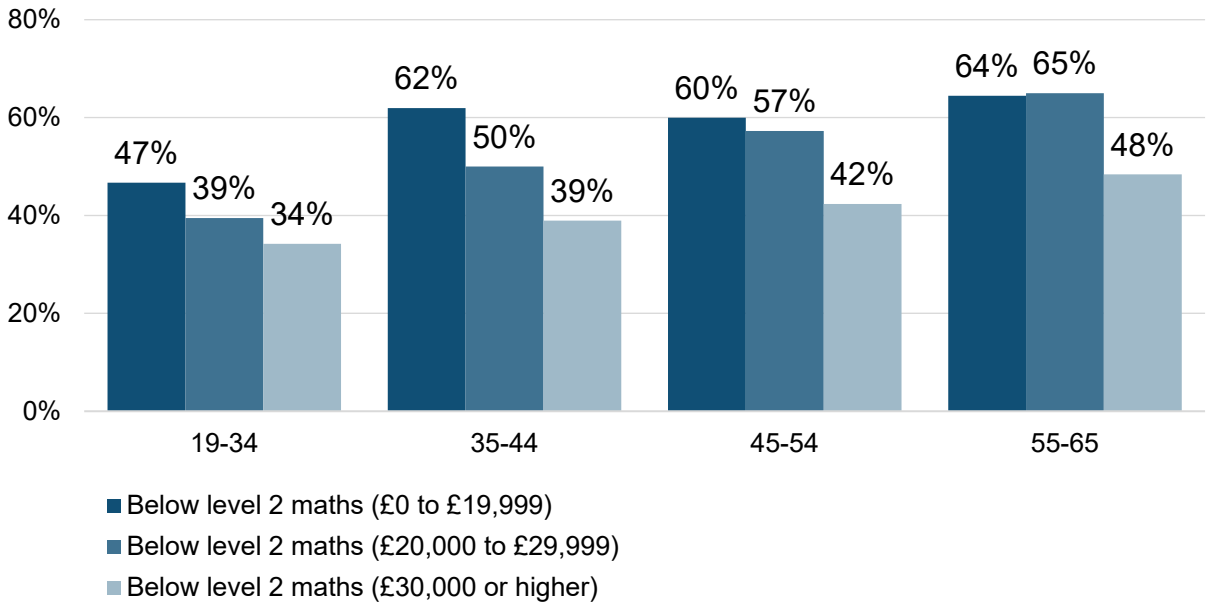
Base: Unweighted n = 16,689. Adults aged 19-65 responding to Understanding Society (2020) who are in part- or full-time employment or self-employed.

[11] Gross labour income is defined as income before tax derived from part- or full-time employment or self-employment.

[12] Skills for Life (2012) similarly found a negative correlation between the gross annual earnings of full-time workers and numeracy skills, although the segment earning less than £5,000, who exhibited numeracy skills similar to that of higher earners, was found to be an exception to this result.

The chart below shows a segmental analysis of the likelihood of low numeracy attainment across both income bands and age groups. The analysis shows that whilst the association between income and the likelihood of low numeracy attainment generally holds for all age groups, there appears to be a stronger correlation between low numeracy attainment and income for younger age groups (i.e. 19-34 and 35-44) than older age groups (i.e. 45-54 and 55-65).

Figure 6: Adults with low numeracy attainment by income band and age group



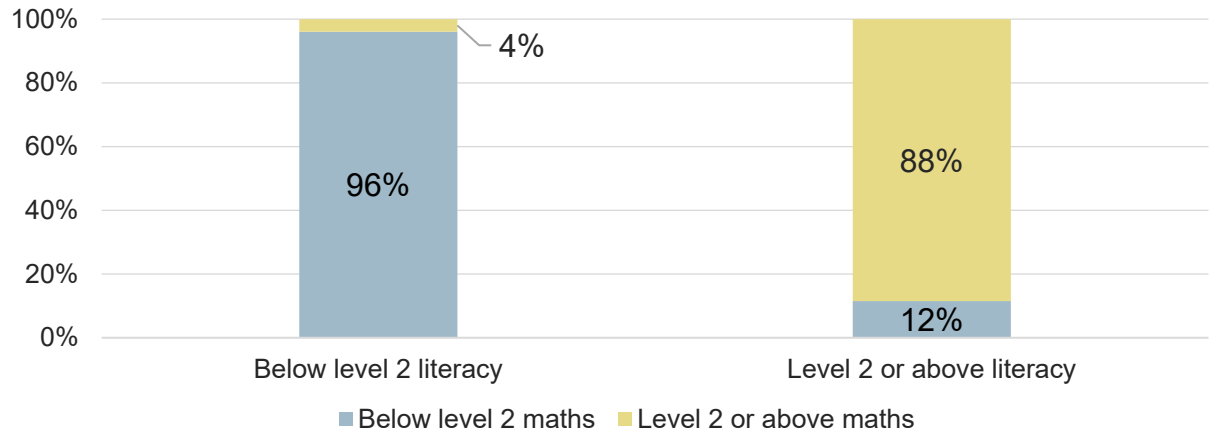
Base: Unweighted n = 16,689. Adults aged 19-65 responding to Understanding Society (2020) who are in part- or full-time employment or self-employed.

Relationship with literacy attainment

Our analysis of Understanding Society (2020) indicated a strong association between adults' reported attainment in numeracy and their reported attainment in literacy. 96% of adults with literacy attainment below Level 2 also had numeracy attainment below Level 2. Only 12% of adults with literacy attainment above Level 2 had low numeracy attainment.[13]

[13] Skills for Life (2012) estimated a correlation coefficient of 0.53 between numeracy and literacy skills levels (a correlation co-efficient is a mathematical measure of how one number is related to another, and varies between +1 and -1, with a positive value indicating that one variable increases as the other one increases). The same analysis found that an individual's literacy level is more likely to be higher than their numeracy level than vice versa, potentially explaining the Understanding Society (2020) results.

Figure 7: Numeracy attainment level by literacy attainment level

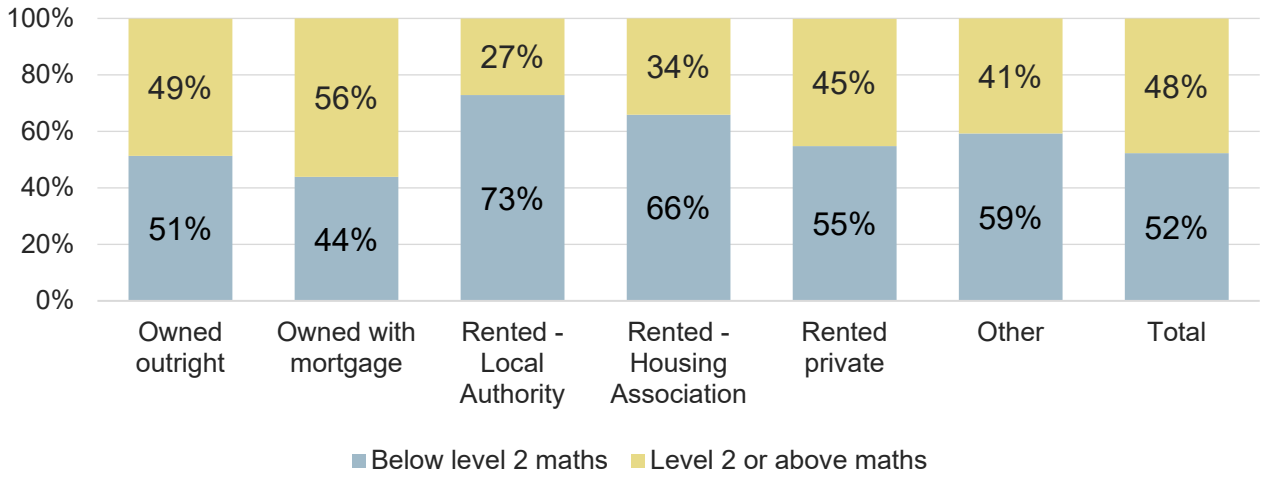


Base: Unweighted n = 22,983. Adults aged 19-65 responding to Understanding Society (2020).

Tenure of accommodation

Our analysis of Understanding Society (2020) indicated that the likelihood of low adult numeracy attainment can vary depending on the tenure of the respondent's household. Adults from households who were renting their accommodation from a local authority or housing association were associated with the highest likelihoods of having low reported numeracy attainment, with 73% and 66% of adults in these groups respectively having numeracy attainment below Level 2. In contrast, adults from households who owned their property outright or with a mortgage had a much lower likelihood of having low numeracy attainment, at 44% and 51% respectively, whilst 55% of those whose household rented their accommodation privately reported numeracy attainment below Level 2.[14]

Figure 8: Numeracy attainment level by household's accommodation tenure



Base: Unweighted n = 22,150. Adults aged 19-65 responding to Understanding Society (2020).

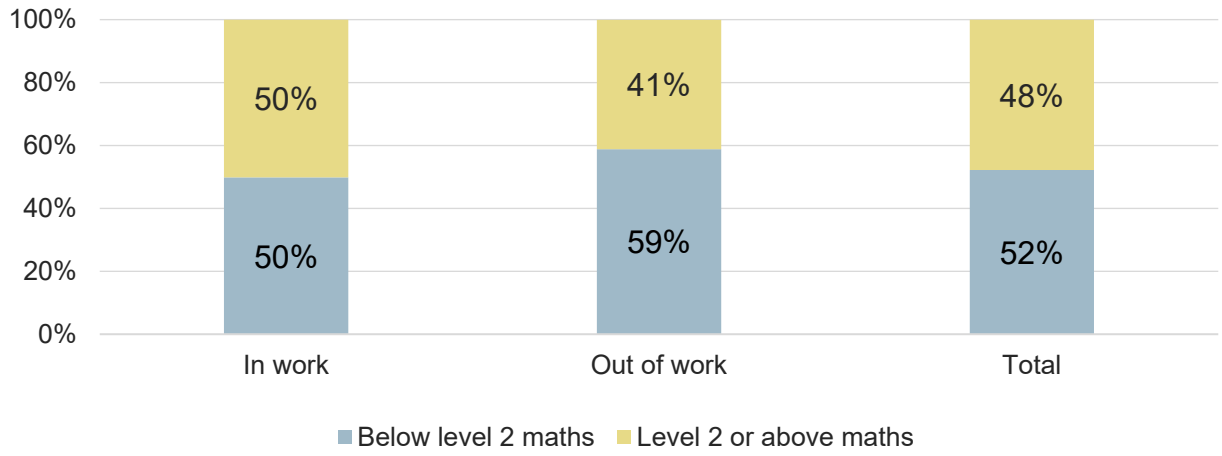
[14] Broadly echoing these findings, Skills for Life (2012) found that the own-occupier segment had the lowest proportion of individuals with low numeracy skills, slightly less than individuals who rented privately and significantly less than those renting from local authorities.

Employment

Work status

Our analysis of Understanding Society (2020) indicated variation in the share of adults with low numeracy skills depending on whether the adult is 'in work' or 'out of work' (with 'in work' being defined as being a part- or full-time employee or self-employed). Our findings show that being out of work was associated with lower levels of numeracy attainment, with 59% of adults who were out of work reporting having numeracy attainment below Level 2 compared with 50% for adults who were in work.[15,16]

Figure 9: Numeracy attainment level by work status



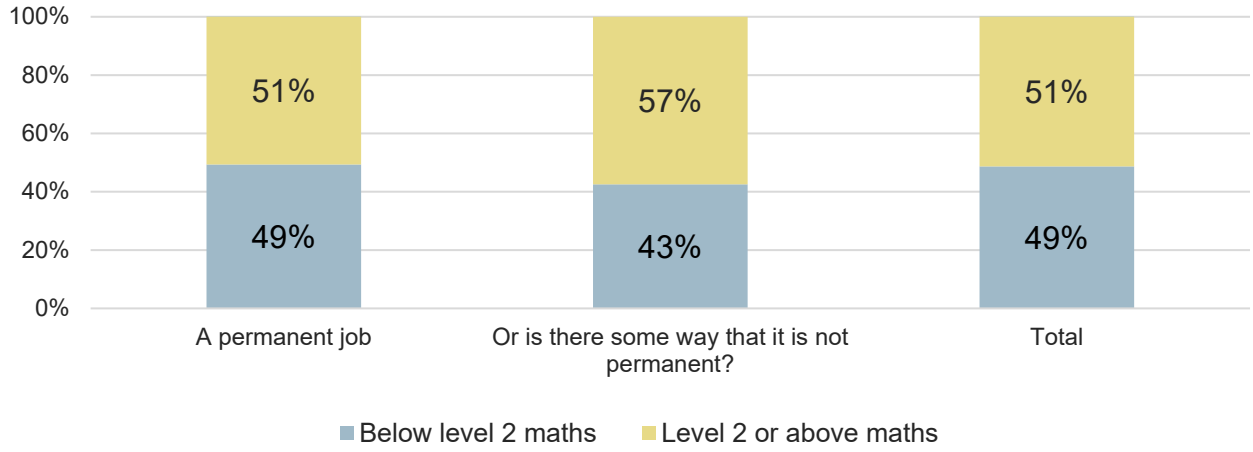
Base: Unweighted n = 22,755. Adults aged 19-65 responding to Understanding Society (2020). Note: 'In work' is defined as being in part- or full-time employment or being self-employed.

Job type

Adult employees responding to Understanding Society (2020) were asked if their job was permanent or if there was some way in which their role was not permanent. Our analysis indicated that the proportion of adult employees with low numeracy attainment was higher for those with permanent jobs, with 49% of individuals in this group having numeracy attainment below Level 2 compared with 43% of those whose role was in some way not permanent.

[16] Broadly echoing these findings, Skills for Life (2012) found that numeracy skills were generally higher amongst individuals who were in work than those who were out of work.

Figure 10: Numeracy attainment level by job type

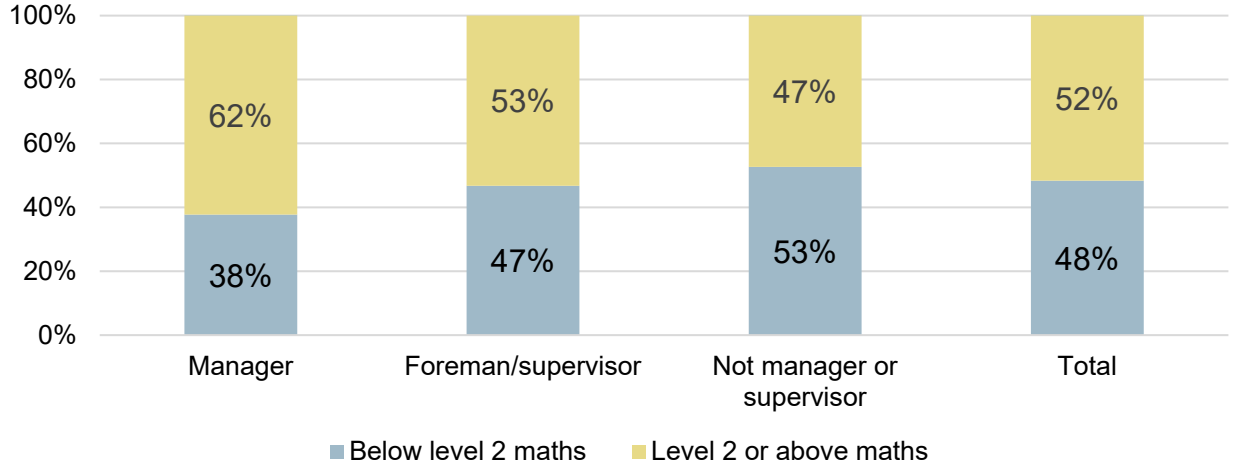


Base: Unweighted n = 16,589. Adults with jobs aged 19-65 responding to Understanding Society (2020).

Employment role

Respondents to Understanding Society (2020) were asked about the nature of their job role, including if they were a manager or supervisor in their current role. Our analysis indicated that being a manager or a supervisor was associated with a lower likelihood of having low numeracy attainment, with 38% and 47% of employees in these groups respectively having numeracy attainment below Level 2, compared with 53% for employees who were neither a manager nor a supervisor.

Figure 11: Numeracy attainment level by employment role



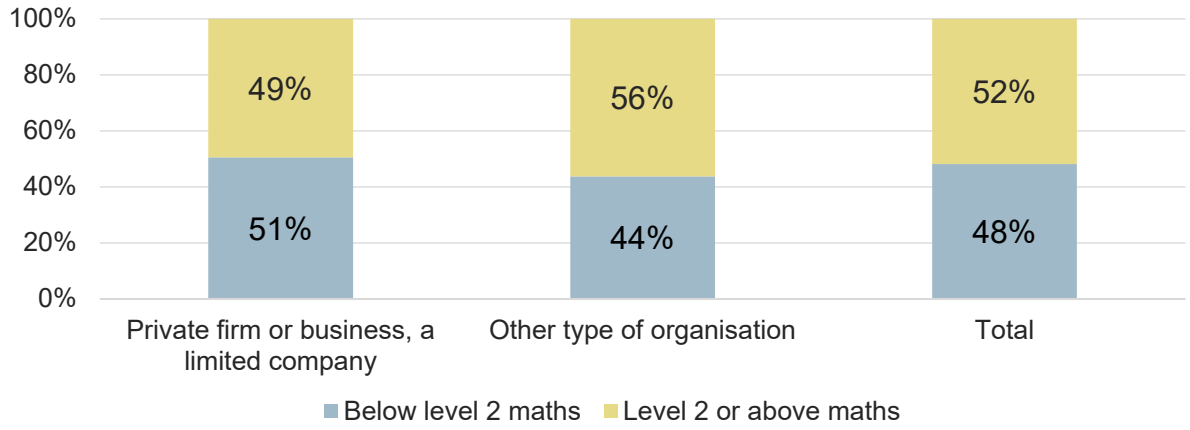
Base: Unweighted n = 14,563. Adult employees aged 19-65 responding to Understanding Society (2020).

Employer type

Employees responding to the survey were asked if they were employed by a ‘private firm, business, or limited company’, or another type of organisation. Being employed by a private firm, business, or limited company was associated with a higher likelihood of

having low numeracy attainment, with 51% of this group having numeracy attainment below Level 2. This compared with 44% of adult employees with low numeracy attainment for those employed by other types of organisations.

Figure 12: Numeracy attainment level by employer type

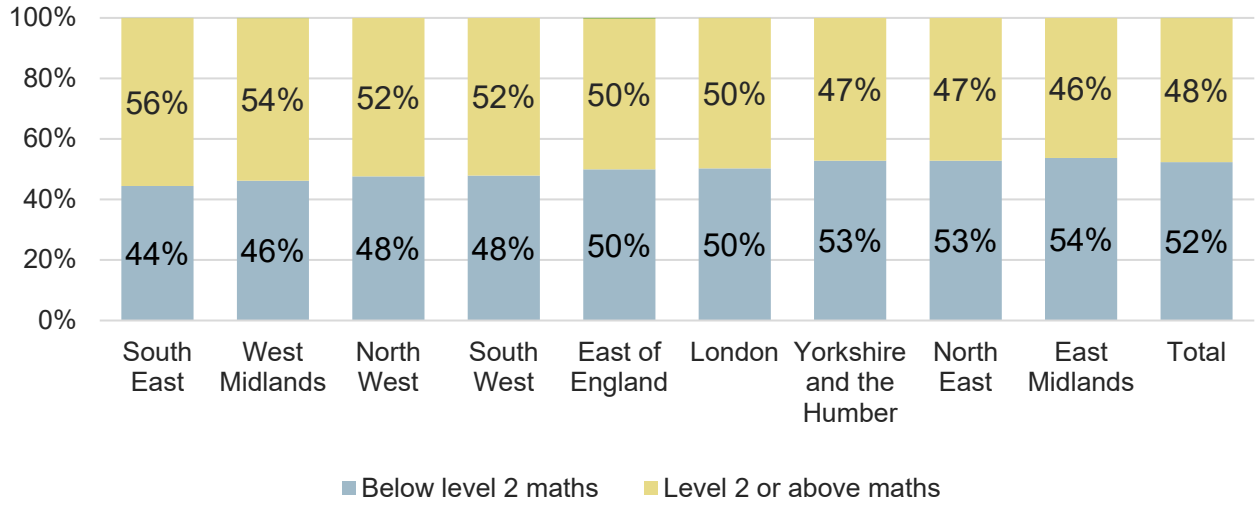


Base: Unweighted n = 14,239. Adult employees aged 19-65 responding to Understanding Society (2020).

Regions

Analysis of Understanding Society (2020) indicated regional variation in the share of the population with low numeracy attainment. The share of the adult population with low numeracy attainment was 44% amongst adults living in England with East Midlands exhibiting the highest share of population with low numeracy attainment (54%) and South East exhibiting the lowest share (44%).[17]

Figure 13: Numeracy attainment level by English region



Base: Unweighted n = 22,976. Adults aged 19-65 responding to Understanding Society (2020).

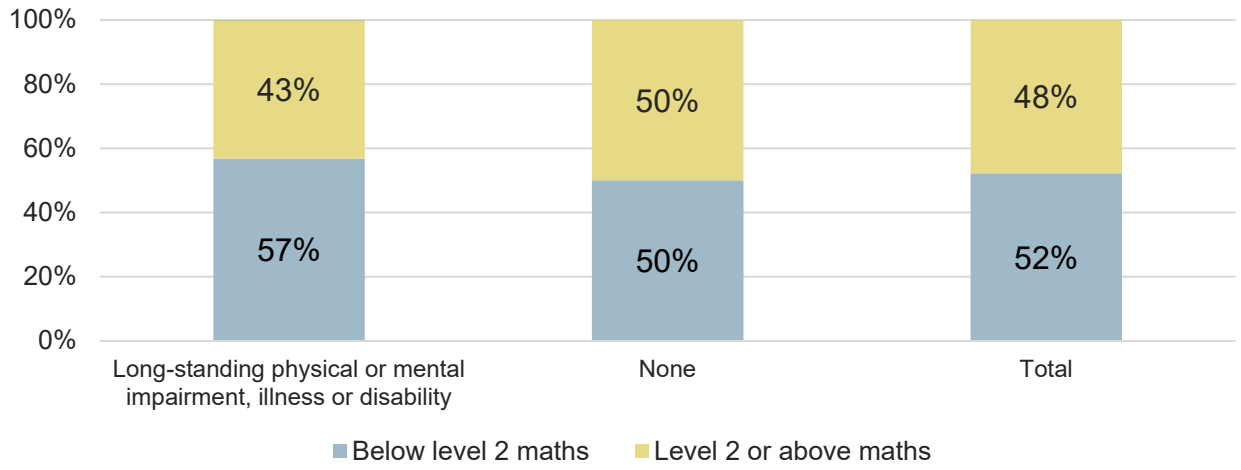
[17] Skills for Life (2012) also found significant regional variation in adult numeracy skill levels, with North West England exhibiting the highest share of respondents with low numeracy skills and South East England having the lowest share. The study excluded any analysis of numeracy skills in Scotland, Wales, and Northern Ireland.

Health and wellbeing

Physical and mental health

Respondents to Understanding Society (2020) were asked if they had a long-standing physical or mental impairment, illness, or disability.[18] Our analysis indicated that those reporting having a long-standing physical or mental impairment, illness or disability were more likely to have low numeracy attainment, with 57% of this group reporting having numeracy attainment below Level 2 compared with 50% for the group that did not.[19]

Figure 14: Numeracy attainment level by long-standing physical or mental status



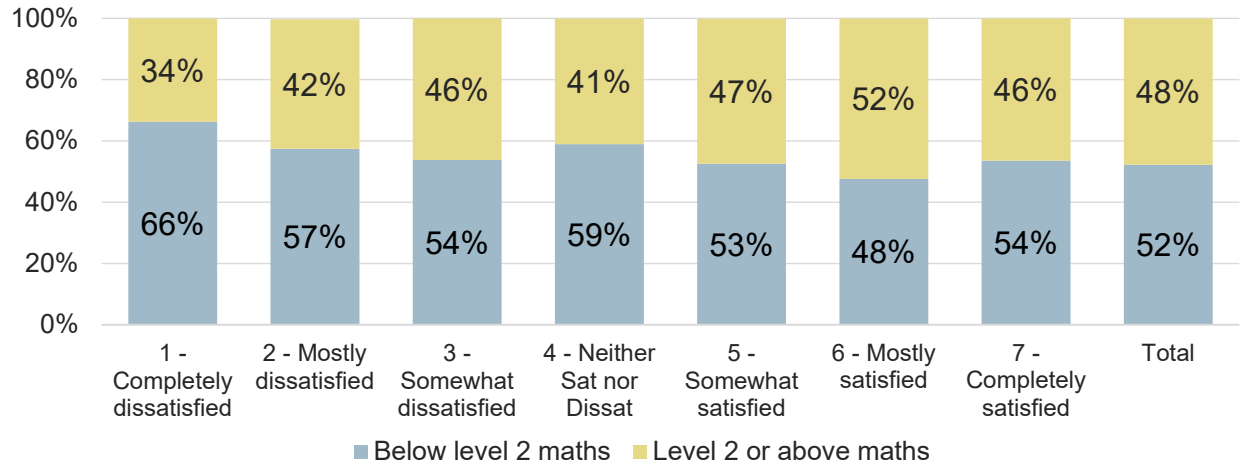
Base: Unweighted n = 22,892. Adults aged 19-65 responding to Understanding Society (2020).

Life satisfaction score

Respondents were asked to score their perceived general satisfaction with life on a scale of 1 (completely dissatisfied) to 7 (completely satisfied). Our analysis indicated that adults with lower levels of life satisfaction were generally more likely to have low numeracy attainment, with the ‘completely dissatisfied’ segment having the lowest numeracy attainment on average (66% below Level 2) and the ‘mostly satisfied’ segment having the highest numeracy attainment on average (48% below Level 2).

[18] 'Long-standing' was defined as including anything that had troubled the respondent over a period of at least 12 months, or that is likely to trouble them over a period of at least 12 months.
[19] The findings from Skills for Life (2012) similarly found that adults who reported having a long-standing illness or disability had lower numeracy skills on average than those who did not report having one.

Figure 15: Numeracy attainment level by life satisfaction score

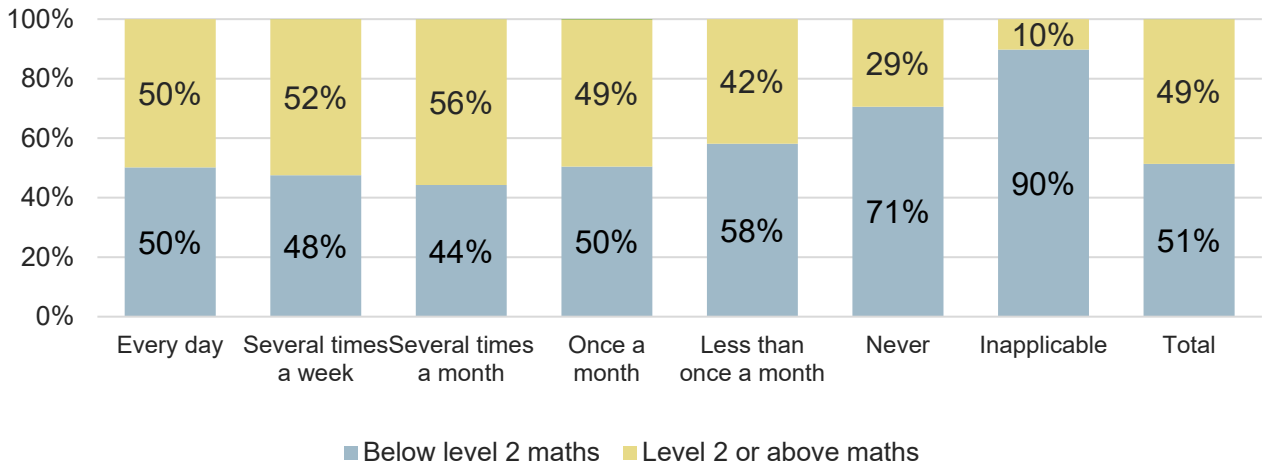


Base: Unweighted n = 22,122. Adults aged 19-65 responding to Understanding Society (2020).

Engagement with technology

Respondents to Understanding Society (2020) were asked to specify the frequency with which they utilised online banking services. Low engagement of adults with online banking services is associated with a higher likelihood of low numeracy attainment, with a larger share of adults with below Level 2 numeracy attainment reporting accessing online banking less than once a month or never. Individuals who were inapplicable for the question – i.e. those who lacked internet access or do not use it at all – exhibited significantly lower levels of numeracy attainment compared with those with internet access, with 90% of adults in this group having numeracy skills below Level 2. Respondents without internet access or who did not use it at all represented around 2% of the overall sample.

Figure 16: Numeracy attainment level by frequency of using online banking



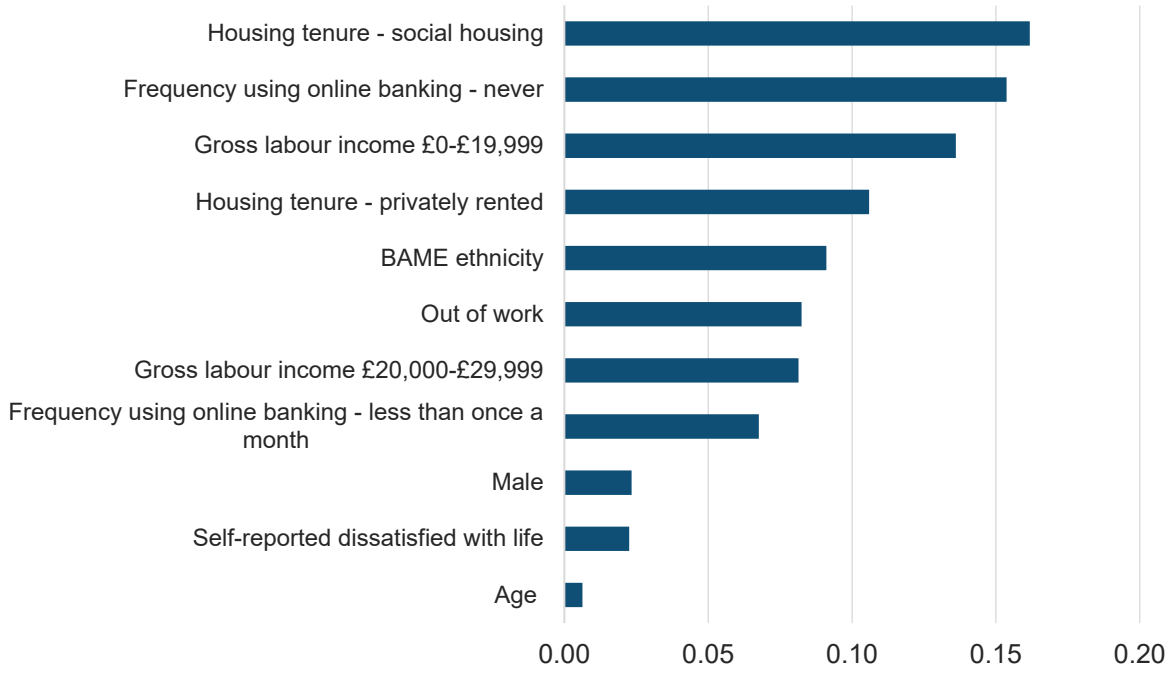
Base: Unweighted n = 22,615. Adults aged 19-65 responding to Understanding Society (2020).

Logit analysis

To supplement the descriptive statistical analysis of Understanding Society presented above, we conducted logit regression analysis to identify which of the factors explored are associated with low numeracy attainment when controlling for other variables of interest. It should be noted that the results from this analysis present correlations and do not necessarily reflect causality in either direction. For example, if X and Y are shown to be correlated, X could be driving Y, Y could be driving X, other variables (Z) could be driving both X and Y, and any combination of these options is possible.

The chart below summarises the factors we explored which were associated with lower numeracy attainment. The figures summarised in the table below are average marginal effects: the average change in the probability of an outcome when the variable you are observing changes by one unit. Using the example of age, our results suggest that an additional year of age is associated with a 0.6 percentage point (ppt) increase in the chance of reporting low numeracy attainment. This means that, for an adult with a 50% chance of having low numeracy skills based on their characteristics, another who was identical in every way except for being a year older would have a 50.6% chance of reporting low numeracy attainment. For categorical variables where individuals will fall into one of several categories, such as housing tenure, the association is estimated with reference to a comparison group. In the case of housing tenure, the figure for an adult in social housing will be a comparison to an adult who is an owner-occupier. This is explained further in the narrative below. More detail is available in Appendix A.

Figure 17: Average marginal effects for the likelihood of low numeracy attainment



Note: Analysis conducted on a sample of 16,697 observations, containing adults aged 19-65. All coefficients are statistically significant at the 1% level.

The interpretations of the results in the table above are as follows:

- **Housing tenure:** Living in social housing was associated with a 16.2 ppt higher likelihood of having low numeracy attainment, compared with owner-occupiers. Living in privately rented accommodation was associated with a 10.6 ppt higher likelihood of having low numeracy skills, compared with owner-occupiers.
- **Digital literacy:** Never using online banking (a proxy for the lowest level of digital literacy) was associated with a 15.4 ppt higher likelihood of having low numeracy attainment, compared with the baseline of those who use online banking more often than once a month. Using online banking only once a month was associated with a 6.8 ppt higher probability of having low numeracy skills.
- **Labour income:** Being in the £0-£19,999 and £20,000-£29,999 income bands was associated with 13.6 ppt and 8.1 ppt higher likelihoods of having low numeracy attainment respectively, compared with the group of individuals with incomes of £30,000 and above. Being out of work was associated with an 8.2 ppt higher probability of having low numeracy attainment.
- **Ethnicity:** Being black, Asian, or belonging to another ethnic minority was associated with a 9.3 ppt higher likelihood of having low numeracy attainment, compared with being of white ethnicity.
- **Sex:** Being male was associated with a 2.3 ppt higher likelihood of having low numeracy attainment, compared with being female.
- **Health and wellbeing:** Self-reporting as dissatisfied with life was associated with a 2.3 ppt higher probability of having low numeracy attainment, compared with those who either satisfied or were neither satisfied nor dissatisfied.
- **Age:** Every year of age over 19 was associated with a 0.6 ppt higher likelihood of low numeracy attainment.

Evidence from the Literature

This section reports the findings from the systematic literature review. The evidence review was undertaken in accordance with the research protocol presented in Appendix A and the approach outlined in the Methodology section. The evidence is divided into four key themes: (i) motivation and encouragement drivers of adult learners to engage and persist in learning, (ii) delivery channels in adult numeracy learning, (iii) effective teaching practices in adult numeracy learning, and (iv) forms of additional support that can be provided to support learners with specific needs.

Engagement

There was a significant amount of literature related to engagement generated through the search process: 93 papers contained content relevant to the engagement of adult learners. Out of the 93 studies, 21 were related to predictors of low participation and identification of numeracy difficulties, 27 were related to motivation to learn, 28 were about identifying barriers to learning, 22 addressed motivation to persist, 22 presented evidence on marketing, and 19 had information on incentives and rewards (with some papers touching on multiple research questions). A few of these studies relied on high-quality experimental methods to test hypotheses. Many relied on small-samples or case studies, so results should be extrapolated with caution as they might be specific to the circumstances of the study, the intervention or the specific population**.** Generally, the strongest evidence was around motivation to participate in learning and barriers to participation, where several high-quality and comprehensive literature reviews were identified. While one randomised control trial on effective communication approaches in the classroom and online was found, there was very little literature on this topic generally. Additionally, the evidence around the use of incentives and rewards to motivate learners was very limited.

Engagement in learning is a driver of improved educational outcomes and proficiency (Coben & Alkema, 2017). According to the review of evidence undertaken by Coben & Alkema, (2017), measuring adult engagement and success in numeracy can be complicated. In a literature review focused mainly on the European Numeracy Framework, Groenestijn, (2011) argued that the adult learning process differs from children in that their past learning experience may be much more informal. As a result, they have processed information from many more sources, and have created their own rules of thumb for numeracy practice. Their skills also may be highly context- and practice-specific for this reason. In-depth observational data collected by Ofsted (2011) from May to November of 2010 for 59 adult education providers found that across nearly all centres, one of the primary challenges for programmes was identifying and recruiting adults with low numeracy skills.

Despite having different learning processes to children, adult skill levels are not fixed and can and do change significantly over time. Lechner et al. (2021) found evidence that

adults can improve their skills through engagement. The authors used longitudinal data from the German PIAAC from 2012-2015 to determine how much adult skills vary over their lifetime. While on average there was little mean change for the population over the period studied, there were considerable individual differences in skill gain, indicating that adult skills are not stagnant. While they cannot link individual skill gain to participation in adult skills education, this demonstrates that adults do have the ability to improve their skills. However, Reder et al., (2020) found, using regression analysis on longitudinal PIAAC data from 2012-2015 that as individuals engage with maths practice, they become more proficient over time. This is in line with practice engagement theory: an educational theory that states that individuals' literacy proficiencies develop as a by-product of their engagement in everyday reading and writing practices.[20] They found that even engagement with short term or informal courses can improve proficiency over time. This highlights the importance of encouraging low-skilled adults to engage in some sort of numeracy practice or education.

Problems, barriers, and motivations

Several of the papers studied were concerned with problems and barriers adults face in beginning their learning process. This section focuses on predictors of low participation and high-level identification of numeracy problems, what motivates adults to learn, barriers they face in learning, and what motivates them to persist. The strongest evidence was around predictors of low participation (relying on quantitative data from large scale surveys), motivations to learn and existing barriers, where there were several systematic literature reviews with relatively up-to-date evidence.

Predictors of low participation

Some groups of adults are more likely to engage in adult education than others. Identifying characteristics associated with low engagement is a useful step in designing engagement strategies.

In an impact evaluation of the Skills for Life programme, which involved a survey of over 2,000 individuals across multiple waves, (Metcalf, 2009) found that the individuals least likely to participate in adult education are older adults, parents with children under schooling age, lone parents, people without qualifications, and those with the lowest level of literacy competence. A nationally representative survey by the Learning and Work Institute, (2021) reports similar results. They found that age is negatively correlated with participation in learning, while social status, being in full time education, and being employed are positively correlated with learning.

The findings from Metcalf and the LWI are supported by Yamashita et al. (2019). Taking PIAAC data on adults aged 50 and over in the U.S., the authors use a structural equation model to determine participation in adult education as a function of motivation, numeracy

[20] Additional discussion on practice engagement theory can be found in the section "Fundamentals of teaching practice".

level, literacy level and other covariates. They find that a greater number of prior years of education is the most significant predictor of higher participation in non-formal adult education and training. The data analysis itself does not provide evidence as to what drives this relationship, but the authors speculated that it may be that learners with more years of education feel more confident in seeking out and attending classes.

Having certain socio-demographic characteristics also increases the probability that an individual has a low level of basic skills. Understanding these characteristics may help policymakers decide how to best target learning programmes. Using data from a cohort of 9,600+ individuals from the U.K., Benseman (2011) suggested that low levels of basic skill proficiency are highly correlated with social outcomes. Adults with skills below Level 2 are more likely to be teenage or single parents and are more likely to have had parents that left school early themselves. Language and migration status may also be correlated with numeracy and literacy. While Benseman's findings are over a decade old, the data examined in this report from the 2020 wave of Understanding Society confirms and expands on the finding that there are strong associations between socio-demographic characteristics and low numeracy attainment.

Evidence from Canada suggests that immigration status is a likely predictor of basic skill proficiency. Mueller & Truong, (2020) analysed data from the Canadian PIAAC and Longitudinal Immigration database. Using a regression model, they find that all immigrant sub-groups have lower average numeracy scores and higher variances compared to individuals born in Canada.

Evidence from survey data from Australia and New Zealand suggests that occupation is also a useful proxy for numeracy skills. An analysis of statistics taken from the Adult Lifestyle and Literacy (ALL) survey from New Zealand finds a correlation between individuals who undertake frequent numeracy tasks at work and those who have higher numeracy proficiency (Earle, 2011). In a similar study Athanasou (2012) took data from the Australian ALL survey and focused specifically on eight occupational categories. This analysis suggested that labourers and machine operators are the workers with the highest likelihood of having numeracy skills below Level 2. Benseman and Sutton (2011) similarly found that having basic skill levels lower than Level 1 is correlated with worse labour market outcomes and experiences.

While large scale surveys are useful, it is possible that using national disaggregated data may mask the scale of the actual problem of numeracy deficiency. In a report drawing upon relevant literature and existing qualitative and quantitative data from the South West of England, the University of Exeter (2002) found that while 22% of adults in the entire region had skills below Level 2, some wards had rates as high as 35%, indicating significant geographic heterogeneity which may influence decisions about provision.

Bathmaker (2007) compiles available quantitative data on the scale of need, learner progress, and learner level of achievement. Within the Skills for Life programme specifically, she found that there was initially a good uptake of adults in numeracy courses but a clear problem of diminishing returns to the number of adults participating

as the programme continued. However, this paper only presents descriptive statistics. Her findings are supported by a theoretical analysis of the basic skills programme in the U.K. by Bosworth & Kik, (2010) who hypothesized that diminishing returns to adult basic skills programmes are a function of a greater proportion of learners being “hard to reach” or unwilling to participate as more and more willing learners complete the programme.

Identifying numeracy difficulties

The primary way in which governments and stakeholders identify numeracy difficulties at the population level is through large surveys administered by international organisations. Tout (2020) examined how the Programme for International Assessment of Adult Competencies (PIAAC) evolved out of predecessor surveys and how it seeks to identify numeracy difficulties and skills. The PIAAC provides information on individuals’ socio-demographic characteristics, mathematics practice and capacity to solve numeracy problems. It seeks to provide a snapshot of skills in the adult population, gather evidence about how proficiencies are distributed across the population, and how education and training systems can improve these skills. For formal, written, assessment, the Framework for the Survey of Adult Skills (OECD, 2012) outlines some of the principles that underpin the way in which PIAAC surveys assess numeracy skills. Survey questions should seek authenticity, have a free-response format and be presented in a way that include a stimulus, like a picture.

While the PIAAC is more sophisticated than previous surveys at testing a greater range of skills, it cannot accurately imitate all real-life uses of numeracy skills in questions and there is no way to socially or contextually situate skills. This is particularly important for adults who use mathematics in a variety of contexts outside of the classroom (Tout, 2020). Tunstall (2020) concurs with Tout that the PIAAC survey is a valid instrument to describe distribution of proficiency levels across population subgroups but is less adept at capturing numerate behaviours in daily life. They add that when developing assessment measures such as the PIAAC, questions such as what the intended use of the assessment is and how the scores will be used should be considered. The author does acknowledge that creating an assessment that includes all these features would be highly challenging and difficult to translate across multiple country contexts. This means that PIAAC results give valuable information about the distribution of numeracy skills in the population and sub-population groups and how those compare across countries, but, without additional research, results cannot identify all aspects of numeracy skills or differences in how these skills are used in daily life.

A significant problem with identifying numeracy difficulties is also a lack of data on those with low skills from national education guidance services (Grotlüschen et al., 2016). In another analysis of the PIAAC and other policy interventions in OECD countries, Windisch, (2015) found that this issue is compounded by a lack of analysis and particularly quantitative assessment of successful interventions, leading to a lack of understanding around what works to engage target populations. Mallows et al. (2015) supported this finding. Using in-depth country case studies, a rapid evidence assessment and analysis of PIAAC data, the authors find that countries examined that perform well in

adult basic skill provision targeted the same types of learners: low-skilled employed workers, immigrants, and the unemployed. However, very few countries have robust analyses of existing programming and good data on target populations. The authors argued that England specifically needed a better understanding of the population of low-skill adults in order to design programmes and appropriately direct funding.

How do individual adults identify/assess their own numeracy skills?

While it is difficult for communities, stakeholders, and governments to assess which adults have numeracy problems, learners themselves may also have trouble identifying their level of numeracy. A further finding from Windisch (2015) is that many adults lack awareness of their own deficiencies in numeracy. Using a combination of data drawn from the British Cohort Study of 1970 and existing literature, Carpentieri et al. (2009) argued that the reason many adults do not view themselves as innumerate is because they use their own lives as a baseline, rather than comparing themselves to others with different levels of skill. Additionally, in a survey of 20 years of research and curriculum development from Australia, Johnston (2002) found that many adults are in fact more numerate than they realise and cannot recognise when they are using maths in their everyday life. These misperceptions, both under and overestimations of skill, lead to a difficulty in identification of numeracy problems.

Additionally, many low-skilled adults use a variety of strategies to avoid numeracy in their day to day lives, further obscuring the problem. In a series of in-depth life history interviews of young adults in the Northeast of England, Cieslik and Simpson (2009) find that interviewees use substitution (substituting numeracy with other skills such as ICT to complete tasks), brokerage (assigning numeracy tasks to others), reticence and avoidance to deflect from poor numeracy skills. While the interviewees did not constitute a representative sample and the results are not necessarily generalisable, they provide insight into one reason why adults with poor numeracy may be reluctant or find it difficult to identify problems and fail to seek out education as a result.

Motivations to learn

Adults have a diverse set of personal, social and economic motivations for participating in adult education. In a review of academic literature from the European context Carpentieri (2014) additionally found that an individual's motivation for pursuing basic skills education may also vary over the course of their life. In a review of the literature, Westwood (2021) found that while adults have disparate motivations for learning, they may be more motivated than children because they have a better understanding of what material they need to learn and how it is relevant to them. Using nationally representative U.S. data, Yamashita et al. (2019) found that motivation to learn is negatively associated with older age and lower education and that men and women have similar levels of motivation to learn, holding all other factors constant.

However, in a comprehensive literature review from the Learning and Work Institute (2019) that included a review of RCTs, existing evidence reviews, and before-and-after studies, the authors found that while many adults may have a passing interest in

attending skills classes, it can be difficult to translate that interest into action. It may also be more difficult to motivate adults to participate in numeracy classes than literacy classes. In a literature review, Coben et al (2003) find that, because it is more socially acceptable to be "bad at maths" than to have trouble with reading, learners have less of a desire to improve their numeracy skills than their literacy skills. A survey of adults in Norway found a similar result (Kvalø, 2008).

Family and social motivations to learn

Many adults have motivations to pursue basic skills courses related to their family and social lives. A commonly cited reason in the literature from many individuals was a desire to become better parents and grandparents or have a greater understanding of and involvement in their child's schoolwork (Swain, 2005; Atkin, 2010; Geraci, 2012; Carpentieri, 2014). The NRDC Learner Study evaluated the Skills for Life programme from 2003-2006 using quantitative and qualitative data. Many learners said they did not want their children to 'have difficulties like them' (Warner et al., 2008). In a literature review from the U.S., Ginsburg (2017) found that many learners want to earn a qualification or graduate from high school to be a good role model for their children. In a series of interviews with supply-side stakeholders and participants from a household survey carried out by the Sussex local council, Bates & Aston (2004) also found that family or social motivations for pursuing numeracy courses may also stem from a major life event such as a promotion, divorce, birth of a child or death of a spouse.

Barnes et al. (2003) evaluated the UK Pathfinder Extension Programme through in-depth interviews of key stakeholders and found that parents supporting their children's education and needs was one of the main motivating factors for participating in the courses[21]. In line with the above findings, the literature review by Ginsburg et al. (2008) found that for some parents the motivation to learn mathematics can be grounded in their family lives, particularly in their desire to support their children's learning, with some parents prioritising meeting the needs of their children over developing their own general mathematical knowledge. Additionally, Dymock & Billett (2008) found that the desire to play a more central role in family life was one of the motivations for adult learners to participate in non-accredited, community-based, adult learning programmes in Australia. An example of a programme targeting parents' incentives to support their children is the Clare Family Learning in Ireland. The UNESCO case study on this initiative found that the programme's focus on helping children learn can make learning attractive to parents and incentivise them to participate (UIL, 2015c).

Social motivations for pursuing basic skills education may come from outside an adult's immediate family. Yamashita et al. (2019) found in PIAAC data from the U.S. that older adults may also be motivated to seek out adult education because of broader benefits it provides regarding their social capital and social network. Social capital is defined by Balatti et al. (2006) as changes in the nature of connections students have with others in

[21] The Pathfinder Extension Programme was an initiative of the (former) Department for Education and Skills. It was initiated in 2001, its aim was to promote adult basic skills and it embodied the main principles of the "Skills for Life" national Strategy.

new or existing social networks. Similarly, Balatti et al. (2006) found in a series of interviews with teachers and adult learners in Australia that 80% of students surveyed gained social capital outcomes as a result of participation in a class. The authors hypothesised that the gains in social capital came mainly from changes in the structure of a student's social network or their social transactions. Additionally, in several interviews with learners and potential learners, the Commissions Research Group (2002) found that some learners' foremost reason for signing up for courses was to meet new people or as an opportunity for socialisation in their community.

Personal motivations to learn

Personal or intrinsic motivations are also important to adult learners. Reasons cited in the literature included drivers as simple as desiring a challenge or possessing a sense of curiosity (Carpentieri, 2014). Older learners may also pursue numeracy courses to keep their minds sharp (Woodhouse & Stevenson, 2018). In observational data collected over 21 months from three further education colleges Swain (2005) found that many learners take numeracy classes to prove that they can succeed in a high-status subject. Windisch (2016) found that common intrinsic motivators include finishing something left unfinished at school, bettering themselves, or fulfilling personal aspirations. However, the author also cites evidence from a Norwegian study that for low-skill workers, extrinsic motivators are more powerful than intrinsic motivators. Personal or intrinsic motivations are also important to adult learners. Reasons cited in the literature included drivers as simple as desiring a challenge or possessing a sense of curiosity (Carpentieri, 2014). Older learners may also pursue numeracy courses to keep their minds sharp (Woodhouse & Stevenson, 2018).

Further, Barger et al. (2022) found in a survey of approximately 400 adult learners, elementary teachers, and undergraduate students that an individual's mindset or beliefs around their own learning may affect their motivation. They found that a "growth mindset", the genuine belief that one's intellectual abilities are not fixed and can improve with practice, is positively correlated with higher motivation for learning mathematics. However, the authors also found that if an individual believes in a growth mindset in theory but does not believe this about their own abilities, it does not positively effect motivation. This indicates that educators cannot instil personal motivation in individuals simply by telling learners that they can improve, but need to cultivate this belief system more deeply in the classroom. While the study found a statistically significant correlation between growth mindset and motivation, it cannot establish that this relationship is causal.

Economic motivations to learn

Increased opportunity or pay in the workplace can also be a powerful motivator for learning. Barnes et al. (2003) conducted a series of in-depth interviews of participants in a pathfinder programme of experimental curriculums in adult basic skills education. There were many long-term unemployed learners who wanted to return to the job market and sought out classes because they found they no longer had a relevant set of skills or the job they previously held no longer exists. Using case studies of four English workplace

learning programmes, Evans & Waite (2008) argued that workplace basic skills classes gave employees new skill sets which allowed them to take on more responsibility, leading to pay raises and promotions as well as giving them increased confidence to participate in more staff development and apply for different roles and opportunities.

Workplace encouragement or opportunity is not the only economic motivation for adult learners. Learners also stated that they signed up for numeracy courses specifically out of a desire to improve their budgeting or money management skills (Barnes et al., 2003; White, 2003).

Many adults also cited wanting to enrol in different courses and needing a qualification from a basic skills course as a reason for signing up. Some also felt like their previous qualifications were inadequate (Warner et al., 2008). The primary motivation for learning being earning a qualification for many learners was also supported by analysis of a U.K. government pathfinder programme from White, (2003). “Pathfinders” were nine areas that undertook new course provision involving new standards and goals set out by the Skills for Life campaign. Outcomes of respondents who participated in a pathfinder programme were compared to those with similar characteristics who did not. Many learners cited wanting a qualification as their primary motivation but there were a diverse range of secondary motivators including various social and personal factors touched on by studies mentioned previously.

External motivations to learn

Motivating factors also may be unrelated to adult learner’s personal characteristics. In a study summarising the findings from a combination of desk-based research, stakeholder consultations, and employer case studies within the South West of England Foster et al. (2008) argued that the supply of suitable courses is the primary driver of engagement and participation, rather than demand based on learner characteristics. Beyond the general supply of courses, accessibility is also an important factor for motivation. Warner et al. (2008) found that ease of access was a commonly stated motivation for signing up for community-based courses, especially for older learners, learners with lower levels of confidence, and learners with disabilities or health issues.

Learners are also more likely to sign up for classes that meet their interests and fit in with their schedules. In an interim evaluation of the Essential Skills in the Workplace (ESiW) programme in Wales, Starks & Wilson (2013) found that uptake of courses was slow when courses were inflexible and only advertised as basic skills classes. Better uptake was associated with a change in the framing of the course as “essential skills” which included a Level 2 qualification as well as ICT skills. However, ICT should not be considered a motivator for all learners. Windisch (2015) finds that for some programmes, ICT reduces face-to-face contact which can itself be a powerful motivator. When reflecting on the experience of the coronavirus (COVID-19) pandemic, experts highlighted the innovation that had taken place in digital learning. This suited some learners, e.g. some students with additional support needs preferred learning from a familiar home environment. But for others, online-only learning did not motivate learners to participate.

Identifying and sizing barriers

Various barriers may prevent adults from participating in basic skills education. These barriers may also be specifically related to numeracy.

Social and emotional barriers

A key barrier to participation in adult basic skills education is a fear of failure or a lack of confidence in one's own skills. Many adults have negative perceptions of schooling, want to avoid environments or places where they have previously experienced failure, have concerns about their own ability to succeed, or are embarrassed and do not seek out basic skills courses as a result. In a review of adult literacy and numeracy programmes in Scotland, Maclachlan & Tett (2006) find that many adult learners have low self-esteem and worry when joining new classes that other learners will look down on them. Many adults also feel that they are too old to learn (Windisch, 2016). In a literature review, Westwood (2021) also found that many adults have an emotional barrier driven by past anxieties, frustrations and failures specifically related to numeracy or mathematics.

Beyond just negative experiences of school, Gal et al. (2020) found in a literature review that through negative schooling experiences, adult learners develop an identity of being bad at numeracy or maths that is at odds with seeking out more education. Maclachlan & Tett (2006) supported this finding, stating that many adult learners identify as "lacking or deficient" based on previous school experience. This then affects whether a learner decides to participate. An evidence review from Yasukawa et al. (2020) also suggests that some target participants for basic skills education associate their schooling experience with social exclusion.

Cieslik (2006) drew upon evidence from two case studies and ten in-depth interviews with his adult students from in his time as a basic skills tutor in the East Midlands to form a theoretical argument. He argued that a lack of self-esteem regarding numeracy is a function of an individual's entire formal schooling and social experience, making it a particularly difficult barrier to overcome. While Cieslik (2006) presents some theoretical findings, the evidence is drawn from a small sample of students from only one class.

The community or social context of the class more broadly can also be a barrier. Windisch (2016) found that many adult learners live in relatively homogenous communities in terms of social class. One barrier may be a fear that improving one's skills could disrupt their existing social connections or community fabric. More generally, adults may be worried about what their friends will think about them signing up for classes or may be intimidated by meeting new people (Learning & Work Institute, 2016). Some adults lack a social network that also participates in education (Yamashita et al., 2019).

The composition of an area where a learner lives may also impact the barriers they face. Adults who live in rural areas, or those in particularly tight-knit communities may fear that their learning will be highly visible to other members of the community and be

embarrassed or unwilling to be seen as someone who needs support with literacy or numeracy (Atkin, 2010). A UNESCO case study evaluated a Slovenian programme that also specifically targeted adults in rural communities. They found that other barriers facing rural communities included poor communication skills and poor access to ICT and information, a lack of confidence in their learning ability, and little ability to adapt to technological change (UIL, 2017).

In a literature review of qualitative evidence, Keiko et al. (2019) proposed that social-emotional barriers can be overcome through the creation of a "numerate environment" that involves both numeracy practice and the broader social context of the learner's life such that they understand the purpose of gaining numeracy skills in relation to their own circumstances. However, these findings may not be widely generalisable as they are largely based on theory. An evaluation of the Skills for Life programme by the Further Education Trust for Leadership (2021) suggested that placing learning in community-based facilities can overcome some social barriers. Students have an opportunity to gain support from their peers and community members with whom they have a shared experience. This may be more salient in disadvantaged areas where there is a lack of formal learning infrastructure.

Specific sub-populations may also face specific barriers. For example, Jurdak (2020) argued in a discussion of the literature that migrants face barriers to learning numeracy including a lack of fluency in the language of instruction, disincentivising engagement. Geraci (2012) found that specific barriers to the Indigenous population in Canada include insufficient funding and facilities, racism and discrimination, and a lack of Indigenous teachers. Carpentieri (2014) also found that migrants are more likely than non-migrants to participate in adult education but may still face unique barriers in attempting to do so. They state that in the U.K., some free basic skills courses are only available to migrants seeking work, excluding those who are already employed, or stay at home parents.

Physical situational barriers

An important situational barrier for adult learners may be their personal circumstances. In a systematic review of the literature, Lord et al. (2010) found that many learners do not participate in classes because they are in poor health or have a learning disability, or feel they are too old to begin learning. Being a parent also can act as a barrier to learning. Lack of access to childcare during class hours represents a major barrier to many adult learners, especially for parents of children below school age (CRG Research, 2002; Atkin, 2010; Geraci, 2012).

For adults who have decided they are interested in pursuing basic skills education, a primary barrier is a lack of time. Many adult learners work uncertain hours or shift work (Atkin, 2010) and have significant family or personal commitments, preventing them from taking the time to attend class. The Learning and Work Institute (2019) highlighted that for adults with busy working and family lives it can often be hard to find space for learning and drop-out rates of programmes can be high. Many courses have a requirement to

attend for a specific number of hours, further preventing time-constrained adults from participating (Barnes et al., 2003). Followed by time, Windisch (2016) found that the next most significant barrier was cost, including course fees and the cost of materials.

Bates & Aston (2004) found that long travel requirements and having to pay for transport were also significant barriers. This was supported by Geraci (2012) in an evaluation of Canadian adult education programmes with indigenous people, who found that for remote populations, transportation and distance are some of the primary barriers facing learners. Further, Jurmo (2020) also found in an analysis of several U.S.-based case studies over the last 20 years that transportation is a barrier to learning for many adults, and specifically those who rely on public transportation or carpools. Some learners within the cited case studies mentioned having to take multiple buses and commuting for over an hour to reach class. Locating classes in places that are convenient to learners, such as workplaces or community centres must then be a major consideration to overcome transport related barriers. Generally, Westwood (2021) concluded that provision of adult education should be flexible in order to overcome physical and situational barriers.

A review of 16 action research projects in Scotland by Coben et al. (2007) analysed the role that ICT plays in engagement and helping to overcome physical and emotional barriers to learning. ICT is also useful in reaching out to hard-to-reach groups that would not otherwise be interested in basic skills courses. The interactivity and flexibility of ICT means that classes do not resemble a traditional classroom environment. Additionally, Galligan & Axelsen (2022) found evidence from a literature review that older learners find online learning for numeracy to be more rewarding than their younger counterparts. ICT was also found to be useful in supporting outreach in rural areas and supporting out-of-hours learning (Coben et al., 2007). The evidence in the report came from tutors' self-reporting and no counterfactual situation was addressed, meaning that the results must be interpreted with caution. Additionally, ICT itself can act as a barrier as some learners do not have the correct skill set or proper equipment (Hall et al., 2022). This points to the importance of tailoring courses and engagement strategies to learners' specific needs.

It may be more difficult to identify adults in rural areas with basic skills needs. Atkin (2010) analysed programmes and interventions in Lincolnshire through a review of qualitative literature. He argued that learners in rural areas are disadvantaged because small population numbers obscure the scale of the deprivation, and many indices favour urban areas. This could potentially lead to a lack of supply of suitable classes in rural regions.

Informational barriers

If adults possess a lack of confidence around learning, they may be reluctant to participate in numeracy if they do not have enough information. Many learners are not aware of numeracy courses on offer around them (Atkin, 2010). In a nationally representative survey from 2021, the Learning and Work Institute found that only 43% of respondents were aware of the availability of free courses to improve their maths and

English. Even if learners are aware of adult education opportunities in a general sense, they may lack confidence to seek out more specific information (Yamashita et al., 2019). Stevenson et al. (2021) found in a literature review that offering taster courses to give learners a better idea of the specifics of a programme is an effective strategy in overcoming informational barriers.

Peterson et al. (2002) argued that one strategy to overcome informational barriers is to offer information about learning through one-stop career centres. Through analysis of case studies in South Carolina they found it was a successful strategy for one local career centre to provide information to patrons on any employment related service. This included state job services, unemployment insurance, and training programmes. This streamlined information and limited the number of organisations the potential learner must interact with.

Recognition of prior learning or qualifications may also limit informational barriers to basic skills education. Meghnagi & Tuccio (2022) suggested with evidence from a review of policy in Europe that allowing individuals to enter courses based on the knowledge they have rather than previous formal qualifications would benefit learners and particularly vulnerable populations as they can enter more suitable courses and require less paperwork to enrol.

Motivation to persist

Determining what leads students to persist in a given course of study and what leads them to drop out is difficult. In an evaluation of adult numeracy and literacy education in the U.K. for the Department of Business and Skills, Vorhaus et al. (2011) found that the demographic characteristics of learners who drop out are not markedly different from those who remain enrolled. While learners who are more likely to drop out do not necessarily share demographic characteristics, the authors found that basic skill learners are more likely to drop out in earlier course stages than later stages, that individuals in lower-level courses are more likely to drop-out compared to those in higher-level courses, and that learners with prior qualifications are less likely to withdraw compared to those with no prior qualifications.

Bathmaker & Pilling (2008) analysed quantitative data from individualised learner records from the Skills for Life programme from 2000-2005. They found that while many adults have taken up numeracy courses, there are fewer qualifications attained by learners in numeracy courses than literacy or ESOL, with 27% of students enrolling on a course achieving a qualification, compared with 50% for literacy and 56% for ESOL. This indicates that there are difficulties unique to persistence in and completion of numeracy programmes that do not impact provision of other basic skills.

Personal and social motivations to persist

In a programme evaluation of a foundation mathematics course in New Zealand, Kane et al. (2007) suggested that dropouts are primarily caused by complexities in the lives of learners including health, finances, or family commitments. Additionally, they found that many young adult learners lack perseverance and do not see learning as a priority. In a series of interviews of adult learners from Wales, Roe (2007) found that 80% of learners stated that they left a course due to personal circumstances as opposed to something related to the course. However, persistence and retention are not straightforward concepts for many learners. Carpentieri (2014) found that when they leave a class, many learners do not necessarily view this as dropping out or as a failure. Further, when many adults leave a course, it is a rational decision based on the other factors and stressors in their lives, weighed against the perceived benefit the class provides to them.

Support from families and peers is also important in maintaining persistence. A literature review conducted by Joseph et al. (2017) focusing on the participation of black women in mathematics in the U.S. found that community influences are an important factor in retention. This involves links with peers of similar backgrounds within classes so that learners feel like they belong, as well as support from those in their social network outside the course. Social support is particularly important for persistence in areas where there is a lack of formal support for learning. Formal support may include one-to-one tutoring, access to higher or university level classes at a younger age, and test prep materials.

The relationship a student has with their peers and the course environment generally is also important. Kane et al. (2007) suggested that retention is improved when institutions try to integrate students academically and socially into their prevailing culture so they feel as if they are part of something larger. This is particularly important for students who may have had past negative schooling experiences. Roberts et al. (2005) carried out an ethnographic analysis of seven case studies where basic skills provision is embedded within vocational programming. In the case studies, the authors found that learners are also motivated by taking on a new personal “professional” identity associated with learning. Along with learning practical skills, they were now part of a community of practice alongside their peers, motivating persistence in the course.

Hume et al. (2018) tests the hypothesis that social ties improve retention with a randomised control trial in the UK. Individuals were randomly paired with a “buddy” in their class and given a joint attendance target of 80% of classes. Learners received an attendance stamp card to share with their buddy and some received a voucher if both them and their buddy met the attendance target. They found that learners who had a buddy had 73% higher attendance than those who did not receive any kind of incentive. Additionally, being paired with a buddy had a greater effect on attendance than receiving an individual financial incentive. The most effective intervention was the buddy system paired with a small financial incentive.

Technical and physical motivations to persist

In the same way that physical barriers prevent learners from participating in adult education in the first place, lack of access to childcare, transport, and other social services can be a reason that learners drop out or do not persist in a course (Carpentieri, 2014). A literature review from the Learning and Work Institute (2019) suggested that partnerships with other social service providers is one effective way of overcoming physical or situational barriers to persistence.

In a literature review, MacLeod & Straw (2010) also found that retention is improved by covering learning costs and offering childcare and meals. They suggested that the physical space feeling welcoming and friendly and being in an accessible location also can improve persistence and retention. This includes provision of programmes in convenient locations such as community centres and libraries (Hall et al., 2022).

UNESCO evaluated a programme targeting construction workers in Colombia. In Colombia, many construction workers have no formal educational qualification leading to an increased risk of accident and workplace exploitation. The *Obras Escuela Programme* (2020) attempted to remedy this by providing on-site lessons to construction workers. They found that on-site lessons provided specific benefits in terms of retention. There was a reduced risk of drop out because workers did not have to sacrifice time and money commuting and learning alongside co-workers and peers with a similar profile increased persistence.

If learners need to take breaks from classes or practice, Vorhaus et al. (2011) found that they should be supported by check-ins and blended learning so they are not penalised for changing circumstances, or else they are less likely to return to classes later on. Use of ICT can assist in flexibility and keeping learners engaged when they cannot commit the time to face-to-face instruction (Learning and Work Institute, 2019). Positive outcomes for persistence and retention are also associated with learners being able to participate in once off or bite-size courses, as well as courses at odd-hours to accommodate shift workers (CRG Research, 2002).

Programme related motivations to persist

The relationship between a learner and a tutor can be an important driver of persistence. In a series of interviews and observations across six case studies in Scotland, Derrick et al. (2008) found that as the course went on, learner attitude was closely related to their relationship with their tutor. Tutors should seek to form an informal, trusting, and relaxed relationship with learners and allow time for one-to-one support (Learning and Work Institute, 2019). Further, based on a series of interviews and classroom observations, Balatti et al. (2007) suggested that learner persistence was stronger when learners felt like they were treated as adults in their course. In settings where numeracy education is embedded within vocational training, Roberts et al. (2005) presented evidence from case studies that a teacher also acts as a skilled mentor and role model and student

persistence is motivated by a desire to gain the respect of their tutor or a goal to become like them.

Vorhaus et al. (2011) also found that student persistence is supported when progress is monitored and recognised on a regular basis through setting and resetting learner goals. They also suggested that noting progress towards soft outcomes such as self-confidence is as important for persistence as acknowledgement of numeracy outcomes themselves. Coben and Miller-Reilly (2014) found in a review of evidence from Wales and New Zealand that Māori learners were responsive when classes focused on social skills, employment skills, and self-confidence alongside basic skills, as they felt the tutors were teaching to their needs rather than a set curriculum. Formative assessment can be a powerful tool in monitoring student's attitudes and motivations. However, not all learners find it effective. Derrick et al. (2008) found that some students found formative assessment to be a waste of time. This highlights the importance of formulation of a strategy that is flexible and specific to the needs of that learner to maintain engagement.

Westwood (2021) also discussed student persistence. He found that adult learners are most likely to remain engaged and enrolled in a course when the content links directly to personal goals for improvement or is in line with students' interests. By extension, Yamashita et al. (2019) found that if adults enrol in classes that do not suit their interests or needs, it can discourage future participation in learning. Further, Carpentieri (2014) highlighted the importance of "scaffolding" in supporting persistence. This ensures that learners are placed in the correct programme, face an appropriate level of challenge and are working towards a personal goal to keep them engaged. Larger class sizes were also associated with higher dropout and non-completion rates (Roe, 2007).

Effective interventions and approaches to engaging adult learners

Several papers examined the most effective approaches in engaging adult learners. While the evidence is mixed on many interventions, there was strong evidence across multiple studies around the use of community marketing and word of mouth, as well as TV advertising. Gaps in the research include a limited number of studies on compulsory attendance and no studies to our knowledge on the use of social media for engagement. While there was one high-quality randomised control trial on effective communication approaches, the research identified in this area was limited.

Effective media campaigns

One of the largest challenges in engaging adult learners in numeracy is making learners aware of the gaps in their numeracy skills and the options for learning available to them. Media and engagement campaigns can play a role in overcoming this.

Community marketing, learning champions and word of mouth

Bates & Aston (2004) found in their interviews of households in Sussex that word of mouth and hearing about programmes from family and friends were more effective marketing tools and were associated with higher enrolments than formal advertising and publicity. This finding is supported by interviews with teachers in the 2003 Pathfinder programme who reported that information passed by word of mouth is the most effective marketing strategy (Barnes et al., 2003; White, 2003; Woodhouse & Stevenson, 2018). Information about courses was spread both through informal social networks and through formal support networks. Informal networks were particularly useful in persuading learners to take the step of signing up for courses as opposed to just raising awareness.

Campaigns can be used to build momentum locally and increase awareness of the importance of basic skills and ways of accessing training. One example cited in our expert engagement work was the “Test the City” initiative, which brought a range of local education providers, workplaces and local services together to try to encourage individuals to assess their skills and access training. In a literature review, Hall et al. (2022) found that partnerships with community organisations and local voluntary sector groups are an effective recruitment strategy. These give educational programmes visibility within the community and tap into existing and trusted support networks. The ABCami programme in Germany engaged hard-to-reach immigrant communities through partnerships with imams and learning sessions that took place in local mosques and other community centres. In these spaces, learners felt safer in their learning and their lack of skills was less stigmatised (UIL, 2015a).

Byrne (2017) surveyed 52 practitioners at the Irish National Adult Literacy Agency annual conference. They found that many practitioners stated that the best ways to promote basic skills courses in communities were through physical posters, speaking to local clubs, Intreo (unemployment) centres, and the Department of Social Protection. Within community marketing strategies, emphasis should be placed on the benefits of taking part, highlighting the non-judgemental environment to remove fear and anxiety from the situation, and demonstrating how maths applies in everyday life and can improve independence (Byrne, 2017). While the report presents useful suggestions, the sample of those surveyed covers practitioners, not learners. Additionally, the group is likely not representative, so the results may not be generalisable to a wider population.

The use of learning champions can also be a successful recruitment tool. Learning champions are former learners who have successfully completed a course and act as a spokesperson for that programme in their community (Stevenson et al., 2021). This helps potential learners to see the merits of a course from a person they trust and reinforces the position that people from their community belong and can succeed in adult learning. A case study evaluating the Clare Family Learning programme found that using community learning champions was effective in engaging Irish Travellers and Roma communities (UIL, 2015).

A Romanian case study by the European Commission (2003) presented a one-stop-shop model to simplify engagement for disadvantaged and minority ethnic groups. This approach combined basic education with prevocational training to enhance integration of marginalised groups, such as the Roma community. In this case, the project aimed at providing the basic standards to pass compulsory education and strengthen relationships with teachers and community mediators. These mediators, people of Roma origin, were crucial to the success of the project, as they ensured the link between school and community.

Large-scale campaigns

Lord et al. (2010) found in their literature review that the primary benefit of large, national advertising campaigns relating to basic skills was to raise the profile of the issue and demonstrate that many people need basic skills classes. This serves to destigmatise learning and encourage individuals to sign up for a course.

TV and large-scale media were mentioned by fewer learners than encouragement from friends and family in interviews carried out by Bates & Aston (2004). However, a few learners mentioned getting phone numbers for programmes from daytime television ads, and several mentioned the “Gremlins” campaign by the DfES. This campaign was relevant as learners related to the message that it is “[their] gremlins” that are preventing them from signing up for a course as opposed to a more substantive reason. An evaluation of the Skills for Life programme reported that over one million people had achieved basic English and maths qualification as a result of the “Get On” TV advertisement campaign and helpline (Further Education Trust for Leadership, 2021).

Within a case study in the South West of England, Foster et al. (2008) found that the national media campaigns “Move On” and “Get on at Work” were successful in engaging learners and employers. However, this study does not provide information on the specific elements of the campaigns that were successful or what appealed to learners and cannot causally link increased engagement with the campaigns themselves.

While TV and radio marketing were found to be successful, in a series of interviews carried out as part of a pathfinder project, CRG Research (2002) reported that several learners stated that they would not respond to flyers and written materials because it required too much reading. A more interactive approach to reaching learners is to use materials such as quizzes. This was raised by several interviewees in our expert engagement work. Quizzes can yield a high reach for a relatively low cost if hosted online and promoted through social media and can be a fun way to encourage adults to use numeracy. However, they are unlikely to work as a tool for engagement if they are not clearly linked to further learning resources or information about provision.

A literature review on programmes in a European context carried out by Beadle et al. (2015) found the media and especially TV to be an effective communication and marketing tool, as low-skilled adults are more likely to watch TV than their higher-skill

counterparts. A specific large marketing campaign they discuss is the National Adult Literacy Agency's Learner Day in Ireland. Within Learner Day, over 200 learners take part in in-person workshops and meet one another. The day both allows learners to meet others in similar circumstances and destigmatises basic skills learning to non-participants.

Campaigns targeted towards specific groups

Recruitment and marketing can be effective when it is geared towards specific target audiences (Beadle et al., 2015; MacLeod & Straw, 2010). In a literature review, the European Commission argued that this is because targeted recruitment and marketing is more effective at engaging segments of the public who lack awareness of their skill deficiencies and available services and because they perceive specific barriers to participation which can be assuaged by messaging within marketing campaigns.

A report from HM Inspectorate of Education (2005) on the state of adult numeracy and literacy education provision in Scotland in 2004 finds that when targeting specific hard-to-reach groups, it may be useful to use specific "hooks" to get them interested in classes they otherwise would not seek out. They specifically cite programmes that target parents by focusing on homework clubs for their children in advertising materials. A specific hook cited by Stevenson et al. (2021) for numeracy learners is regaining confidence lost in school.

Targeting advertisement to specific groups can also be as simple as adjusting course names or offering a more extensive range of taster courses (Hall et al., 2022). Coben et al. (2007) reported best practice for policymakers and educators when attracting hard-to-reach groups to basic numeracy classes. They suggested that classes are marketed using other skills, such as ICT proficiency, to avoid the stigma of the basic skills tag. However, while this tactic is sometimes successful, it can also bring in learners who do not have a need or wish to address basic skills.

Targeted campaigns could also seek to engage employers, as they have considerable influence in whether their employees seek out basic skills training. A series of employer learning case studies focused on effective practice from the Learning and Skills Improvement Service (2010) gave several recommendations on how to engage employers in adult learning with marketing. The strategies they found to be the most effective based on the case studies assessed were e-marketing and making web information on learning programmes accessible, place-based engagement with visits from learning programme staff to workplaces, and the use of intermediaries who can act as go-betweens between employers and learning programmes. This includes individuals such as external skills brokers, HR and training staff, voluntary sector staff and union learning representatives.

Effective communication strategies

There are few examples of experimental research to determine what communication strategies are the most effective at engaging learners (Hume et al., 2018).

Using a series of randomised control trials, Hume et al. (2018) explored how messaging-based interventions impact learner engagement. In one such experiment, they sent encouraging texts to learners in randomly selected classrooms on Sunday evenings, when learners were most likely to be planning their weeks. The classes that received the texts had a 21% increase in attendance and were 16% more likely to pass all their exams compared to control classrooms. Another intervention had randomly selected learners complete online “value assessment” surveys intended to encourage learners to reflect on their core values and progress. Compared to the text messaging intervention, completion of the values assessment survey did not have a statistically significant effect on either attendance or pass rates.

Much of the information on successful in-class communication for engagement comes directly from teachers or practitioners, and how they interact with learners. In a case study of the learning programme Success Factor for Essex, Woodhouse & Stevenson (2018) found that high levels of engagement were closely linked to framing provision in terms of how the course can help the learner progress to a specific goal or job role.

In classes delivered completely online, effective engagement with learners may be more challenging. In a series of interviews with teachers and learners in technical education courses, a report by Cowen & Wilson (2022) found that since COVID-19 and online learning being more commonplace, teachers had to resort to more creative strategies to engage students online. This included running competitions to boost motivation and more regular formal check-ins with students.

In a literature review focused on online provision of adult numeracy since 2016, Galligan & Axelsen (2022) found that the use of online learning materials provides mixed results for engagement and retention. Some studies cited that retention rates were lower online, while others found a relational link to time, with negative short-term effects in terms of class-level persistence and performance, and more positive effects in the long run as compared to fully in-person classes. The authors hypothesised that the mixed finding may be the result of differences in teaching styles and uses of the online material. Additionally, because many of the papers cited examined the transition to online learning as a result of COVID-19, it is possible that the adverse short-term effects are based on other stressors related to the pandemic.

Use of incentives and rewards for learners

Part of the Pathfinder innovations evaluated by White (2003) included offering learners a £250 grant attached to course attendance and successfully completing a final exam. Teachers surveyed by the evaluation reported that the grant improved student learning attitudes more than expected, and employment outcomes were best for the courses that

offered the grant. The above findings offer preliminary evidence on the effectiveness of financial incentives but may not be widely generalisable as the pathfinder institutions and learners were not selected randomly.

Barnes et al. (2003) also examined the Pathfinder extension activities through a qualitative evaluation. Among the programmes evaluated were the Fixed Rate Replacement (FFR) and Financial Incentives. FFR courses compensated employers for the time learners spent away from work, while the Financial Incentive courses were numeracy and literacy courses that provided weekly compensation to the learners. According to the evaluation of Barnes et al. (2003), the compensation allowed the programme to reach groups of learners who could not attend any daytime classes otherwise. No participant said that they would have attended the courses without the paid time off work.

The above findings are supported by limited evidence from Latvia. In a qualitative literature review and a statistical analysis of averages of data collected for approximately 240 unemployed adults, Laskova & Strode (2013) found that a large percentage of learners stated that receiving a state grant or free education was their primary incentive for signing up to a course.

Hume et al. (2018) also found evidence of the efficacy of financial incentives. They designed a randomised control trial in which some parents enrolled in classes in children's centres were given £25 vouchers for attending 60% of classes and an additional £25 voucher if they attended 80% of classes. The control group was given no attendance incentive. The treatment group's attendance improved by 21.8 percentage points compared to the control group. This indicates that a small financial incentive can increase attendance and retention for parent learners.

However, the evidence base on financial incentives is mixed. The Learning and Work Institute (2019) evidence review cites evidence from a trial carried out in UK adult literacy classes in 2008 where attendance was lower among learners in the classes where financial incentives for attendance were paid than in the control group. The researchers speculate that this result may be related to the finding from wider research in the behavioural science literature that providing financial incentives to activities which are intrinsically rewarding (developing literacy skills could be such an activity) could be demotivating. In addition, some studies also found that receiving rewards based on the level of engagement could negatively affect learners' engagement itself. The mixed nature of the evidence base suggests that additional research is needed to determine when, how, and for whom financial incentives can be effective and where they may not be effective at all.

A UNESCO case study from Chile found that when prisoners were offered reduced sentences for attendance and completion of basic skills courses, it boosted participation and engagement (UIL, 2017). While this is an example of a successful incentive system, the prison learning context is likely not widely generalisable.

Use of incentives and rewards for providers and employers

Financial incentives may also be effective in motivating learning providers to take on hard-to-reach or very low-skill learners. Engaging and teaching the lowest-skill learners is a resource-intensive process as it generally requires greater input from tutors to build learners' trust and more individual attention for each learner. In evidence from the English speaking world, the Learning and Work Institute (2019) found that funding frameworks can disincentivise engagement for the lowest-skill learners, as funding is often awarded based on measurable impacts such as attendance and qualifications received, which are likely to be lower for this group. Benseman (2011) agreed, drawing on evidence from the UK and New Zealand to suggest that education providers are incentivised to target Level 2 and Level 3 learners as it is more cost-effective to teach them despite the social benefit of targeting Level 1 learners.

Benseman and Sutton (2012) also found evidence that providers are less willing to work with the lowest-skilled adults. They conducted interviews with adult education providers in New Zealand. Providers argued that there was no incentive under existing funding regimes to take on learners with very low skill levels. Since they tended to make slow progress within the time available, providers struggled to match government's goals when they recruited these learners. Instead, providers believed that these students required very small class sizes or one-to-one teaching. Usually, these learners also require speaking and listening skill development.

One potential option for incentivising learning providers to take on Level 1 learners is to implement funding based on total progress (or "distance travelled") rather than qualifications earned. In a 2014 programme evaluation of 36 pathfinder institutions through interviews and limited data analysis, the Department for Business, Innovation & Skills (2014) analysed the effects of implementing a "distance travelled" funding mechanism. They found that while learners were motivated by the progress-based system, tutors found it hard to use in practice as many tests were not sensitive enough to measure the progress made by learners because of the similarity of some pre-test and post-test scores. In contrast, a case study evaluating a continuing education programme in Chile argued that the programme's success was partially due to a results-based approach. Organisations received payment based on students' performance, which lessened the amount of programme supervision required from managing bodies (UIL, 2017).

A lack of incentives to invest in low-skilled adults is not a problem confined to classroom-based learning. Based on an analysis of PIAAC data from Norway, Sweden, Finland, and Denmark, Tikkanen et al. (2015) found that employers also do not have sufficient incentives to invest in skills training for low-skilled workers. In the pathfinder programme analysed by White (2003), some workplaces were offered fixed rate replacement costs for the hourly wage of employees enrolled in training. This was associated with better attendance and more engagement from workplaces. Finlay et al. (2007) supported this finding with their series of case studies on U.K.-based workplace skills training

programmes. Several providers interviewed stated that they would not have begun basic skills training if not for government funding. They also found that employers are not convinced by the supposed payoff in terms of greater workforce productivity as a result of investment in skills training. The evidence reviewed by the Learning and Work Institute (2019) also found that funding is a key factor in employers' decision-making about whether to run a basic skills programme. It was highlighted that when funding runs out, employers are generally unable to continue to offer provision. This is especially true for SMEs (small and medium sized enterprises) that are less likely to have a well-resourced training programme as part of their pre-existing infrastructure.

Peterson et al. (2002) suggested that to boost participation in workplace basic skills programmes, employees should be both recognised and offered increased responsibility and pay for successful completion and participation. There are some examples of educators using rewards within the classroom to incentivise learning and boost extrinsic motivation. In a quasi-experimental classroom-based study of the effectiveness of step-by-step teaching[22], part of the intervention involved teachers awarding bonus points for students grasping concepts. While some adult learners found this effective, others thought it was childish and disengaged as a result (McDonald, 2013).

Role of compulsory attendance

Some learners take up numeracy and literacy classes because they are compelled to do so by, for example, an employer, benefits scheme or job-seeking programme.

In 54 life history interviews of students and practitioners in three English institutions, O'Grady & Atkin (2005) found that learners who are forced to attend a programme lack full engagement, are resistant to participating in future learning, and that the experience reinforced the belief in learners that they are "failures". Within the interview group, they found no increased employment benefit of enforced training, and many individuals had to reengage with the same programme later following another unemployment spell. An evidence review carried out by the Learning and Work Institute (2019) also found that, while mandatory provision as part of a Jobcentre Plus programme increased attendance initially, it increased reluctance to participate further in adult learning.

Within an employment context, in a literature review focused on participation and motivation, Carpentieri (2014) cited evidence that voluntary participation in learning was correlated with higher rates of participation in further education than mandatory provision. While the effect was small, this finding was statistically significant.

[22] Step-by-step learning is where information is explored one piece at a time so that a learner must show understanding of the previous material before moving on.

Delivery channels

A considerable part of the literature examined alternative methods of delivering adult basic skills training. The delivery methods identified in the literature included flexible learning, with a focus on digital learning and blended learning – combining face-to-face and digital elements, workplace-based training, community-based training and learning programmes for whole families. Each delivery method offers different benefits and can meet different learner needs.

Our search identified 70 studies related to the delivery channels listed above, with 18 papers exploring flexible, blended and digital training, 28 on workplace training, 17 on community-based learning and a small number of papers (10) on family learning, with some papers being relevant to multiple topics. Most papers in this section based their findings on either literature reviews or case studies and observational data. A smaller number of papers used interviews, surveys and questionnaires to evaluate programmes, while only a couple of papers used quasi-experimental methods

Regarding flexible, blended and digital learning, the most recent evidence is focused solely on the digital elements of learning. The literature on this topic includes two quasi-experimental studies exploring the impact of online learning products and tools, a few literature reviews, and a small number of papers using survey data with providers and learners to explore their views and experiences. A relatively large part of the literature is also based on case studies of specific programmes. These provide useful insights and are sometimes based on robust data collections and evaluations, but generalising evidence from cases studies should be done with caution as they usually capture impacts specific to the examples and contexts examined. The literature on workplace training is the richest across all topics in this chapter, but it lacks quantitative evidence and robust evaluations of the impact of the programmes discussed (e.g. considering the counterfactual). Around a third of the papers discussing workplace training are literature reviews, while a few papers use data analysis to explore the impact of such programmes (e.g. comparison of outcomes before and after the programme, use of panel data). The rest of the literature utilises case studies, small numbers of in-depth interviews, observational data and guidelines published by expert organisations.

Finally, the smallest number of studies is related to community-based training and family learning. There was also a lack of highly methodologically robust approaches to assessing the impact of community-based training. Around half of the studies identified are based on case studies. The remaining studies in this area are either literature reviews or use in-depth interviews and focus groups. Overall, while there is no research question in this chapter that it is not explored at all by the literature, there is a lack of evaluations of programmes based on either randomised controlled trials or quasi-experimental methods. Such evaluations might provide more generalisable estimates of the impact of programmes across different delivery channels and methods.

Flexible, blended, and digital learning

Flexible learning

Phillips & Smith (2010) reviewed UK and international evidence on developing adult basic skills via flexible learning. They concluded that, *"*evidence about basic skills through flexible learning was very limited and there was little robust evaluatory evidence available*"*, suggesting that this was an under-researched area at the time of their evidence review.

On definitions, Phillips & Smith (2010) noted that these have been often used on an imprecise basis in the literature with "the terms open, distance, flexible and remote learning [being] used 'increasingly loosely' to describe a wide variety of learning delivery modes", though this should not be the case. The authors then defined the key aspects of providing flexibility to learners regarding "how, when and where", particularly in terms of variable modes of study, locations, times, and pace both for learning and assessment. Related concepts were also defined, including blended learning, which combines features of flexible learning with direct teaching from trainers (often face-to-face), and distance learning, which includes study not under the continuous, immediate supervision of trainers but benefitting from the planning and guidance of trainers.

Phillips & Smith (2010) concluded that the main principles for the effective delivery of flexible learning are taking account of the individual, course design and tailoring to learners' needs and anticipating barriers, including IT barriers. One of the key takeaways from this study was that flexible learning has evolved to incorporate a wide range of technological developments. Arguably, this may mean that the more recent evidence base on blended and digital learning can be seen as having subsumed the evidence base on flexible learning.

Blended and digital learning

The current digital landscape has increased internet access and enabled new tools for problem-solving (Rosen and Vanek, 2017). Those tools led to new options and additional flexibility in the methods through which people receive education. Blended learning combines face-to-face and online instruction, with learners having some degree of control over the time and pace of learning. However, the distribution of time between each form of instruction depends on the goals of the adults, the curriculum, and the resources available (Rosen et al., 2020).

Benefits of blended and digital learning

Integrating digital technologies within instruction can enrich and expand learning opportunities, for instance, by enabling learners to attend classes online if they cannot do so in-person (Belzer, 2020). It can also support adults with changing circumstances and those at risk of discontinuing their education (Vorhaus et al., 2011).

Distance learning in blended models can comprise many different formats including video courses, discussion forums, social software like blogging or messaging services, and specialised software, such as virtual learning environments (Phillips and Smith, 2010). A Virtual Learning Environment (VLE) is a web-based platform supporting the digital aspects of an educational course. A questionnaire distributed among 38 adult training providers across England suggested that web-based platforms should be organised into sections and provide different areas for teachers and learners (Learning and Skills Improvement Service, 2010). These platforms could have built-in monitoring tools, and they should create communities of learners who would be able to contribute via forums and message boards. These providers also outlined the essential *do-nots* for virtual learning environments: uploading worksheets that don't connect with the rest of the course, paper-based course materials and assuming that learners have high IT skills (Learning and Skills Improvement Service, 2010).

UNESCO presented international examples of the use of online portals to support classroom learning. A case study on the Turkish Web-Based Literacy programme (UIL, 2017k) featured a portal design for students to independently track their own progress. The web-based tool fostered autonomy and independence, while it was also clearly structured and user-friendly, allowing those with low levels of computer skills to make use of the technology. The Virtual Assisted Learning Programme in Colombia also makes use of a VLE. Students spend half of their time on-site and the other half at home completing self-directed individual and collaborative work. Computer-based work also reinforces what was learned in class (UIL, 2017j).

Interviews with participants, combined with quasi-experimental methods, shed some light on the average effect of online learning products on national tests in the USA (Murphy et al., 2017). Online products were web-based instruction tools that could be accessed when learners were outside of the educational settings. These tools contained skill development instructional content, including graphs, images, and animated video presentations. On average, using online products had a positive impact on maths scores. However, the quality of teaching and differences in the curricula could act as confounders. Students' attainment depended on the intensity of use of this product and their skills at using it successfully. Following interviews with practitioners in 13 delivery sites, Murphy et al. (2017) found that students needed time to become familiar with the technological product that would be used.

Learners are likely to be more engaged with media-rich digital resources. In fact, technology-rich learning has a positive impact on reading, writing, and numeracy skills. It makes learning interesting and accessible, according to a review by Belzer (2020). However, technology by itself does not produce better outcomes. The literature review conducted outlined a central principle for successfully integrating technology into adult basic skills education: learning opportunities should be focused on problem-solving and critical thinking rather than replicating workbooks on a digital platform.

A lack of digital literacy can create disproportionate disadvantages for some adult learners even if many might already be familiar with social media platforms, messaging apps, or other sites. According to the review by Belzer et al. (2020), instructors should try to integrate technologies that students can have easy access to and feel comfortable with. Doing so prepares students for learning outside the classroom. For instance, public posting on Facebook and public discussions on social media increased learners' engagement. The use of social media platforms created interactive learning experiences and resulted in more complex thinking and writing. Additionally, online content and visibility increased adults' self-efficacy (Belzer, 2020). The review also suggested that teachers should encourage learners to use technology for activities they are confident about, but that they should use guided instructions for new and challenging concepts (Belzer, 2020).

According to a case study conducted by UIL (2017), key components of technology-enabled adult numeracy education in Canada were the use of discussion forums, which encouraged peer engagement across the country, and the freedom to choose activities. The AlphaRoute programme, launched in 1996 to support adults unable to attend traditional classroom-based literacy programmes, provided students with a web-based assessment resource to work at their own pace and determine their skills level.

Some of these digital learning models might not be ideal if programmes target disadvantaged populations or rural areas with limited access to internet. There are ways to overcome this, however. For instance, in Colombia, the Sistema Interactivo Transformemos Educando sought to improve educational opportunities for vulnerable groups (UIL, 2022). Classes took place in technology-enriched environments in community settings. Students were given digital tablets to support thematic work and learning from home. To handle access issues, these tablets had a battery life of up to six hours and did not require internet (UIL, 2022).

According to a case study by UIL (2017) of an adult numeracy learning programme in Ireland, learners may also benefit from the increased levels of privacy and autonomy that home-learning provides. In this case, students had a 30-minute phone call with a tutor every week alongside online group sessions. To supplement learning, the National Adult Literacy Agency (NALA) aired a programme on the national broadcaster, which included learners' testimonials and up to 10 minutes of didactic content. According to the case study, the broadcasting element was a satisfactory source of information for the target audience (UIL, 2017l).

Quasi-experimental research by Moreno-Guerrero et al. (2020) studied a specific case of distance learning that revealed further benefits. In the treatment group, all course materials were posted online and there were no lecturing activities. The programme included one group session in class, and two hours of individualised face-to-face tutoring every week. However, these activities were not compulsory and almost none of the students attended the centre to ask questions or receive support. In the control group,

the pedagogical approach was based on the oral and face-to-face presentation of the theoretical contents. They found that e-learners scored significantly better on motivation, participation, and conceptual understanding. These learners scored higher on their final qualifications as well as their self-evaluation. However, the biggest difference was in autonomy, mainly because the e-learning method encouraged self-regulation of learning.

The need for face-to-face and ICT support

Ambitious technological solutions can be hindered by limited resources, accessibility issues, and the unintended consequences of increased flexibility. For instance, research reviews found that due to limited access to computers, learners can lose confidence and motivation (Windisch, 2015). Additionally, it is important that online and digital tools are coupled with support for ICT skills. According to a research review of adult numeracy training, adults with poorer ICT skills are more likely to drop out if their acquisition of skills is not supported (Vorhaus et al., 2011). Interestingly, problems with digital tools might not always be related to age. In a systematic review of online mathematic courses, older learners found online learning more rewarding than younger learners across several studies. Instead, their challenges related more to maths anxiety than to anxiety around using new technologies (Galligan and Axelsen, 2022).

A review of policy interventions suggested that e-learning can better support adult education when paired with face-to-face input from the tutor (Windisch, 2016, 2015). The interactivity and flexibility can help those with poor experiences in school, but it can also isolate and inhibit personal interaction (Coben et al., 2007). The review by Windisch (2015) found that face-to-face contact with teachers and peers is a powerful motivating factor, and its absence might be felt keenly. Additionally, not all learners have the self-discipline to benefit from distanced e-learning. For this reason, face-to-face contact, or nudging via telephone or email, can be necessary to support adult learners (Windisch, 2015). The review by Galligan and Axelsen (2022) also found that reducing live lecturing attendance was associated with an increase in surface level learning behaviours such as rote learning and memorisation because students relied on recorded lectures.

A survey of 149 adult learners studied the effect of a non-compulsory online component in three Canadian community colleges. A quarter of the students avoided the online component completely, and 60% did not view the activities online as easy to use. Notably, 30% of these learners lacked confidence in their computer skills (Li et al., 2018). Overall, 80% of the students were satisfied with their success in this course, but the authors concluded that adult basic skills learners might prefer face-to-face learning (Li et al., 2018). Most students indicated that instructors' responses, face-to-face feedback, and individual support were critical to learning and encouraging. However, the online component enhanced communication with instructors and made more resources available according to 11% of students. Additionally, in terms of inclusion, the online and digital component was highly valued by people who required assistive technology, while a third of respondents appreciated that the online content allows them to keep up with work when they were not able to attend face-to-face classes (Li et al., 2018). According

to the authors, this programme provides some insights for future provision: invest in technical support, develop user-friendly and inclusive designs, and encourage face-to-face feedback in blended programmes.

In our focus group, participants reflected on the impact of COVID-19 on online learning. They argued that digital resources had improved in quality and permitted flexible and modular delivery which fitted around learners' personal circumstances. However, they emphasised that there were a range of barriers to participating in online learning including a lack of digital skills among learners, digital poverty, and having to work in environments that were not conducive to learning. For this reason, they argued that online learning may need to be supplemented by digital skills courses, and individuals may need support with data/equipment costs or access to learning spaces.

Lastly, digital teaching poses some challenges to professionals. For instance, the visual nature of mathematics can be difficult to translate online, while distance teaching and learning place constraints on effective communication of mathematical syntax, language, and symbolism (Galligan and Axelsen, 2022). The discussion by Rosen and Vanek (2017) suggested that teachers required sustained professional development, coaching, and technical assistance to work in blended or fully-online learning environments. Coben et al. (2007) covered 16 projects intended to incorporate ICT into adult numeracy in Scotland. Tutors in these programmes highlighted three main ideas that supported their practice and skills: maintaining some personal contact with the group of learners, freeing up some time to meet with professionals to learn new applications, and good learning materials.

Workplace training

Investing in company staff training and skill building is expected to increase motivation, decrease turnover and positively affect performance, leading to benefits for a wide range of stakeholders including workers, employers, learner families, communities, labour unions, agencies and local governments (Chartered Institute of Personnel Development, 2005; Jurmo, 2020). In what follows, we discuss motivating factors and benefits of workplace training, challenges, teaching methods, broader good practice and the outcomes as presented in the literature reviewed.

Motivation and engagement in attending workplace basic skills training

Adults are usually more difficult to engage than children as they have responsibilities, commitments, and previous negative experiences with formal education that may make them unwilling to learn and improve their skills. Delivering adult basic skills training in the workplace can support adults to overcome such challenges by providing learning opportunities at times and locations that are convenient and welcoming for learners.

Kersh et al. (2012) examined employees' motivation and engagement in literacy and numeracy programmes, focusing on workplace courses. The authors analysed data

collected through interviews and surveys with learners, tutors, and managers before and after the implementation of Skills for Life workplace courses. The key benefits of workplace training compared to other forms of education highlighted by respondents were: (i) learning with colleagues in a familiar setting, (ii) tutors' role in this setting, which was seen as informal, relaxed, more approachable, and friendly, and (iii) the convenience and accessibility of learning provided in the workplace and during working hours. They also found that adults may be more motivated in a workplace environment because it does not carry the same negative association as a classroom. This is especially relevant for learners who have had negative previous experiences with schooling.

In a systematic review of the literature on basic skills in Wales, Roe (2007) found that being encouraged by an employer was more likely to be the primary motivation for taking up basic skills classes for older adults (45+). On the other hand, according to the managers who participated in the research, some of the factors that may potentially decrease learner motivation include (i) high tutor turnover, (ii) non-constructive feedback from training providers or tutors and (iii) learners' specific needs and abilities not being considered (Roe, 2007).

Improved job-related outcomes as well as social outcomes can also be a significant motivating factor for employees. One of the questionnaires distributed by Kersh et al. (2012) asked participants to identify the two most important outcomes that they expected from their course. 51% of the learners in the sample mentioned learning new skills, while 35% mentioned the ability to improve their performance in their current job. Other expected outcomes that indicate the sources of motivation of this group of learners included increasing the chances of promotion or a better job, meeting new people, making their current job more interesting and earning more money.

Evans & Waite (2008) brought together evidence from case studies of four workplace training sites in England involving 42 employees and 6 supervisors/tutors. The data sources included in-depth employee questionnaires and manager and tutor interviews. The authors concluded that workplace learning sites are important for the interweaving of formal and informal learning opportunities. They suggested that formal workplace learning increases employee awareness of the importance of learning and engagement with informal training opportunities. Additionally, in line with the rest of the literature, the authors found that formal workplace learning has better accessibility compared to courses delivered in other settings, and it can contrast with, and compensate for, previous negative educational experiences. Conversely, they concluded that workplace training can be negatively affected by pressure from managers or supervisors to miss learning opportunities to fulfil workplace duties. Finally, they argued that workplace learning programmes should be supported by learning-rich working environments, rewards and promotion strategies to ensure the success and sustainability of the programmes.

Stevenson et al. (2021) identified a list of factors that should be considered by providers when developing and planning workplace basic skills provision. Firstly, according to the research reviewed by the authors, understanding employer motivation, considering employer needs, and communicating effectively with them based on their needs and sources of motivation are important in approaching and engaging employers. Additionally, including basic skills as part of the organisations' training and development plans can be central for employers as well as employees, as it will reduce any stigma associated with attendance of basic skills training. The above suggestions were partly based on guidance provided by the Learning and Work Institute that was included in the evidence review conducted by Stevenson et al. (2021). The guidance was developed following primary (interviews and workshops with stakeholders and experts) and secondary research (review of existing evidence).[23]

Browne & Booth (2003) conducted a case study on workplace literacy training in a bus company in England. The authors asked the participants during informal interviews about their main considerations and feelings related to this specific workplace training. Participants' responses revealed some of the motivating factors in attending workplace training, including promotion and vertical career progression, improved literacy skills, gaining confidence and respect and job security.

Union learning representatives

Unions can play a role in recruiting learners who would not otherwise participate in adult education. A literature review carried out by the Chartered Institute of Personnel Development found that union learning representatives can disseminate information and convince employees of the merits of improving their numeracy skills (Chartered Institute of Personnel Development, 2005). Not only can unions spread information about available programmes and encourage sign-ups, but they also create a different learning atmosphere focused on collective benefits and opportunities for workers to come together.

Finlay et al. (2007) also finds that union learning representatives (ULRs) are important for encouraging learning. They found that workers are most responsive to ULRs, as compared to managers because they trust them more and feel that they better understand their concerns since many of them participate in the same training programmes. A successful example of the use of union learning representatives comes from a work-related basic skills programme for New York City public transit workers in the early 2000s. Feedback from participants in the programme suggested that union networks were effective in promoting the courses (Jurmo, 2021).

A literature review of workplace numeracy learning in Australia found that while the debate around content is mostly led by employers and the government, input from workers and unions should also be required to align objectives. According to Yasukawa

[23] Learning and Work Institute (2020) "Better basic skills: better business. A guide for learning providers"

et al. (2014), workers are interested in developing their skills but there are differences between how management/employers view such needs and how workers do. This has implications for curriculum development and course planning. Consequently, union representatives can contribute to ensuring that the curriculum is aligned with workers' needs. Finally, promoting basic skills training among employees can benefit unions as well by benefiting their individual members, increasing the negotiation power of their members and bringing people together (Yasukawa et al., 2014).

The challenges of workplace basic skills training

Kersh et al. (2012) discussed a set of limitations and shortcomings of workplace programmes based on the Skills for Life courses delivered at the workplace. A small number of participants were concerned or faced challenges with workplace training because of the pressure of complying with shifts, learning not being a priority in the workplace, fear of negative perceptions surrounding low skills from colleagues and their preference for taking longer courses or separating learning from work. Finally, the authors also highlighted the key challenge of continuity and sustainability of funding together with concerns related to the range and level of courses that can be delivered in the workplace.

Related to the issue of continuous and sustainable funding identified by Kersh et al. (2012), Wolf et al. (2010) conducted a longitudinal survey of sites providing workplace literacy training between 2004-2006 and found that only a few employers continued the provision of training after government subsidies were discontinued. The authors suggested that short-term funding might not be the most efficient and sustainable way to incentivise employers to provide training.

According to Waite et al.'s (2014) theoretical examination of sustainable Skills for Life workplace provision, for most employers, worker learning is not a priority and it is usually a lower-order decision.[24] Based on this framework and drawing on longitudinal data and recent research findings, the authors concluded that it is difficult in practice to secure the sustainability of courses in most organisations. Some key barriers identified by the authors included pressure to adapt programmes to shift patterns, the diverging priorities of providers, training managers and line managers, organisational changes and the impact of the economic downturn of 2008-2009.

Teaching methods in workplace training

There is a consensus in the literature that numeracy training contextualised within work activities and everyday life can be more efficient than solely theoretical approaches. The research conducted by Kersh et al. (2012) indicated that if workplace basic skills education is embedded and contextualised in relevant work activities and tasks, learner engagement and motivation could be increased. The tutors in the sample also highlighted

[24] According to the authors, first-order decisions concern markets and competitive strategy and second-order strategies concern work organisation and competitive strategy.

the importance of learners understanding the course's relevance to their everyday life. Additionally, according to the suggestions of Newton et al. (2006) based on a review of the literature related to literacy, English language, numeracy and IT (LLNIT) skills programme facilitators should have some understanding of situated learning to adapt work activities and use context-specific learning methods.

In line with the above findings, FitzSimons & Boistrup (2017) addressed the ability to use mathematics in the workplace and the implications for mathematical skills training. According to the authors, it is essential for workers to be able to recontextualise formal mathematics beyond the classroom. For this reason, mathematics and numeracy teachers need to become familiar with vocational subjects and should prompt learners to consider the differences between classes and their workplace. Instead of paper-and-pen tests, holistic approaches adapted to the industry would allow learners to identify an issue or problem of importance to them, investigate it in various dimensions and find potential solutions (FitzSimons & Boistrup, 2017).

FitzSimons et al. (2005) considered the example of the chemical industry, where workers need the appropriate numeracy skills to manage company procedures, including preparation, storage and transport of final products. A case study of numeracy training in this industry concluded that problem-solving activities helped learners to develop and practice numeracy skills, using business or industry case study examples. Additionally, video materials relating to specific situations that learners might encounter could be used to provide contextualisation (FitzSimons et al., 2005).

The ability to transfer learning from basic skills training into the workplace was the core research question of the review conducted by Cameron et al. (2011). This review found that programmes need to be relevant to what adults want to learn as well as to companies' and individuals' needs. According to this review, near transfer is more likely to be successful than far transfer.[25] For instance, good practice could involve using a manual that workers use on their job or work-related task simulation. Teachers must use a wide range of examples and generate opportunities to reflect on this learning (Cameron et al., 2011).

Since basic skills training should be relevant to workplace tasks, it should also evolve in line with changes at the workplace. ERGANI, an independent non-profit organisation of professional development for vulnerable populations, argued that teachers' practice should be up to date and based on digital tools in order to keep up with the changing workplace in which employees need to use their skills (Fenech et al., 2018). A review of academic research on adult basic skills training found that conditions for effective workplace learning include voluntary engagement, extensive contact time, and sustained formal and informal opportunities for skills training (Carpentieri, 2014).

[25] Near transfer is the transfer of knowledge between similar contexts.

BCWL is a programme funded by the Norwegian Ministry of Education to support basic skills training in the workplace (UIL, 2017h). One of the main lessons learnt was that it is necessary to devote time and resources to mapping the needs of different learners as these can vary greatly. A survey rolled out among participants showed that the course increased enrolment in workplace learning and self-confidence.

Good practice in workplace training

A number of studies recommended good practice examples for workplace training, exploring a wider range of factors beyond teaching methods, including what language should be used to increase engagement, appropriate funding, and workplace characteristics that enhance motivation, participation and attainment, such as support from employers and colleagues.

Cameron et al. (2011) reviewed the literature to identify what is known about the factors that support and hinder learning transfer in the workplace. The authors concluded that work environments that provide opportunities to practice new skills soon after the course, allow for support from peers, and provide appropriate feedback from supervisors to learners, ideally in one-on-one discussions, can positively impact the ability of learners to apply knowledge and skills to their work activities. On the other hand, poor communication between employers and employees, low employee morale, a lack of encouragement and time pressures on employees from the organisation can act as barriers to the transfer of knowledge.

Newton et al. (2006) reviewed the literature to identify current practices and opportunities to develop literacy, English language, numeracy and IT (LLNIT) skills. The authors concluded that supervisors and line managers are key to the implementation of training, but they can also be key barriers if they do not see the need for such training. Good practice identified by the authors indicated that managers and advisers should be involved in the development of curricula to ensure they are work-relevant and work-focused. In line with other studies, the authors highlighted the importance of language when it comes to training programmes as well as skills. For example, in the LLNIT skills setting, employees may feel more comfortable to say that they attend a computing course rather than a basic skills, literacy or numeracy course. Finally, the authors also suggested that current employees become sign-posters of learning opportunities, increasing engagement. The authors also identified key knowledge gaps that were present at the time of the report. Firstly, they only found some indications of effectiveness of LLNIT skills development programmes rather than evidence based on systematic evaluations. Additionally, the research identified very little hard evidence on the value of LLNIT learning to the organisation.

Foster et al. (2008) used a wide range of qualitative and quantitative data, including reviews of the literature and data, interviews, case studies, learner biographies, focus groups and a mystery shopper exercise to identify employer and employee attitudes towards Skills for Life and ESOL training provision within businesses in the South West

of England. Based on analysis of data collected through the research activities listed above, the authors provided a set of recommendations for Skills for Life and ESOL training with some of them being applicable to any workplace programme targeting basic skills. The research highlighted the need for effective delivery through various mechanisms, such as companies using existing tests to identify the learning needs in their organisation and trade unions being furtherly funded to increase their capacity in reaching out to smaller employers and their workforce.

The authors also highlighted areas where additional support and funding would be beneficial for both learners and employers. They specifically cited (i) small and medium companies who usually lack in-house training resources and union representation, (ii) voluntary and community providers who need to be able to respond to the needs not met by formal providers, and (iii) informal learning routes. The remaining suggestions focused on close collaboration between providers and employers, including ensuring channels of communication and responsiveness to the needs of each organisation, as well as sharing good practice.

Payne (2002) explored the available evidence to identify factors determining effectiveness of workplace basic skills learning programmes and concluded that there was no systematic collection of evaluative data. However, drawing on the outcomes of a Learning and Skills Development Agency (LSDA) expert seminar held in May 2001 and a list produced by Workbase in New Zealand, Payne (2002) compiled a set of suggested good practices. The author also considered further sources from the literature. Among others, the recommendations included ensuring that programmes reflect local circumstances, considering basic skills as part of the firm's overall training, accepting that considerable time commitment is needed, using curricula that reflect real-life uses of literacy and numeracy, securing support from senior management, conducting a learning needs analysis, using marketing within the workplace, ensuring that marketing aligns with worker interests and uses positive language, and scheduling provision within working hours. The author also recommended the involvement of trade unions in the workplace strategy and in providing guidance for learners. Finally, offering accreditation where this was relevant or required was also suggested.

Finlay et al. (2007) drew on data from in-depth interviews and secondary data sources from eight sites of work-based learning to argue that, among other insights, funding injections and short-term initiatives are unlikely to ensure that the full benefits of learning in the workplace are realised. They further suggested that there is a need for more sustained funding from government and employers and for legislation in the form of regulation of certain jobs. More specifically, the authors proposed that if particular qualifications are a prerequisite for employment in certain jobs, workplace learning motivation is increased for both employers and employees.

Peterson et al. (2002) examined workplace literacy and basic skills development programmes in South Carolina. The authors presented the five basic steps needed for a programme to be developed in the workplace, according to the guidelines developed by

the Institute for the Study of Adult Literacy at the Pennsylvania State University. The steps included (i) developing awareness within the community, (ii) developing readiness within the company, (iii) conducting a situational analysis to determine the business needs and its capacity to address those needs, (iv) negotiating the intervention with the provider to ensure that the programme will meet the specified needs of the company, and finally (v) establishing a partnership for programme planning and implementing the programme with clearly established systems of support. Although the guidelines are outdated (1990) and the specific report is more focused on literacy workplace programmes, the highlighted focus on meeting the needs of the specific company and workers could be relevant to any basic skills training provided at workplaces.

The National Centre for Vocational Education Research (2011) in Australia hosted a forum to explore adult language, literacy and numeracy in the workplace. The forum concluded with a list of recommendations for future action based on the discussions during the conference as well as background papers prepared for the forum. The recommendations were broadly in line with the literature and highlighted the need to raise awareness within industries, communities, networks, providers and government departments, the importance of using positive language and moving away from a deficit model to avoid stigma and encourage participation, and the importance of workplace education brokers such as Union Learning Representatives. Finally, they suggested sustainable and learning-based funding instead of qualification-based funding.

As part of the National Workforce Literacy Project, a series of roundtable discussions with employers from the manufacturing, construction and service sectors were conducted in Australia in 2009 aiming at understanding the views of employers on the effect of low levels of numeracy and literacy in the workplace (Australian Industry Group, 2010). The discussions were followed by a survey, which gathered responses from 288 companies. Overall, 31% of respondents believed that literacy and numeracy skills development in the workplace with the support of co-workers could be an effective measure. The employers who participated in the research also suggested that customised programmes adjusted to business needs were more likely to be successful, with individual needs identified through performance appraisal systems. Additionally, the employers highlighted the importance of the ability of managers/supervisors to support, mentor and coach learners in the effectiveness of programmes.

Finally, according to the Learning and Work Institute (2019), the complexity of the skills landscape has led to company decisions about the provision of learning being delayed because of challenges in finding courses that fit the needs of the sector. For this reason, a guiding body could assist employers in navigating skills provision opportunities.

The impact and outcomes of workplace training

Numeracy skills

Gauly et al. (2020) used longitudinal data on adult numeracy skills from the German sample of the Programme for the International Assessment of Adult Competencies (PIAAC) to examine whether participating in job-related training programmes can positively affect the numeracy skills of participants. The authors used econometric techniques (e.g. OLS and Fixed Effects regressions) to control for various sources of potential bias as well as variables that could affect attendance at training programmes and participants' skills. The cross-sectional analysis showed that job-related training was positively associated with numeracy skills. However, this relationship disappeared when the authors controlled for previous levels of numeracy or when they related changes in training participation with changes in numeracy. Consequently, the authors expressed their doubts as to whether job-related training can have such spill-over effects and suggested that courses explicitly targeting numeracy skills may be required to foster the improvement of such broad skills among adults. Another interesting finding emerging from this research was that numeracy predicts selection into job-related training. Consequently, it seems that individuals with higher numeracy skills are more likely to attend job-related training.

Labour market outcomes

Ananiadou et al. (2004) reviewed the literature on the impact of workplace basic skills training on individuals, focusing on the effect on wages and employability. The authors found that individuals with better mathematics and reading skills have higher earnings and are more likely to be in work, even when the authors accounted for other factors. The second research question explored by the authors was whether individuals with low basic skills may have increased wages and employment probabilities after training. The findings were inconclusive, as significant effects were only found when using specific measurements (e.g. self-reported improvement in basic skills rather than measures of test scores or qualifications obtained) or only for specific populations (e.g. men who left school with low-level qualifications who acquired a degree in their 30s or early 40s in the UK, or female immigrants who took upper secondary courses in Sweden).

Ananiadou et al. (2004) concluded that, at the time, there was a clear evidence gap on the effects of basic skills improvements on labour market outcomes, as well as on information on the extent and nature of basic skills training provision in the workplace and longitudinal data for people attending such programmes. The authors also highlighted that researchers should not extrapolate findings from children and young people to adults nor assume that because individuals with better skills have better outcomes, low-skilled individuals would have similar outcomes if educated further. Researchers should always consider the impact of individual characteristics and prior experiences before generalising results and forming expectations. Due to the evidence gaps discussed above, Ananiadou et al. (2004) reviewed the literature on broader work-based training.

The authors found evidence that workplace training can have a strong impact on wages, with employer-provided courses having a greater effect on employee wages, employability and turnover than non-employer-provided courses.

Wolf et al. (2010) conducted a longitudinal survey of 53 sites of workplace basic skills training subsidised by the government. Although learner satisfaction was high, the impact of the training on learner workplace-related outcomes (e.g. improvement in skills, job satisfaction, behaviour that could lead to increased productivity) before versus after the training was less clear. However, there was a small increase in the probability of learners pursuing further education and reading more compared to the general population. It should be considered that all but one of the sites included in the survey offered literacy training and thus the results should be extrapolated to numeracy skills training with caution.

On the other hand, a more recent literature review by Stevenson et al. (2021) showed that adult basic skills learners can gain statistically significant employment returns. According to the authors, research evaluating learning below Level 2 demonstrated a 7 percentage point increase in the employment rate of the basic skills learner population after learning. The authors also found evidence suggesting that learners can access better quality work, resulting in increased job satisfaction, pay and security.

Personal and social outcomes

Apart from labour and skills related outcomes, research has shown that participation in basic skills learning can result in a range of positive personal outcomes. Stevenson et al. (2021) found evidence showing that such learning can lead to improved self-esteem, well-being, and more confidence to complete tasks.

Kersh et al. (2012) indicated that Skills for Life provisions at the workplace is often associated with a range of outcomes and skills that can be used both within the workplace but also in broader settings and life situations. According to more than 50% of the managers who participated in the research, the most important outcome of the training course was increased staff confidence, while such positive experiences and outcomes may contrast with previous negative formal learning experiences. In line with Kersh et al. (2012), Newton et al. (2006) found evidence, albeit limited, suggesting that that learners gain confidence as a result of LLNIT development and that the applied nature of LLNIT work-based programmes enables participants to quickly understand and recognise the outcomes, benefits and utility of attending such courses and developing their skills.

Starks & Wilson (2013) conducted an interim evaluation of the Essential Skills in the Workplace (ESiW) programme in Wales. The interim outcomes of the programme were explored through a survey of 107 employers and 212 learners combined with data collected by the Welsh Government. According to employers who participated in the sample, employee skills and confidence were improved together with better

communication, improved customer service skills and reduced sick leave. Additionally, half of the employers reported improved productivity and public image. The vast majority of the employers mentioned that the learning provided was made relevant to the workplace and/or job responsibilities, while a third of employers had further invested in skills development by providing further essential skills training. The learners were also satisfied with the programme and reported that it was useful for improving their skills both at work and at home, while they also reported feeling more confidence and more willingness and enthusiasm to learn and take on more responsibility at work, improved job satisfaction (for more than half of learners) and greater potential for increased salary (just under half of respondents). When extrapolating the results of this report, it should be taken into account that the evaluation of the programme was interim and that only 44% of the learners had qualifications below Level 2. Consequently, while the programme targeted basic skills and is relevant to this research, the population who attended ESiW programmes may have different outcomes than the targeted population of the Multiply programme.

Community-based learning

Community-based learning is a teaching and learning approach that combines instruction with intense community engagement to foster skills, cohesion, and active citizenship. (UIL 2017). Community settings have the potential to smooth the barriers to entry to adult education. Voluntary and community groups can improve identification and recruitment of adults in need of additional training, learners can feel more comfortable in familiar and non-classroom settings and distance and transportation costs are likely to be lower in community settings (Bates and Aston, 2004).

Outcomes and benefits of community-based learning

The Learner Study project studied retention, achievement and progression rates among basic skill learners in the Skills for Life campaign in England. Using learner records, in-depth interviews, and focus groups, Warner et al. (2008) found that community learning settings were good at motivating attendance given their ease of access and convenience. This was particularly the case for older learners, learners with low confidence, and learners with learning difficulties and disabilities. The interviews conducted by Warner et al. (2008) in England found that provision within learners' communities or near their homes was highly valued by them.

According to CRG Research (2002), providing a range of learning settings supports a community-wide approach to engage hard-to-reach learners, for example by combining community-based and voluntary-sector providers with established further education provision. Additionally, a study of community provision in the review by Learning and

Work Institute (2019) found that embedding basic skills training within community-focused provision resulted in higher learner retention.[26]

Embedding basic skills training in community-learning settings also facilitates the development of vertical and horizontal progression pathways for learners (CRG Research, 2002). Hodgson et al. (2007) analysed eight sites of Adult Community Learning (ACL) by interviewing 59 professionals and 92 learners. One manager of an ACL centre in this study suggested that adults learning basic skills could enter classes of vocational, technical, or general programmes because these were taking place within the same facilities. Additionally, basic skills tutors could support adults in vocational programmes who might not have accessed specific numeracy training. Learners also benefited from being in a centre that had a strong understanding of their learner base, and working actively and collaboratively with the community (Hodgson et al., 2007). A case study conducted in New Zealand suggested that community learning models can be cost-effective, as they use existing physical infrastructure and can invest in individual support (Neal and Seelig, 2013).

Success factors

In community provision, enabling learners to develop supportive relationships with peers and tutors is a successful enhancer of persistence. The review by the Learning and Work Institute (2019) found that tutors could develop informal, relaxed, and supportive atmospheres. According to the report, tutors should get to know learners and their needs and establish productive relationships of trust. One-on-one support from a trusted advisor was a crucial element to encourage active engagement (Learning and Work Institute, 2019). A case study of a programme in New Zealand providing literacy and numeracy training to adult learners in collaboration with community organisations showed that self-paced materials and autonomous learning can free up coaches and allow them to focus their time on motivating learners and providing feedback (Neal and Seelig, 2013).

More generally, friendly and welcoming staff and opportunities for both formal and drop-in provision seem to be key to social inclusion in ACL settings, with staff including local community members and people with experience of being learners themselves (Hodgson et al., 2007). Community ties and informal events can also improve engagement if used as recruitment strategies. For instance, the Literacy Alberni Society (LAS), an organisation focused on free adult education programmes, hosts regular social events to get to know people within the community. These activities increase brand recognition, raise awareness about basic skills needs, and attract potential learners or volunteers. In

[26] Community-focused provision is defined as a form of provision that recognises the community identity of learners, the affinities within their community, the advantages of providing group experiences and the need for sustained input over a period of years. Hannon et al. (2003). Community-focused provision in adult literacy, numeracy and language: an exploratory study. https://www.researchgate.net/publication/265183919_Community-focused_provision_in_adult_literacy_numeracy_and_language_an_exploratory_study

these events, LAS invites the wider community as well as families and partners of learners. (UIL, 2017g).

It is important for community-based learning to focus on the needs of the specific learners and community. In Pember (2019), while information was collected mostly on learners' performance, the practitioners' action was driven by their assessment of students' welfare. Practitioners used the data collected to identify where performance could be improved, but they devoted most of their time to making sure learners felt safe and were progressing (Pember, 2019).

In the most vibrant sites of adult community learning, community and voluntary groups have a strong understanding of potential learners and they are flexible to react and respond to changing needs. For instance, Hodgson et al. (2007) interviewed teachers across eight sites of adult community learning in England and found that in an area of high unemployment, community workers supplemented the local Skills for Life campaign with targeted support to job seekers. Workers in one of the community settings reacted to news about factory closures by sending information on basic skills courses to those at risk of losing their employment (Hodgson et al., 2007).

The report by Yasukawa et al. (2020) suggested that a national network should mobilise action at the local level and facilitate connections between providers and public services, schools, and libraries to meet the needs of the community. Similarly, the UNESCO Institute for Lifelong Learning declared that literate communities are made of independent, confident, and effective lifelong learners (UIL, 2017a). For this reason, country strategies should strengthen access points for literacy engagement, such as libraries, cafes, and community centres (UIL, 2017a).

Case studies and interviews conducted by Pember (2019) outlined some of the success factors of adult education in community settings, including the combination of different services under one model of provision. For instance, a hub-wise model, comprising health and wellbeing services and arts and maths courses, was successful as residents became confident to engage with new services. Additionally, coaches and mentors supported learners to find progression pathways to education, employment, volunteering, or life satisfaction.

The research by Pember (2019) also addressed the importance of local leadership's focus on the needs of their community. Interviews and case studies suggested that adult education responds better to community needs if local leaders are elected and genuinely involved in governance of adult education institutions. The case studies also suggested that community settings undertake several levels of scrutiny (own advisory boards, local authorities, and democratic scrutiny by local councillors and peers), which results in service plans being in line with local needs. Local councils and councillors are able to ensure that ACE provision is informed by local needs, labour markets, and national policies (Local Government Association, 2020).

A key factor for the success of community programmes is their funding. According to managers in ALC settings, if planning is short-term and uncoordinated, resources could be wasted. Hence, community learning planning needs to be long-term, locally coordinated, and collaborative, with a focus on sustainability and capacity-building for the future (Hodgson et al., 2007).

Another key element of a programme is whether it is linked to formal accreditation. According to ACL providers, there needs to be a recognition of community non-accredited training. Adults learning basic skills usually take time to develop self-confidence and skills. Accredited courses follow structured curricula within institutional constraints, and thus learners often need external support from non-accredited courses to get through (Dymock, 2007). Case studies from Australia found that individuals who pursue unaccredited learning in community settings first are more likely to succeed when they progress to accredited provision (Plant and Stevenson, 2022). However, a review of evidence conducted by Dymock & Billett (2008) suggested that non-accredited learning is not only a pathway into accredited courses, but also a means for "building confidence, resilience and self-worth, enabling learners to make connections with family and the wider community".

Finally, people in some geographic areas might face specific challenges to engaging with basic skills provision. For instance, learners in rural areas are often disadvantaged, because their needs are overlooked in favour of urban areas. Access and transportation costs, as well as a lack of childcare services, are usually aggravated in rural communities. Additionally, people accessing basic skills training might feel intimidated or might be uncomfortable as they feel too visible in small communities (Atkin, 2010). Lastly, supply-side elements can undermine the quality of basic skills education. For instance, qualified tutors are not always available in rural areas (Atkin, 2010).

The Learn Local campaign in Australia is currently trialling a hub and spoke model[27] to provide services to sparsely populated areas. Local, community, and voluntary organisations, which are already established, are used to reach small numbers of potential learners. The role of the central authority is only to produce pre-accredited teaching resources and assessment tools, train the workforce, and map progression pathways (Plant and Stevenson, 2022). In Mexico, the Education Model for Life and Work (MEVyT in Spanish) provided flexible opportunities for adults who missed formal schooling. Authorities equipped 3,500 community settings with ICT and library facilities, and also invested in several mobile community learning units – buses with computers, connection, videos, and television sets (UIL, 2017d). The success of both these programmes suggests that productive and cost-effective programmes that reach rural

[27] A distribution method in which a centralized "hub" exists. Everything either originates in the hub or is sent to the hub for distribution to consumers. From the hub, goods travel outward to smaller locations for further processing and distribution.

and isolated learners can be achieved through flexibility and collaboration with existing community structures.

Family learning

As discussed in the section on Engagement, an important situational barrier to learning is the time available for adults with significant personal commitments, such as being a parent or a carer. An alternative delivery model to adult learning that can support parents in overcoming time and resource challenges is the provision of family learning programmes including basic skills training. This section discusses evidence on family learning programmes and their outcomes.

The evidence review by Wilkin et al. (2010) presented several insights on the impact of basic skills family learning programmes on the participants and their families. 'Family learning' was defined by the authors as learning programmes including children and older members of the family, particularly, but not exclusively, parents. Participants were found to receive various significant benefits in three main areas: strengthened family roles and relationships, greater engagement with learning in the home, and improved living conditions in the household. The first category of benefits included improvements in disciplining skills resulting in greater confidence in parenting and a "more supportive home environment". The second category of benefits included increased time spent by parents reading to their children, an increased number of books for adults and children in the household, and increased use of libraries. The third category of benefits included improved budgeting and financial management of households, increased income levels, and increased support received, such as subsidies and other benefits.

Wilkin et al. (2010) also mentioned specific benefits for the children of participating families such as: (i) improvements in children's literacy and numeracy skills, (ii) improved academic development more generally (e.g. attitude towards and attendance at school), (iii) advances in other aspects of child development (such as motor skills and cognitive growth), and (iv) improvements in social and interpersonal skills. In addition, Barnes et al. (2003) found that common activities among parents and their children could have beneficial outcomes. During the residential course, mothers played games using shapes, numbers, and colours, and undertook a map reading exercise on a visit to the zoo. These exercises appeared to foster cooperative working and personal development of the participants, especially the trip to the zoo, which allowed numeracy and map reading to be incorporated into a "fun" setting, helping to facilitate family learning.

The literature reviewed by Ginsburg et al. (2008) found that many parents commented that their children were introducing them to new mathematical ideas and procedures. Even though a few parents expressed feelings of frustration or even shame due to their knowledge limitations, most parents did not report feeling embarrassed or denigrated before their children by asking them to explain mathematical tasks. They acknowledged that if they were to be most helpful to their children, getting help from them was

sometimes required. Along with that, parents were quite comfortable with the idea of learning maths with their children. Finally, parents also sometimes realised that the mathematics skills acquired for, or thanks to, their children could be useful to them beyond being able to help them with homework.

The National Centre for Vocational Education Research (2010) presented a set of good practice guidelines for adult learning programmes and pointed out the importance of learners' existing networks. It was recommended to not only allow family members and friends to be part of the courses (e.g. by attending celebratory events), but also to set up teaching in a way that would offer them the opportunity to actively participate in courses (e.g. concurrent companion courses for children so that families can learn alongside each other).

UNESCO case studies provide examples of how family learning can benefit participants, including specific populations of learners. Firstly, the Prison Family Learning Programme (PFLP) in the UK (UIL, 2012a) is an intergenerational and in-prison non-formal family learning programme primarily targeting imprisoned mothers and their children. Its main objectives are to teach the participants basic skills (i.e. numeracy, reading, and writing skills), good parenting practices, and how to support their children's educational development. Its approach has been to enable parents and children to interact and learn together through games, art, and other creative activities. Evaluations of the PFLP have concluded that apart from significantly strengthening family bonds, the programme has equipped participants with crucial social skills, facilitating the prevention of re-engaging in criminal activities and promoting the successful reintegration of mothers into their families.

Another example of a family learning programme is the Mother Child Education Foundation in Turkey. The programme has been running Family Literacy Programmes (FLPs) targeting adults' and young children's skills (UIL, 2015b). These programmes have been focused on families from poor and marginalised areas. The classes included early childhood education and adult basic skills components with practical elements as well as women's rights and parental support components. Evaluation studies found that it has been instrumental in combatting illiteracy, especially among young women, and increasing women's participation in decisions and in the development of their families and communities.

Students and Parents in Cooperative Education (SPICE) was an American family learning programme specifically targeting families at risk of exclusion from education such as teenage-parents or families with children with SEND (UIL, 2019b). They used a comprehensive case management model where basic skills training was tailored to each family's needs. Teaching methods utilised both online platforms and in-person instruction within the home. Parents benefitted from the home-based component of the programme, as they could more easily integrate basic skills into their day-to-day lives.

Parents as Literacy Supporters in Immigrant Communities (IPALS) was a Canadian programme where recent immigrants received preparation for their children's entry into Canadian schooling system (UIL, 2021). They received basic skills classes and were given opportunities to build a social network in their community. The programme was found to be successful because it was culturally tailored to the participants (including providing instructions in multiple languages) and families were consulted on the time and place of the programme and topics that should be covered. Also, it was found that families benefited greatly from the connections made with other families in the programme.

The UNESCO case study of the Clare Family Learning programme in Ireland found various benefits of family learning for engagement, completion, and attainment outcomes (UIL, 2015c). A key finding from this case study was that family learning can be successful in engaging hard-to-reach parents. Additionally, most parents who completed a family learning class continued onto other learning opportunities. Furthermore, the case study found that the element of fun was important to participants. Parents enjoyed completing a task or making something with their children because there was a sense of achievement and completion in it. Many vulnerable parents did not have the experience of playing with their own parents and might need help with passing this skill on to their children.

In its report that summarised case studies, interviews, and discussions around adult basic skills, the University of Exeter (2002) discussed ways that family learning could be supported. It was mentioned that the integration of basic skills within other areas of participants' interest could work effectively, especially in settings such as family learning. Similar insights regarding family learning settings came from the Learning and Work Institute (2019) report. According to its findings, family learning appeared to work best when it was embedded as part of a wider learning programme.

Additionally, the University of Exeter (2002) report pointed out the potential of information and communications technologies to act as a hook for learners with basic skills needs in both workplace and family settings, and it was suggested that this area should be further investigated. It was also mentioned that the contexts of adult, community, family, and workplace learning should be distinguished and separately supported due to the different requirements they present.

Teaching practice

This section discusses the evidence relating to teaching practice in general, rather than to any particular delivery channel. It includes a short discussion of some theoretical approaches that are prominent in the literature and goes on to discuss the specific case of embedded numeracy and some specific principles around teaching and course design. It concludes with a section on assessment of skill levels, monitoring of progress and approaches to feedback.

In total, 98 studies in our review were found to be relevant for teaching practice. Of these, we found 11 studies that covered practice for embedding adult numeracy skills training in other courses. 36 studies focused on the role of teachers in the classroom and teacher qualifications and training. 41 studies focused on the design and characteristics of adult numeracy courses, while 28 contained material relevant to assessment, monitoring and feedback for adult learners. Most of the evidence is based on case studies and observational data, but there are some areas where national initiatives such as Skills for Life programmes in the UK have permitted evidence gathering from larger samples of courses covering more learners. There are a few small-scale experimental studies into the use of specific teaching practices, but these are in the minority. The key gaps identified in the literature were related to home learning, practice between sessions, and dual classroom teaching.

Fundamentals of teaching practice

There are several theoretical frameworks that can underpin course design and teaching practice in adult numeracy education. One prominent approach in the literature is to define the practice of teaching adults – or andragogy – as distinct from the teaching of children (Westwood, 2021). Adults are conceptualised as more self-directed, more focused on the relevance of what they are learning to their lives, and as having more life experience from which to build learning activities (Bates, 2017; Westwood, 2021).

Many of the same implications emerge from an approach based on person-centred principles that consider the cognitive preparedness, psychosocial characteristics, and motivations of learners (Gal et al., 2020) as a basis for designing teaching and learning activities.

A social practice approach conceptualises adult numeracy as basic maths skills applied in daily life (Hillier, 2007; Derbyshire et al., 2009). This approach recognises basic skills as diverse and complex social practices, instead of mechanical, functional skills used to decode academic problems (Maclachlan & Tett, 2006). Adult learning of basic skills can take place in three settings: (i) formal learning environments, in which it is the focus of the activity, (ii) non-formal learning environments, in which it is embedded in other activities, such as workplace or vocational training, and (iii) informal contexts, in which learning happens in a non-intentional and experiential manner in everyday life.

Numeracy skills learnt in class are not always easily transferred to daily practice, even if there are attempts to use real-world contexts (Oughton, 2007). "*Practice engagement posits that individuals' literacy proficiencies develop as a by-product of their engagement in everyday reading and writing practices and, reciprocally, that literacy proficiencies affect levels of engagement in reading and writing practices*" (Reder et al., 2020). Expanding from this definition to broader basic skills suggests that proficiency in basic skills benefits from informal everyday literacy and numeracy practices, while people's basic skills also affect their level of engagement in these activities. For instance, following

a sample of German adults in the PIAAC, Reder et al. (2020) observed that people with higher numeracy skills engaged more often in daily numerate behaviours. Therefore, a holistic view of adult numeracy should consider gaps in opportunities to access adequate learning opportunities and to practise outside of formal learning environments (Gal et al., 2020).

However, Ackland (2014) argues that the traditional social practice approach can miss some critical elements which are not strictly functional. For instance, it may be valuable for numeracy education to cover the role of large numbers in public discourse: posing the question of how big a billion is could lead learners to engage in investigation about economy-wide developments.

Embedded numeracy

Embedding numeracy means explicitly teaching numeracy skills within other subjects, courses, or training settings. This approach links basic skills to a broad curriculum or learning objectives, usually related to personal or professional life and development (Beadle et al., 2015).

Embedding numeracy into vocational or practical learning overcomes barriers to engaging in education and reduces stigma attached to attending a basic skills course, as it is publicly presented alongside other activities, such as health and safety, or internal workplace processes (Bates and Aston, 2004; Learning and Work Institute, 2020). For instance, the research review conducted by Carpentieri (2014) found that embedding basic skills education into vocational and workplace programmes can reach individuals who might not access standalone basic skills programmes. It might be a particularly promising approach for adults with unpleasant memories of school (Musset, 2015). These programmes also facilitate engagement with employers, as they can be work-specific, and encourage people to take up learning with practical outcomes (Bates and Aston, 2004; Carpentieri, 2014).

Integrating basic skills with vocational learning increases learners' perceptions of the relevance of basic skills (Learning and Work Institute, 2019). Interview-based case studies cited by the National Centre for Vocational Education Research (2011) reported that students who acquired new professional identities through vocational work also increased their receptiveness to learning numeracy skills. According to a review of basic skills education, embedding reality-based numeracy within vocational courses – for instance, numeracy for nurses, or maths for the electrical trades – increased adults' motivation (Westwood, 2021). However, this requires specific effort to determine the numeracy needs associated with areas and sectors of employment (Westwood, 2021).

Casey et al. (2006) followed a sample of adult learners of Literacy, Language, and Numeracy (LLN) in further education colleges in England. Learners in embedded courses had higher retention and completion rates. 93% of learners with numeracy needs on fully embedded courses, where numeracy skills were taught as part of the vocational training,

achieved an Entry Level or Level 1 numeracy/maths qualification, while only 70% did in non-embedded courses where numeracy training and vocational training were entirely, or almost entirely, separate. The benefits from embedded learning spilled over into the main field of vocational training. Adults in embedded learning also reported higher satisfaction levels and felt more prepared for work than those who undertook separate provision (Casey et al., 2006).

However, research suggests that the links between numeracy skills and the development of other skills through formal training need to be made explicit. One way of doing so is ensuring that numeracy and vocational educators work together as a team so that their combined expertise informs the final learning experience (Neal and Seelig, 2013). To successfully embed numeracy practice with vocational training, work must be shared among specialists instead of giving one teacher responsibility for both vocational and basic skills content (Casey et al., 2006). The main success factors of embedded numeracy learning in the literature review conducted by Beadle et al. (2015) related to formal shared planning between numeracy and vocational training staff. Time must be allocated for this shared planning, allowing specialists to successfully integrate basic skills into vocational training.

Front-end delivery is one model of integrating basic skills training into apprenticeships and vocational education. Here, basic skills training, including numeracy, is concentrated at the beginning of apprenticeships programmes. According to Cranmer et al. (2004), interviews with teachers and learners showed that these models had led to increased prioritisation of numeracy learning. Programmes also offered early opportunities to test skills level, which was motivational for the rest of the course if students achieved early success (Cranmer et al., 2004).

Finally, a programme evaluation in New Zealand found that self-paced learning materials improved the outcomes of learners in embedded numeracy courses (Neal and Seelig, 2013). This programme included four courses (personal strengths and goals, financial management, health and wellbeing, and career development) with embedded literacy and numeracy. Materials were designed for self-managed learning and learners used self-reflective journals to monitor their personal and academic experiences. Coaches provided one-to-one mentoring opportunities to support those who faced additional challenges with numeracy and literacy. According to Neal and Seelig (2013), another important contributor to the success of the programme was the inclusion of images within the materials and the use of appropriate vocabulary to maintain learners' interest throughout the course.

Teachers' practice, qualifications, and training

Teachers are central to learner outcomes in adult numeracy. Effective practice requires skilled teachers with deep subject knowledge. Effective instruction requires teachers to be able to anticipate difficulties, plan content, and enhance motivation and understanding

among learners (Westwood, 2021). There was generally strong evidence around teachers' practice, qualifications, and training, with several literature reviews and one randomised control trial. The literature identified on teacher training was limited and relied heavily on case studies.

Approaches to teaching

A review of RCTs in adult literacy and numeracy programmes found that, among the experimental research since 1980, only 6 studies had found significant positive outcomes in educational attainment (Torgerson et al., 2004). In successful interventions, teachers often used modified comprehension learning strategies, avoiding conventional methods of teaching on a board (Learning and Work Institute, 2019).

Observation of numeracy courses suggested that teaching is less effective when it consists solely of lecturing. Instead, encouraging learning by doing and solving problems in contexts that are meaningful to learners allows learners to put the skills they have learned into practice (Roberts et al., 2005). These case studies, studied in England by Roberts et al. (2005), suggested that extra help with computational processes is much more useful to learners when they are engaged in a task than after completion. According to the authors, the gap between the learners' existing knowledge and carrying out the task might only become apparent to both teachers and learners as they conduct the activities.

According to the review conducted by MacLeod and Straw (2010), small-scale studies in the United States suggested that teachers should approach numeracy through multiple intelligences (MI) lenses.[28] In these studies, which were also reported by Torgerson et al. (2004) and Coben et al. (2003), 10 teacher-participants reflected about MI theory to inform instruction. Teachers realised that the MI theory encouraged them to use more open-ended assignments. According to these participants, the most engaging lessons included team-building exercises and real-life problems to display their strengths.

One of the strongest findings in the literature on adult basic skills education is that reciprocal teaching has positive effects in reading comprehension (Torgerson et al., 2004; MacLeod and Straw, 2010; Lord et al., 2010; Learning and Work Institute, 2019). This method consists of teacher and students taking turns to lead a dialogue on an idea or section of a text. Initially the teacher is expected to model the activities of summarising ideas, questioning understanding, and clarifying. This approach has two main functions: monitoring progress and fostering comprehension. Learners are expected and encouraged to take over the teacher's role as they gain confidence (Torgerson et al., 2004). There is no comparable evidence base for numeracy education, but the findings from literacy skills courses may be more broadly applicable.

[28] The theory of multiple intelligences proposes the differentiation of human intelligence into specific modalities, rather than defining it as a single ability. These intelligences include bodily-kinesthetics, interpersonal, verbal-linguistic, logical-mathematical, intrapersonal, visual-spatial, and musical intelligence.

Sometimes, it is easier for teachers to take over and set out correct approaches without giving adequate chance for learners' self-reflection. Swain and Swan (2009) observed 24 teachers from 12 adult education providers in England. When this happened, learners were unable to follow rationale, and were disengaged from the subject. Instead, when teachers consistently used probing questions to assess what learners knew, learners became less passive and dependent on the teachers. In the best cases, teachers exposed learners' misconceptions, which led a to a vivid cognitive surprise and furthered learning (Swain and Swan, 2009).

Effective attainment can also be achieved with adequate scaffolding of learning. This ensures that learners are placed in the correct programme, have an adequate level of challenge, and are working towards a personal goal to keep them engaged (Carpentieri, 2014). Derbyshire et al. (2009) suggested scaffolding to support learners in tasks that are slightly more difficult than they can manage on their own. This proposal was part of a curriculum development model published by the National Adult Literacy Agency in Ireland and includes the gradual removal of support systems as learners progress (Derbyshire et al., 2009).

McDonald (2013) assessed whether a step-by-step teaching (SBST) approach improved learner outcomes. In SBST, a learner must demonstrate understanding of material before moving on to new content. The goal is to support the learners' incremental progress to the desired level of proficiency. Following a sample of 35 learners (aged 18 to 50 years old), the evaluation found that, in groups where teachers used SBST, learners improved their attitudes and attainment. However, this was conditional on their initial view about the teaching method. Students who found the method childish and inappropriate did not improve their performance or attitudes towards learning.

Mental Number Line Training is a numeracy teaching practice that asks learners to solve a computational task using a number line.[29] Sobkow et al. (2019) compared the performance of Polish learners who undertook a Mental Number Line Training with learners who undertook standard arithmetic training. There were no significant differences across groups, but both trainings improved objective and subjective numeracy scores as well as numerate behaviour (Sobkow et al., 2019).

Multiple practitioners

A review conducted by McIntosh (2004) found that institutions where basic skills teachers were supported by teaching assistants showed greater improvements in learners' attainment. In general, learners benefit from teachers having additional support, whether it is from regular volunteers or assistants in the classroom (Learning and Work Institute, 2019).

[29] A number line is a line on which numbers are marked at intervals and it is used to illustrate simple numerical operations.

An Ofsted report investigated the role of learning support tutors in 29 colleges across the UK. Their role was to work closely with subject teachers to make sure numeracy was contextualised and relevant to the substantive courses. Successful tutors focused their support on numeracy and transferable skills, rather than training-to-the-test. In-class support was less effective if tutors were focused narrowly on the tasks at hand or had assisting roles such as handing out worksheets rather than being directly involved in the planning of the lesson or encouraging the student to find the correct answer themselves (Ofsted, 2007).

From a social capital approach[30], engaging with multiple teachers, or collaborative delivery of content, can help develop new ties. For instance, by learning with a range of teachers, staff, or experts, learners can meet new professionals and observe interaction across sectors and practitioners (National Centre for Vocational Education Research, 2010).

Teachers' qualifications and training

A review of literature and cross-country comparison across the OECD found that often teachers do not have specific training for adult education (Windisch, 2015). They may therefore struggle to design and deliver courses targeted at adults. Vorhaus et al. (2011) conducted a literature review to inform government provision. According to their findings, teachers need both good generic teaching skills and field-specific understanding of the topic. This matters because teachers have an impact on the outcomes of those they teach. In England, following random samples of 84 adult education teachers and 237 of their learners, Cara and de Coulon (2008, 2009) looked at adults' skills before and after undertaking numeracy courses. The study found that teachers' qualifications in maths had a significant effect on learner attainment: learners made more progress with teachers holding at least an A-level in maths compared to a GCSE equivalent or below. Teacher experience also had significant effects on their pupils' attainment (Bos et al., 2002; Cara & de Coulon, 2008). One potential reason for this, indicated by interviews with learners in Ireland between 2006 and 2007, is that less experienced tutors tended to rely more on purely scripted classes, which might not fit the diversity of needs, background, and interests in the class (McCaffery, 2009).

The report by Fenech et al. (2018) on workplace learning found that the lack of specialisation of teachers led to them playing many different roles, such as networkers, guides, pedagogues and motivators. This, in turn, demotivated skilled education professionals from choosing work-based basic skills training as a career. The authors suggested that teachers and trainers should thus have specific training and clearly

[30] By social capital approach the authors refer to the ways in which networks are drawn or created during a numeracy programme. Hence, this approach will emphasise connecting learners to teachers, other learners, institutions, systems, and other networks (National Centre for Vocational Education Research, 2010).

designated classroom specialisation, as well as a clear understanding of what workplace training entails in the specific context.

Training for teachers of adult numeracy

There is a large literature on the most effective way of training teachers to teach adults, and to teach adult numeracy specifically. In most cases, these studies do not track the impact of teacher training on subsequent teaching and outcomes for learners. Nevertheless, given the impact teachers can have on student outcomes, this literature helps to identify teacher training practices which might support learner outcomes.

As a tutor and course leader, Gibney (2014) observed that teachers can exhibit mechanistic and unreflective teaching practices. For instance, case studies conducted by Brooks (2014) found that teachers often taught in a way that would support their own style of learning – meaning that their own mathematics learning experience influences their beliefs about teaching methods.

In a survey of newly qualified teachers in the U.S., many teachers reported that their primary focus when teaching was on calculation or computation skills. Teachers recognised the limitations of over-relying on computational skills, and the importance of other instructional practices – providing real life context or the language aspects of maths problems. However, practitioners indicated that computational skills were what they mastered and were familiar with (Ginsburg, 2016).

Loo (2007) used questionnaires with prospective adult numeracy teachers in England and found that they recognised the need to join up subject specific knowledge with generic teaching standards. The report conducted by Hudson (2006) suggested that teacher training should include subject knowledge, subject-specific pedagogies, and general pedagogic skills. Mallows et al. (2013) reviewed the challenges across Europe and reached a similar conclusion. They argued that teachers of adults should consciously avoid replicating school practice – in fact, they should be better prepared to teach in less formal arenas than a traditional classroom (Mallows et al., 2013). Finally, in Australia, despite basic skills programmes achieving considerable success in the late 1990s, the report by Coben (2006) found that there was still a need to build capacity among educators to apply new methods, topics, and delivery modes into their existing skillset.

There is evidence from a range of sources that training teachers in specific techniques and methods can be effective in giving them the skills they need to teach adults effectively. For instance, the use of questioning is a standard technique in teaching, but in the case study by Griffiths (2006) this was extended to the use of open questions to engage adults in maths problems. However, the key factor is to make explicit what basic skills are being targeted (Falk et al., 2002). According to this literature review conducted on behalf of the Adult Literacy and Numeracy Australian Research Consortium, literacy and numeracy will not be taken seriously by adult educators if they appear to be an afterthought in their training.

Teacher training activities based on collaborative methods among teachers were effective in the UK. In fact, even if their usage of the teaching toolkit was limited in class, teachers used it as a source of ideas and inspiration (Kirby and Sellers, 2006). In this example, by the end of the training programme, teachers took greater consideration of pupils' self-confidence, they saw assessment, objectives, and lesson planning linked to learning practice, and they were greater supporters of collaborative learning in problem-solving (Kirby and Sellers, 2006).

A randomised controlled trial in England studied the impact of Neurolinguistic Programming (NLP) training in combination with innovative maths pedagogy, with a sample of 24 teachers and 173 adult numeracy learners. NLP training consisted of learning to support emotional management among pupils, as well as learning to use influential language to promote engagement, motivation, and attainment. Maths pedagogy included training teachers to apply higher-order questioning[31], effective problem-solving, and collaborative teaching-and-learning techniques (Allan et al., 2012). After pre- and post-treatment testing, the authors found that learners' scores improved three times more when their teachers had undertaken both NLP and pedagogy training, than in the control group where teachers received no training at all. Test scores were also better if teachers had only taken pedagogy courses, but results were less significant under different specifications.

Similarly, the Teachers Investigating Adult Numeracy (TIAN) project engaged adult education teachers about how to implement effective mathematics instructional practice (Bingman and Schmitt, 2008). The key aim of the teacher development course was for teachers to implement instruction that (i) focused on problem-solving, (ii) involved students, using communication to consolidate mathematical thinking, and (iii) provided opportunities to connect mathematics to their lives. Questionnaire responses after the course found that undertaking this professional development course made teachers keener on using problem-solving and exploratory methods. After the course, observations found no significant changes in students leading discussions in class, however, they found an increase in teachers encouraging students to communicate maths using various media, and in opportunities for group work (Bingman and Schmitt, 2008).

After reviewing two decades of workplace basic skills training in the USA, Jurmo (2020) concluded that those developing and delivering curricula need to be creative to engage with learners. Diverse academic backgrounds in anthropology and understanding the cultures of programme participants and their employment can be valuable for instructors and people in charge of adult education (Jurmo, 2020).

An action enquiry is a process of transformational learning that individuals and organisations use to reflect upon their own pedagogical practice and generate new

[31] Questions that require answers that go beyond simple and direct information. They take learners into abstract thinking, justifying opinions, and hypothesising.

insights. This process can drive incremental changes and risk assessments, and it can promote action in timely manner. McKim and Wright (2012) piloted an action enquiry project among vocational educators in New Zealand. The authors found that encouraging teachers to reflect on their practices both independently and with peers gave teachers more confidence in their work.

Course characteristics

Throughout the review, this report has discussed the importance of approaching adult education as distinct from school learning. However, adult learners themselves might bring a wide range of backgrounds and experiences. There is no “one-size fits all” solution, but flexible strategies can support effective approaches to adult education. Successful solutions display and discuss contents relevant to different life or workplace situations, and they can make use of different venues and teaching methods (in-class, fieldwork, or visiting experiences) to match different needs, and engage learner groups (Learning and Work Institute, 2019).

Content and personalised learning

One of the key recommendations from the literature is that numeracy training for adults should be contextualised with everyday examples (Hillier, 2007). Course activities and materials, such as handouts, must be appropriate for adults – not recycled materials for school-age children – and organised in a way that allow self-study (McIntosh, 2004).

The literature reviews on policy interventions by Windisch (2016, 2015) showed several cases in which adults learned better in authentic activities rather than in simulated situations. For instance, price comparisons were considerably more accurate in a shopping activity than when doing identical calculations on a paper-and-pencil test in the classroom (Windisch, 2015). For this reason, mathematical and numeracy practice should be presented in a context in which it takes place, but also build on the knowledge learners already have Geraci (2012). The use of authentic materials, derived from learners’ everyday activities, is linked to positive attainment, and learners also become more likely to report a change in their out-of-class daily practice.

Civil et al. (2020) reviewed an intervention with immigrant mothers in the US. Conducting basic arithmetic tasks offered them the opportunity to work on foundational skills that their children were learning in school. In problem-solving tasks, complex computations were applied to daily situations to show learners their existing knowledge and build upon it. These activities were making popcorn for a school cinema event and cooking *tamales* for a group of friends. In these activities they could rely on their intuition and experiences to sense-check the mathematical approach. For instance, in the tamales task, they could estimate how much dough they needed (Civil et al., 2020).

On a similar note, McIntosh (2004) and FitzSimons and Coben (2009) found that discussion of real-world topics maintained high interest and expectations among

learners, and it improved the effectiveness of basic skills teaching. In interviews with adult learners in the USA, Jameson (2020) found that they felt anxious about learning maths if they perceived large differences between academic and everyday maths skills. For this reason, they argued, adult learners should be encouraged to transfer their real-world experience to the classroom. Students have better perceptions of courses if they can build on prior knowledge or experiences. Familiarity with the resources being used makes them particularly receptive (Jameson, 2020). In Colombia, the ESPERE programme teaches literacy and numeracy skills alongside emotional and communicative competencies. Facilitators make use of topics of social relevance to introduce numeracy teaching. This programme achieved 95% of students passing tests to the first cycle, and 89% to the second cycle (UIL, 2019a).

However, finding relevant contextual elements to teach numeracy is not always straightforward. Brooks (2015) conducted two case studies in adult numeracy education. In one of the groups, learners had a wide range of distinct backgrounds. This made it difficult for teachers to identify contexts that were truly relevant to everyone. However, in the other group the teacher managed to identify common grounds (all learners were mothers of young children), and could develop situated activities based on learners' use of mathematics in real life contexts (Brooks, 2015).

To fit different preferences and backgrounds, teachers can combine group work with personalised content. In these exercises, teachers played a facilitating role, providing resources and activities that differentiated learning experiences. Students explored different topics and areas of interest, and then returned for peer group discussions (Rosen et al., 2020).

Nonetheless, Oughton's (2009) case studies in England showed that students do not always respond to contextualised numeracy problems. In this case, students were presented with a problem that required them to work out fractions and percentages regarding the number of fatal workplace accidents. The results found that students extracted the numerical information they needed to get the right answer without responding to the context, even if numbers were meant to provoke concern.

Interestingly, a case study of adult education in Finland found that not all adults in education settings responded in the same way to content, as they brought different experiences to the class. On one hand, older adults were not familiar with abstract mathematics or problem-solving methods, common in school maths. Instead, they had trained in basic computational methods in their earlier schooling years. But on the other hand, younger adults in vocational programmes might have more problems with basic calculations (Hassi et al., 2010). In a case study in Brazil, research found that appropriate materials encouraged reflection and logical reasoning. However, it was very important to exercise learners' attention and memory, as well as refresh concepts repeatedly (Santos Cade, 2015).

In response to the Forum on The Challenges of Adult Numeracy in the United States, Braaten (2017) suggested that curriculum development should be guided by three questions which summarise many of the findings in the literature on curriculum development.

- Does this meet my students where they are?
- Can they use it now?
- Can they use it again soon?

Class atmosphere

Building healthy and productive relationships between teachers and learners, and among learners, is one of the key success factors in adult education training (MacLeod and Straw, 2010; Neal and Seelig, 2013).

According to HM Inspectorate of Education (2005) tutors of adult literacy and numeracy provision in Scotland were committed to creating warm relationships with learners. Staff showed interest in the wider achievements of their pupils and made use of humour and informal language. This close relationship then enabled lecturers to anticipate the needs of the learners, and they could support those who were reluctant to participate (HM Inspectorate of Education, 2005).

Roberts et al. (2005) reviewed seven cases of educational settings where learning of adult literacy, numeracy, and English for Speakers of Other Languages (ESOL) was embedded into vocational training instead of being taught separately. The development of a healthy relationship with the teacher, who was also a skilled mentor, supported attainment. Ethnographic research and field visits showed that a comfortable social context mitigated leaners' maths anxiety (Roberts et al., 2005).

Interviews with 57 students and 18 teachers across 4 adult education courses in Australia suggested that the relationships learners had with their teachers were the most significant factor affecting their outcomes, and what they valued the most (Balatti et al., 2006, 2007). This was especially true for those who brought previous bad experiences from school. One student said, "*It's like chalk and cheese. You get treated with respect, your opinion is valued, and everyone can make comments*" (Balatti et al., 2007). In the end, changes in student quality of life were a result of combination of human capital (e.g. numeracy skills) and social capital (social network and connections with peers and practitioners) outcomes. The study found that 80% of students interviewed had gained social capital outcomes as a result of their participation in the course (Balatti et al., 2006).

In a review of successful practices, MacLeod and Straw (2010) found that peer networks formed in the classroom helped those with low confidence, increased retainment and achievement, and supported lifelong impact of these courses. However, this role can also be played by voluntary workers from local and community organisations (MacLeod and Straw, 2010).

Classroom agreements[32] about being respectful to each other can shape the perceived warmth and safety of the classroom environment. Based on experiences as an adult numeracy teacher in the USA, Bates (2017) concluded that classroom agreements should be in place to guarantee respect and avoid teasing. The author found that it was useful to get students comfortable demonstrating problem-solving on the board, with the class applauding afterwards to support their peers – even if they did not succeed at the time (Bates, 2017).

The location of learning also impacted outcomes. In residential courses[33] organised by DfES, research found that learner satisfaction was linked to personal benefits, such as having a nice venue and a lunch every day – interconnecting personal growth and competence development (Barnes et al., 2003). According to teachers interviewed by White (2003), outdoor activities were also highly successful, especially in developing self-confidence and other soft outcomes.

The findings in the review by Dymock & Billett (2008) pointed to the development of a 'learning identity' as a key element of engagement in the learning process, as it brings adults into more active, productive, and satisfying lives. For instance, several case studies in the UK found that, in the process of Vocational Education Training, students developing new professional identities through practical work became more receptive to learning literacy and numeracy skills (National Centre for Vocational Education Research, 2011).

Barnes et al. (2003) evaluated several adult skills programmes in England. They found that breaking a class up into small groups was key to enhancing learners' enthusiasm for exercises set in class. In this case, smaller groups supported more individual support and attention, but wider group work was also important to encourage mutual peer-support. Making use of competitive activities also fostered team spirit.

Digital contents and tools

The current digital landscape provides a myriad of opportunities to engage with digital tools within educational settings and environments. Namely:

i) Increased access to internet with smartphones,

ii) Technology to solve problems at work, at home, and daily situations,

iii) Technology to improve and practice basic reading skills,

iv) Technology for broader access to information, and

[32] Classroom agreements, or classroom contracts, are frameworks of behaviour expectations when in class. A set of rules, agreed among learners and the teacher, designed to shape how the classroom operates.
[33] These courses were added-on to existing basic skills courses of a traditional type, offering the learners a two- or three-day away break in a hotel.

v) Technology to shape cultural identities and use local and transnational resources (Rosen and Vanek, 2017).

There was good evidence on the use of digital tools and ICT, but all studies identified were published before 2020. The availability of digital tools and how teachers integrate them may have significantly changed due to the COVID-19 pandemic.

Learning technology can improve progress and achievement. However, the evidence supporting this is mixed, and it depends on the type of provision and teaching methods (Vorhaus et al., 2011). The evaluation of UK adult training programmes conducted by Barnes et al. (2003) found that integrating ICT skills into basic skills training requires additional planning resources. However, students appreciated spreadsheets, databases, and activities designed specifically for their basic skills provision (Barnes et al., 2003). These findings are also aligned with the review of workplace case studies in England. According to adult education project leaders in South West England, ICT was popular with students and could therefore be a hook for engaging adults (University of Exeter, 2002).

In England, 150 students took part in an evaluation phase of ICT-based teaching strategies for literacy numeracy, and ESOL. 80 of them completed both pre- and post-tests after 40 hours of class time. Mellar et al. (2007) found that learners who use ICT for basic skills doubled the value of their time, as they acquired two sets of skills at the same time. Learning seems to be independent, as they found no correlation between ICT skills, confidence scores, and changes in basic skills. However, ICT was a motivating factor, particularly mobile technologies, as they allowed teaching to move outside the classroom (Mellar et al., 2007).

Tutors' self-reporting about the use of ICT in adult numeracy in Scotland suggested that ICT served a specific motivational purpose, given their interactivity and visual stimulation. Pupils became more reflective about numeracy and came up with different ways to interpret figures if displayed visually (Coben et al., 2007). In addition, digital tools permitted flexibility to adapt materials and progression pathways. They supported putting activities into meaningful context (e.g. checking utility bills), and instant responses to, and feedback on, their assessments were appreciated (Coben et al., 2007).

Although tutors suggested that interactivity and flexibility can help those with poor experience of school lessons, they mentioned that it might also undermine personal interaction skills (Coben et al., 2007). Mellar et al. (2004) carried out observational research in classrooms in Further Education Colleges in England. Some of the observed good teachers' practices were the combination of multiple ways of providing information (data projector, handouts), and the opportunities for peer-learning.

There are a number of examples globally of programmes which have used digital tools to support adult skills learning. For example:

- Maths Everywhere, in the UK, is an interactive learning tool, based on a phone application aimed at teaching numeracy skills at adults of all ages. The majority of users are drawn from learning programmes across the country. This app breaks down contents in three modules: (i) tools, which relate numeracy to issues they might encounter, such as splitting up a bill, (ii) theory, which introduces learners to numeracy rules and mathematical theories and (iii) practice, which prompts learners to solve calculation problems, using the rules they saw in the previous module. Motivational pop-up messages and video tutorials are designed to be eye-catching and keep learners motivated and engaged (UIL, 2014).
- The Cell-Ed programme in the US aimed to overcome barriers to access to literacy programmes. It provided free literacy micro-lessons via mobile phone, specifically targeted to immigrants. These micro-lessons had four categories: (i) learn to read, (ii) English on the go, (iii) Citizenship on the go, and (iv) Skills on the go. A randomised control trial, conducted between 2012 and 2014, found that users had improved their literacy and English skills after four months (UIL, 2018b).
- The ICTs in Andragogical Mediation programme in Costa Rica encouraged students to identify problems within their communities, and to consider how skills developed in their ICT courses could generate solutions. Learners were encouraged to research social issues and develop projects, using their mobile phones and resources in the computer lab. The programme was supported by local groups, like churches, NGOs, and community centres, and some of them contributed with facilities and digital equipment. The programme achieved a 95% completion rate (UIL, 2017f).
- In Norway, teachers and prison staff facilitated a numeracy programme for prison inmates over a four-month period. Adult numeracy learners used Microsoft Excel and calculators to improve skills. They were also encouraged to play a computer game in their spare time which made use of newly developed skills (UIL, 2018a).

Finally, IT solutions might also be used to track performance and support teaching and learning. For instance, the Danish Ministry required instructors to document learner progress using a checklist. Instructors in one of the general adult education courses developed an IT solution to track learners' learning portfolios. This tool allowed learners to monitor and assess their progress and access teachers' notes about their performance, as well as to store their best products and their test results (Looney, 2007).

Duration and structure

Adult learners might require more time to brush up on skills than young people in other types of provision. Reviews of policy interventions in England suggest that better gains for learners are associated with courses lasting longer than 100 hours (Vorhaus et al., 2011; Beadle et al., 2015). Breaks from learning should be supported with distance and blended learning to avoid penalising learners for changing life circumstances (Vorhaus et al., 2011).

Bos et al. (2002) reported the results of 11 studies of welfare-to-work programmes in the USA. These studies investigate adult education services provided to a disadvantaged group for whom participation was mandatory. The report found that, in maths courses, skills stopped improving if courses took longer than 6 months. There was no evidence that those who were mandated to participate benefited any less from participation in terms of attainment than those who volunteered.

The optimal distribution of time in terms of teaching and self-study is not clear (Beadle et al., 2015). Very intensive and highly structured courses show that rapid progress can be made with working adults in basic skills training. In England, teachers noted the value of adults learning every day instead of once or twice a week. However, for those who had not been studying for years, long days were difficult to follow (Barnes et al., 2003). Highly intensive courses organised by DfES caused significant learner fatigue and it was a challenge to maintain learners' interest. One out of five learners thought that 60 hours of teaching in a period of no more than four weeks was too intensive. In this study, intensive and highly prescriptive courses did not provide successful outcomes. Participation in new courses after completion was 19 percentage points below traditional courses, meaning that learners on intensive courses did not progress to new learning opportunities. The rate of achieving qualifications on intensive courses was below the average of other pathfinder extension courses (White, 2003).

This report also studied residential courses in pathfinder extension programmes in England. These courses were added on to existing basic skills courses of a traditional nature, offering the learners two or three days away in a hotel. On effort, interest shown, and relationships with peers and teachers, the majority of teachers considered that learners' performance was better relative to traditional courses (White, 2003). These courses also had better outcomes than highly intensive ones on learning continuation, and increased employment rate by 10 points, compared to traditional courses (White, 2003).

Funding arrangements

A small number of papers discussed the broader funding arrangements and structure and provided relevant recommendations.

The report by the University of Exeter (2002) summarised findings and recommendations of various cases studies and previous reports, with some of them addressing funding arrangements. Firstly, according to the report, financial contributions from employers can ensure greater commitment to the learning process and the long-term sustainability of the programmes. Additionally, a combination of employer and government funding should be allocated to the development of the programmes including planning, marketing, consulting, promotional materials, training needs assessment, materials development, employee replacement costs, and evaluation.

The provision of specific funding for individuals with learning difficulties or disabilities was also suggested by the literature reviewed by the University of Exeter (2002), together with the proposal that funding should target those who would not otherwise be offered learning opportunities by their employees. The report discussed that funding methodologies should ensure equality of opportunity and access, as well as improved technology-based resources and equipment in adult learning programmes. Other recommendations included: (i) financial incentives to be provided to firms whose staff takes time off for training, (ii) paid time off for learners, (iii) free learning provision and accreditation for employees with approved providers, and (iv) the provision of information, advice and guidance.

The guidance provided by the National Centre for Vocational Education Research (2010), focused on adult learning programmes in Australia, highlighted the importance of adequate and ongoing funding to the success of such programmes. The authors suggested that effective partnerships among agencies, organisations, and service providers working in adult education develop when funding is available and ongoing, and when those most in need of support can be reached through partnership arrangements. Proper funding was considered so important that even excellent relationships between community members, teachers and learners were deemed meaningless if they were not supported by long-term funding, allocated through a government department, and mediated through the service providers. Moreover, Barnes et al. (2003), within their evaluation of Pathfinder extension activities, highlighted the importance of having ongoing support and funding to facilitate collaboration (among government bodies, Pathfinder agencies, service providers, and other organisations), as well as the need for small grassroots organisations to receive financial support rather than funding being concentrated amongst recognised service providers.

The HM Inspectorate of Education (2005) monitored the progress of adult learning programmes in Scotland and evaluated the effectiveness of the funding streams. The authors observed teaching and learning across local authorities, analysed questionnaires, and conducted interviews with learners and personnel. The evaluation highlighted that although most resources were appropriate and engaging, not all tutors had easy access to the resources because of poor communication and distribution systems. Additionally, the report revealed that most of the programmes delivered through partnerships among different government bodies and organisations did not allocate funding efficiently. Funding through partnerships did not support an agreed development strategy but instead operated through a bidding system through which providers accessed funds for specific programmes. Overall, arrangements for accessing funds from the partnerships were often described as cumbersome and bureaucratic.

The report of the Chartered Institute of Personnel Development (2005) examined the issue of adult basic skills deficiencies in the UK at the time when the report was written and highlighted that low-skilled people in employment had been a priority for funding and support from the UK government. It was also mentioned that even though a few

employers offer basic skills training at their own expense, many organisations benefit from government schemes and subsidies.

Identifying numeracy needs, assessment, and feedback

Early identification of numeracy needs

In adult education programmes, the first thing learners typically do is a diagnostic assessment to inform a tailored learning plan. Initial assessments can be particularly important when learners have a spiky profile – they know some things but have important gaps in fundamental knowledge (FETL (Further Education Trust for Leadership), 2021). However, especially in sensitive settings, care needs to be taken to deliver the assessment in a non-threatening manner (CRG Research, 2002).

Entry assessments support the identification of strengths to build on, and the evidence review conducted by Vorhaus et al. (2011) found that these are more effective where teachers help learners acknowledge their prior knowledge and misconceptions. The review of assessment mechanisms conducted by Dymock & Billett (2008) also found that the processes that worked best were those comprising of a joint activity between learner and tutor. In fact, a network of workshops for basic education in the north of France eliminated entry diagnostic tests, as they could be off-putting for those with bad experiences of school. Instead, they conducted welcoming initial interviews as a first step in their assessment process (Looney, 2007). A group of adult educators in New Zealand found that their initial diagnostic assessments were a challenge for learners who often had not been involved in formal learning for some time and might be “mathematically rusty” in some areas rather than lacking knowledge (Kane et al., 2007). They repeated some elements of the initial diagnostic assessment after two weeks to try to get a more accurate picture of their students’ needs.

Some diagnostic tools also seek to identify learning gaps and their causes. Within a student group, Mann (2022) examined the use of the Four Resources Model (4RM) which breaks learner needs into four critical competencies: (i) breaking the mathematical code, (ii) making a meaning, (iii) critical analysis, and (iv) making effective use of learning. They interviewed young Australian adult students and mapped their learning needs against the elements of the model. According to the author, this can inform an identification of learning needs and curriculum design to address those needs. For instance, teachers could identify gaps in the first step and provide worksheets for learners to break the code of symbols. Teachers could also increase learners’ ability to make a meaning by using familiar examples, or they could gamify active use of mathematics at a later stage (Mann, 2022).

Teachers’ practice to identify difficulties should also consider both vertical and horizontal knowledge of the curriculum, i.e. knowledge of what students learn at different points in time, and what they learn at the same time in different contexts, formal or not (Edwards, 2014). For instance, in their case study research, Swain and Swan (2009) observed how

practitioners began each session by asking the class to describe what they knew about the topic and followed up with responses challenging this understanding (Swain and Swan, 2009).

Assessment, monitoring, and feedback

Monitoring and recognising progress on a regular basis support learning persistence by setting and resetting learner goals. An evidence review of adult education programmes found that it was particularly important to recognise small steps, and to measure progress towards soft outcomes such as self-confidence (Vorhaus et al., 2011).

In fact, the evidence review conducted by the Learning and Work Institute (2019) found that, in workplace learning, the most notable progress is found in soft outcomes such as increased job confidence. According to one large survey of learners on Skills for Life courses in the UK, soft outcomes were even more important than formal qualifications, as they encouraged them to progress to further learning or make life-changing decisions (Learning and Work Institute, 2019). However, using data on 1,649 adult learners in England, Brooks and Pilling (2011) did not conclude that Skills for Life programmes improved soft outcomes, like attitudes or self-confidence, amongst learners. Learner evaluations in the Fight Against Illiteracy programme in France include assessments of learners' autonomy, motivation, and confidence as well as cognitive development. Each element was broken down into sub-themes to observe and measure changes in spheres of individual life, behaviour, and interactions within the learning group. After completing the programme, participants reported higher self-confidence, stronger social bonds with their peers, and greater autonomy (UIL, 2017e).

Some of the literature suggests that focusing on hard outcomes such as gaining specific qualifications, instead of soft skills or wider outcomes, risks leaving disadvantaged learners behind (Learning and Work Institute, 2019). For instance, if programmes need to meet hard targets, there is a risk that providers will be unwilling to engage more disadvantaged learners. These adults are less likely to proceed quickly to gaining qualifications, and the rate of progress towards attaining qualifications is often linked to funding or performance targets (Warner et al., 2008).

The discussion on the impact of adult basic skills programmes, by Carpentieri et al. (2020), found that although it is unlikely that programmes produce measurable short-term impacts on numeracy skills, they do lead to measurable changes in behaviours. These practice gains would, over enough time, contribute to improvements in actual numeracy skills (Carpentieri et al., 2020).

Formative assessment

Formative assessment is the regular and interactive assessment of learner progress to identify learning needs. Regular assessment supports teachers to adapt their practice based on updated identification of progress and learning gaps (Looney, 2007; Windisch, 2015). Interviews with teachers across the OECD conducted by Looney (2007) and a

later research review carried out by Beadle et al. (2015) suggested that this assessment builds healthy relationships with learners. Both sources found that constructive feedback was important for effective formative assessment, and Beadle et al. (2015) found that using questioning techniques to prompt learners and elicit information was more effective than simply relying on learners' memories.

According to the literature review by Carpentieri (2014), formative assessment increased learners' persistence and motivation, and it is linked to a range of positive outcomes for learners' attainment and lifelong learning. However, Derrick et al. (2008) looked at how contextual factors can undermine the effectiveness of formative assessments. Time-pressures, performance-measures, and funding policies could push teachers to merge teaching into assessment to meet the targets. This seems to follow the letter of formative assessments, but it does not follow the spirit. Instead, successful formative assessment encouraged learners' independence. Learners were motivated by the self-identified goals, the nature of collaborative learning, and a clear understanding of the assessment criteria (Derrick et al., 2008).

In the spirit of formative assessment, guidelines provided by the Learning Skills Improvement Service (LSIS) for Skills for Life activities recommended developing Individual Learning Plans (ILP). This should include desirable outcomes, regular monitoring of progress, and measuring the impact of new resources and approaches (Learning and Skills Improvement Service, 2010). In Letter For Life (LFL), an initiative in Portugal aimed at improving literacy, numeracy, and digital skills, curriculum design started with learners outlining their expected learning outcomes and goals. The team conducted a qualitative analysis of each learner in terms of outcomes and engagement, mainly using written texts produced by learners and their own observations in class (UIL, 2018c). This research suggests that giving adult learners opportunities to reflect on their own progress and experiences encourages independent learning and intrinsic motivation.

Feedback and recognition of progress

One of the main successful features of ICT interventions is that learners appreciate instant responses and feedback about their assessments (Coben et al., 2007). However, following a survey of 149 adult students of Literacy and Basic Skills in Canada, Li et al. (2018) found that in blended learning courses, one-to-one support, and face-to-face feedback were critical for students' learning.

Appropriate feedback in workplace basic skills learning can also increase transfer to daily practice. According to the review by Cameron et al. (2011) feedback from both instructors and peers consolidates learning and transfer of good practice. Feedback should ideally take the form of one-to-one discussions, and buddy systems can be put in place for reflection on learning achievements and the application of new information.

According to the Learning and Work Institute (2019), both formal and informal measurement of progress should be considered, as recognition supports learners'

confidence and encourages persistence. The review included workplace learning, in which the employer publicly recognised learner success, as well as family learning, in which children could watch their parents receive certificates in celebration assemblies.

The evidence review conducted by Geraci (2012) also found that adult numeracy teaching should recognise students' achievements during the course. This could be achieved, for instance, by providing opportunities to gain credits and accreditations, as well as to formally celebrate accomplishments.

Digital tools to carry out short screener tests can give a general indication of the entry level of learners. Reiter et al. (2006) developed a Natural Language Generation system which generates short feedback reports for adults who complete these screening tests. They suggested that these reports can add on to existing assessment processes and provide extra feedback for learners (Reiter et al., 2006). The authors argued that some feedback reports used terminology that was useful to tutors, but not to learners. According to the authors, these tools should match feedback to students' interests and use non-technical terminology (Reiter et al., 2006).

Assessment tools

Assessment tools provide a statement of learners' current skills level, learning gaps, and support needs (Byrne, 2017). However, this is not always an easy task. Research commissioned by the Department of Business, Innovation and Skills (BIS) looked into 36 programmes at adult education institutions in England. The authors interviewed stakeholders and collected pre- and post- test scores. Findings suggested that assessment tools were not sensitive enough to measure changes in the skills of low-level learners, or for adults with spiky profiles[34] (Department for Business Inovation & Skills, 2014). Similarly, to assess learners' attainment, Swain et al. (2008) administered a numeracy test to 8,730 randomly selected adults aged 16 to 65 in England. Following the results of the test, the authors found that assessment instruments should be more sensitive to small changes in learners' progress, and they should balance curriculum areas and real-life items (Swain et al., 2008).

The review by Coben and Alkema (2017) found that it is challenging to accurately capture short-term proficiency gains in traditional course tests. According to the review by Coben and Alkema (2017), there is not a measure of numerate behaviour and practice that could be taken "off the shelf" for use. However, they outline several possible solutions to measure adults' numeracy practice in addition to tests: observational information (e.g. workplace practice), task-simulation interviews, and surveys to address self-confidence, frequency of use, complexity, and intensity of practice.

[34] The authors define spiky profiles as adult learners with different skill levels within a Level of Education. For instance, being secure in spelling words of specific types, but having problems with words of other types. These profiles make assessment harder, and prior attainment might not be fully reliable.

Additional support

This section covers support for adult learners with SEND and support for adult learners with maths anxiety, as well as the wider benefits of support from peers and families to adult learners. Our interviews and focus group confirmed that adult learners may need additional support for many reasons. However, this is the area with the smallest evidence base: only 30 studies included in the review were found to contain relevant content.

Ten papers in the systematic review provided useful information on support for adult learners with SEND and learning difficulties, with none of these papers covering dyscalculia. The methods used in these studies ranged from experimental approaches to qualitative evaluations of interventions – through questionnaires, interviews, and workshops – and literature reviews. The evidence mostly relates to the US and tends to focus on the most severe levels of learning difficulties. Consequently, an evidence gap was detected on additional support for people facing less severe learning difficulties. Also, the studies applying experimental approaches were based on small samples.

Additionally, only four papers focused on support for learners with maths anxiety and 16 studies discussed peer and family support. The four studies focused on maths anxiety used self-reported data to measure the level of maths self-efficacy and maths anxiety within the examined samples and conducted reviews of the broader literature to come up with their recommendations. The 16 studies that examined peer and family support are mostly extensive evidence reviews and case studies including evaluations of specific interventions. There are not many experimental approaches discussed within these studies, but the examined literature and interventions cover a wide range of countries and types of provision.

Support for adult learners with SEND

Gilley et al. (2021) assessed, through an experimental approach, a technique for teaching real-world maths problems to three young adults (21-year-olds) with extensive support needs enrolled in post-secondary transition programs for students with disabilities that served students aged 16 to 22 in the US. This technique included mathematical problem-solving related to a real-world task (cooking) where an instructor demonstrated the approach, followed by participants attempting problem-solving using the task analysis, plan and calculator provided.

This study concluded that, for the sample studied, basing interventions on real-world “contextualised” tasks and a schema/plan-based approach with diagrams worked well for SEND learners in enabling independent, accurate maths problem-solving. One caveat to this is that not all learners were able to then generalise the skills learned to other problems.

Boote (2005) reviewed literature and interviewed practitioners and experts in vocational education and training in England, Scotland, Ireland, Netherlands, Switzerland, Italy, and

France to investigate various approaches to developing learning skills for individuals with disabilities. The report concluded with various recommendations about the importance of learning skills and how best to help individuals with disabilities to develop learning skills. Firstly, inclusion of individuals with disabilities was highlighted as important for achieving positive outcomes, including training teachers in disability awareness. Secondly, the author concluded that teaching of learning skills should be incorporated into all aspects of training rather than being taught as a free-standing module because the latter is often overlooked or dismissed by students.

Santos et al. (2007) conducted an initial end-user evaluation of an online intervention called Accessible Learning Platform for Europe that was rolled out initially in the UK, Spain, and Greece. The research included online questionnaires, workshops, and interviews with stakeholders like tutors, customers, and learners. The study concluded that there was a high degree of consensus about the importance of adapting learning materials to achieve accessibility. This applied equally to adapting language and to making use of the full range of assistive technologies available.

Kellems et al. (2016) evaluated the effectiveness of teaching multi-step maths skills to nine adults with disabilities. The target group participated in an 18 – 21 postsecondary education program in the US using a video prompting intervention package, focusing on the number of steps completed correctly pre- and post-intervention. The multi-step maths calculations related to three real-world examples to calculate: (i) tips, (ii) item unit prices, and (iii) adjustments to a recipe. Eight out of the nine participants showed significant improvements in attainment immediately after receiving the video prompting intervention. A booster session was delivered after three weeks with follow-up testing six weeks after the initial intervention showing a high level of maintenance (persistence) of increased attainment. Kellems et al. (2016) comment that their results demonstrate the value of portable devices (e.g. iPads, smart phones) as effective tools for teaching adults with disabilities.

Kellems et al. (2021) extend the work of Kellems et al. (2016) to investigate a similar intervention but with an extension to include “Augmented Reality” (AR) in a study with three adults with learning disabilities solving multi-step real-world calculations, again in the US. The description given of AR is as follows: *“Information about the user’s immediate environment is superimposed with cameras on mobile devices, and information is added from digital sources such as videos and audio… [the] system is characterized by (a) combining the real and virtual worlds, (b) providing interaction in real time, and (c) aligning real objects or places with digital information in 3D”*. In-keeping with the earlier study, all students showed a fast, significant improvement in attainment that was maintained over time, again highlighting the efficacy of digital technologies as interventions for individuals with disabilities.

Bottge and Watson (2002) conducted research with adults in prison in the US with emotional and learning disabilities to assess a method of instruction using video-based

problems to improve maths-based problem-solving skills. The participants were four males who resided in a forensic mental health hospital in the Midwest having committed crimes but in cases where they were found not guilty by courts due to severe mental illness. In addition to learning disabilities, all participants experienced one or more “psychotic features”, implying relatively severe mental illness. Video-based instruction performed well, with all the individuals learning to compute fractions and solve a multi-step, video-based maths problem with follow-up assessment showing that skills were maintained six weeks following instruction. In assessing engagement, the authors found high levels of engagement with video-based maths problems and high levels of motivation to solve them. In line with several of the studies above, this study demonstrated positive results from use of digital technologies in teaching individuals with learning disabilities. For instance, according to the review by Rosen and Vanek (2017), using digital and technological support for having written text read out loud, often by an automated text reader and known as auding, can improve the ability of adults with severe reading disabilities to gain information from digital text.

The Reading and Writing Circle is a small community-based programme, with around 20 participants with learning disabilities or difficulties, in Norway. It tries to help participants to master daily tasks and to enhance their employment opportunities. It is based on the Equal Man principle, a peer mentoring approach in which a former participant takes on the role of a mentor. In general, there were two to three Equal Men per class (Hussain, 2010). The course received positive feedback from participants. Its success was attributed to the effective collaboration of instructors and learners, and to an environment that supported learners to build confidence and to develop skills for self-advocacy.

Gaunt et al. (2012) evaluated a numeracy programme with young adults with Down syndrome. In these sessions, teachers used repetition, individual tutoring and concrete materials such as base ten blocks. The five participants joined game sessions to practice what they learnt, as games have a positive effect on the emotional component of learning. The results of pre- and post-programme testing show that individuals with Down syndrome can learn numeracy sills with gaming and repeated practice. However, the small sample size means that more research is needed to test this finding (Gaunt et al., 2012).

Hua et al. (2012) examined a very specific tool to master daily practices. Their experimental research with young adults with intellectual disabilities tested the effect of a specific three-steps cognitive strategy for calculating the bill and the tip at a restaurant. This method was called TIP, which was a mnemonic device (Take a look at the total bill, Identify the tip by multiplying it by 15%, Plus the total and find out how much to pay). Students had not received any instruction on how to calculate a tip and total bill outside this intervention, and students in the control group did not receive this training. In the end, students in the experimental group outperformed the control group in the final assessment. The TIP strategy required only six sessions, with a total duration of three hours. The authors argue that teaching functional living skills will prepare young adults

with disabilities to be successful in daily living and improve their quality of life (Hua et al., 2012).

Support for adult learners with maths anxiety

There is little evidence on this topic in the literature with only four papers from our systematic review focusing on this topic, and with Jameson (2020) noting *"The least understood barrier faced by adult learners are psychological barriers"*. They go on to highlight the importance of this evidence gap because *"while a person's actual ability level matters in their success, their belief about the likelihood of success is quite influential to whether they succeed and their behaviors and thoughts surrounding the task"*. In our focus group, it was argued that maths anxiety is to be expected in classes of adult learners, largely because of previous negative experiences of education. Incremental recognition and rewards for progress were recommended as well as a focus on what adults were learning as opposed to whether they would pass a specific test.

In their review of the literature, Jameson (2020) noted that previous studies have observed high levels of maths anxiety in adult learners, with higher levels in female adult learners and a correlation between age and levels of maths anxiety.

Jameson (2020) conducted interviews with five highly maths-anxious female adult learners to focus on the drivers of maths anxiety, noting that this group was chosen due to adult learners and female students being more likely to report higher levels of maths anxiety. Four out of five participants were in the age range of 30 to 33 and one participant was 61. Following thematic analysis of interviews, the amount of time that had passed between the participants' last and current educational experiences emerged as the most important theme and was noted as a theme for all participants. Other themes identified from interviews included perceived differences between academic and everyday maths, and family as a positive source of motivation.

Jameson & Fusco (2014) analysed data collected from 226 undergraduate students (60 traditional students and 166 adult learners) and found that adult learners self-report lower levels of maths self-efficacy and higher levels of maths anxiety. Following a review of the wider literature, this paper went on to make policy recommendations. Some recommendations related to the benefits of peer mentors (a focus of a later section of this systematic review). Others included enrolling adult learners in developmental mathematics courses to allow them to have mastery experiences that develop self-efficacy, and framing course information in such a way that adult learners see it as meaningful and relevant.

Siivonen (2013) reported on narrative life history interviews with 20 general upper secondary school graduates, in Finland, who graduated from school as adults. Fifteen of the participants were female and five were male, covering a wide age range from individuals in their 20s to some aged over 60. She found that self-perceptions of competence in maths tend to be formed at an early stage in education and can turn into a

fear of maths. Her conclusion is that tackling these negative self-perceptions is key to lifelong learning.

Additionally, Roberts et al. (2005) highlight in their report that certain elements of embedded numeracy training in vocational curricula can help with maths anxiety. Specifically, it was mentioned that a social context in which learners feel comfortable can assuage the maths anxiety of adult learners.

Peer and family support

Peer support

Overall, the evidence shows positive impacts of peer support on various outcomes for participants. The most common outcomes observed were learner engagement and course completion. Personal and employment-related outcomes were not mentioned in the reviewed studies.

Barnes et al. (2003), who evaluated five different types of courses in the Pathfinder Extension Programme in the UK, found peer effects of residential courses on the participants' outcomes. The evaluation methodology was based on in-depth interviews of teachers and participants, and the five types of courses examined were: (i) residential, (ii) fixed rate replacement, (iii) intensive, (iv) highly structured, and (v) financial incentives. Every type of course included a numeracy component. Residential courses included intensive study away from domestic and other commitments providing the participants with the opportunity for team-working and social skills development. They offered a chance for participants to bond as a group and were described as invaluable for the development of "soft skills" such as confidence and teamwork. Additionally, this type of courses was found to develop increased levels of trust among the participants. It was also reported that group work provided a context for reciprocal support, and many learners found it less embarrassing to experiment amongst their peers than with teachers. This effect was particularly prominent in ICT basic skills courses, however the reduced levels of negative feelings thanks to peer support were observed in numeracy and literacy courses too.

The University of Exeter (2002) summarised case studies, interviews, and discussions with key stakeholders and experts in adult basic skills education in the South West of England and across the UK. The authors mentioned that peer support and constructive peer pressure can have positive outcomes regarding learners' engagement irrespective of the type of programme examined, whether ICT related or SME [35] based. Engagement in literacy and numeracy programmes can also be supported by unions' involvement. According to the report, unions have access to workplace and to non-traditional learners

[35] SME stands for small and medium-sized enterprises.

and, thus, they can provide independent peer support available through learning representatives and other trusted intermediaries.

The review of Lord et al. (2010), which examined UK and international evidence on the development of adult basic skills, presented evidence that positive relationships among learners are associated with positive impacts. It was highlighted that supportive peers could play an important role in helping those who lack confidence or high self-esteem, and those who have negative feelings and concerns. It was also found that encouraging informal learning in the workplace (i.e. observations of colleagues, workplace discussions, and peer exchange of best practices) is an effective way to help employees gain basic skills as it is a strategy that employees are likely to use if they want to learn something and it is not associated with formal education.

Additionally, the evidence review by Halsey et al. (2010) noted that while employees might have received formal training in the past, there might be a need for further contextual, on-the-job mentoring and support. According to the review, many employees prefer training that is informal, immediate, on-the-job, and taught by peers or supervisors. Learning from more proficient colleagues, mentoring, and peer coaching were found to be highly valued by employees with basic skills needs, while they were also enthusiastic about gradually gaining greater responsibilities in their job through mentoring and support.

The Learning and Work Institute (2019), in its evidence review on how to improve adult basic skills, highlights the effectiveness of practical and social support in helping adult learners to persist. According to the review's findings, enabling learners to develop encouraging and supportive relationships with their fellow learners and tutors can aide persistence. In particular, learner peer support groups that can continue working together once the course is completed have proven beneficial. Another effective type of peer support has been one-to-one support from a named and trusted advisor, usually a community member or a co-worker. The support of a worker previously known to the learner was found to facilitate engagement of hard-to-reach or vulnerable learners, and the review characterised it as a crucial part of peer support. In line with the above findings, Jurmo (2020) summarised the efforts for workplace basic skills development over two decades (mid-1980s to early 2000s) in the United States and cited peer support from fellow workers as an effective strategy for learner engagement and retention.

Furthermore, Looney (2007) conducted a multi-country review of formative assessment in adult education settings with specific reference to basic literacy and numeracy. Among the insights of the review was the finding that peer mentoring can be beneficial for learners. It was mentioned that the presence of peers can help new learners feel comfortable as they step back into a classroom environment and expose deficits they have long tried to conceal.

Yasukawa et al. (2014) examined the literacy and numeracy "crisis" in Australian workplaces through a literature review and a case study about the Union Learning Fund

(ULF) in the UK, finding positive peer effects that could be observed where participants were involved in the design of the programmes. The reviewed literature in Yasukawa et al. (2014) included interviews and qualitative evidence that workers were happy to improve their skills and spoke enthusiastically of learning from their fellow workers, in contrast with the finding that a formal education programme organised by the management would not have succeeded. This finding was based on previous literature's conclusions that an alternative workplace education program, organised by workers, would have been more welcome because it would have focused on their own perceived needs. Additionally, Yasukawa et al. (2014) concluded that involving union representatives in learning encourages a more "bottom-up" approach to it. Employees are more likely to be honest and open about their basic skill needs to a peer than to a manager, and such initiatives create a sense of community and solidarity among workers. Similar findings regarding the role of union representatives were reported by the Chartered Institute of Personnel Development (2005). It was pointed out that Union Learning Representatives (ULRs) help to identify and promote learning activities in their workplace.

Balatti et al. (2006), who examined the social and human capital outcomes experienced by 57 learners after participating in accredited adult literacy and numeracy courses in Australia, found considerable effects. The three new networks[36] to which students gained membership as a result of participating in the course contributed significantly to the learning experience and social capital outcomes reported by participants. The network of fellow students appeared to contribute significantly to these outcomes in conjunction with the relationships between participants, their teachers, and other staff as well as the overall feeling of belonging to a class comprising teachers and students. Balatti et al. (2006) reported that it was the interaction of these three networks that offered the greatest benefits.

Another source from the Australian context is a guide from the National Centre for Vocational Education Research (2010). In this guide, good practices for teaching adults using a social capital approach were presented. [37] The social capital approach emphasises the importance of networks and shared norms to facilitate cooperation. One of the points included in the guide was that teachers can facilitate the development of stronger bonds within student groups and change the way people share information and perceive themselves by promoting interaction between learners. In addition, in one of the case studies presented in a report by the National Centre for Vocational Education Research (2010), the importance of peer effects and peer support is showcased. The course was a Certificate in Business for Workplace Re-entry, delivered over an eight-

[36] These networks were the network of fellow students, networks the individuals created with the teachers and staff members, and the network that operated as a 'class', comprising teachers and the student group as a whole.

[37] The guide was based on research conducted by Jo Balatti, Steve Black, and Ian Falk. Their report "A new social capital paradigm for adult literacy: Partnerships, policy and pedagogy" (2009) is available at: https://www.ncver.edu.au/research-and-statistics/publications/all-publications/a-new-social-capital-paradigm-for-adult-literacy-partnerships,-policy-and-pedagogy

week period. The participants were job seekers or people over 45 years of age looking to gain skills to increase their job prospects. Many learners commented on the fellowship they experienced within the group and how this helped them progress. It is worth mentioning that when an online self-paced financial literacy component was introduced, the feedback from learners was very negative. One of the key reasons for that was the lack of interaction among the learners and the lack of group activities. As soon as these issues were addressed, the learners regained their enthusiasm.

In general, there is a consensus in the literature that peer support can have a positive impact on engagement and attainment of learners. An UNESCO case study on ESPERE: Schools of Forgiveness and Reconciliation in Columbia (UIL, 2019a) showcased that peer support may also benefit other personal outcomes. The ESPERE initiative aimed to promote the development of basic skills in conjunction with emotional and communicative competences. The target groups of the programme were individuals of all ages that were either victims of armed conflicts, in vulnerable conditions, or ex-combatants and their families. The UNESCO case study on this initiative showed that peer evaluation, peer-led teaching, and experience exchange were able to change participants' attitudes towards forgiveness and reconciliation and lead to more functional personal relationships.

Family support

This section discusses family-related outcomes, the benefits of family support to adult learners, as well as the importance of providing additional support to parents and carers to enable them to overcome the resource and time challenges in attending adult learning.

Family-related outcomes

Adult basic skills learning can contribute to a wide range of outcomes other than the immediate targets of improved skills and employability, such as improved family relationships. The evaluation of the effectiveness of adult literacy and numeracy programmes in Scotland by HM Inspectorate of Education (2005), based on questionnaires and interviews with learners and key personnel, found that programmes contributed to improved family relationships and participants' ability to perform better in their family roles. Participants reported increased capacity to contribute within their family as well as in their community and at work, and substantial gains in self-esteem and confidence.

Case studies by UNESCO also showcased the impact of adult basic skills learning on family life. For example, The Manukau Family Literacy Project (MFLP) in New Zealand, which aims to improve the basic skills of parents with poor education who want to support their children's learning, was found to have considerable impacts on the participants and their families, including parents progressing to further education or employment, children's improved attainment and motivation to go to school and better child-parent interaction and communication (UIL, 2012b). Additionally, the ESPERE: Schools of Forgiveness and Reconciliation programme in Colombia was found to strengthen the

relationships within the participants' family and community (UIL, 2019a). The programme also led to intergenerational learning due to parents and grandparents being able to support children and learn together, and improved family dynamics. However, some of the key effects of the programme (e.g. on the reconciliation skills of learners) were primarily related to literacy skills and less related to numeracy skills.

The importance of family support

The evidence review of the Learning and Work Institute (2019) included insights about the role of the participants' family context in learning. It cited studies concluding that the prime motivation for parents to participate was to support their children's learning rather than to develop their own. In addition, it was found that a key trigger for engagement was the encouragement of family or friends along with personal motivation and professional advice. Experimental evidence suggests that social support interventions, like updates on the learners' progress texted to learners' friends and family, could improve attendance and achievement rates (Hume et al., 2018). In addition, research suggests that public recognition, such as celebration assemblies, in which children get to watch their parents' achievements be recognised, motivates learner persistence (Learning and Work Institute, 2019).

An example is Alphabetizing People Deprived of Liberty, which was an in-prison education programme that targeted men and women serving sentences in penitentiary institutions in Chile. Learners were taught basic numeracy skills to help them function in everyday life and make them self-sufficient. Participants' families were involved and given the opportunity to be present during the graduation ceremony to strengthen family relationships and build inmates' self-confidence and motivation (UIL, 2015c).

On the other hand, having family responsibilities can also be a barrier to access, participation and persistence in adult education. Providing childcare support could be one way to support families in overcoming these challenges. According to the evaluation of the residential courses in the Pathfinder Extension Programme provided by Barnes et al. (2003), participants felt that they benefited by taking their children to a residential course with nursery provision. The fact that the mothers were removed from a setting filled with distractions allowed them to cover a lot more ground than usual. This benefit highlights that, in a context without nursery provision, accessing the courses could be challenging for people with childcare and family responsibilities. In addition, it was suggested that if courses were extended, they would require provision of childcare facilities or financial support for childcare for those that attended, to ensure equality of access.

Conclusion

Multiply is a programme aimed at helping adults to improve their numeracy skills by offering adults who do not already have a GCSE grade C/4 (Level 2 qualification) or higher in Maths or equivalent, and need to improve their numeracy, free flexible courses that fit around their lives. This systematic evidence review has synthesised the evidence base for interventions to improve numeracy skills among adults with below Level 2 qualifications in Maths, aiming at informing the development of policy and provision in this area.

We have addressed the following research question: (i) what lessons can be learnt from adult skills policy in this area over the past 20 years, (ii) what is known about adults (19+) in the UK who have limited skills, and (iii) which approaches appear to be the most and least successful in supporting different groups of adults to improve their numeracy skills, up to and including Level 2. To address the research questions, we have carried out a systematic search of the literature, data analysis of publicly available data and interviews and roundtable discussions with sector experts.

To explore what is known about adults who have low levels of numeracy, we have analysed the Understanding Society survey. Around half of adult respondents have achieved a Level 2 numeracy qualification at some point in their life. Additionally, the data analysis showed that the likelihood of having achieved such a qualification varies based on a range of characteristics, including ethnicity, income, and employment. Adults with below Level 2 numeracy qualifications were also highly likely to report that they did not have Level 2 literacy qualifications and to engage less with technology than the average respondent.

The evidence review included a total of 209 studies, which were relevant to four key themes: (i) motivation and engagement of adult learners, (ii) delivery channels, (iii) teaching practices, and (iv) additional support for adult learners with specific needs. Most of the research identified was in the form of small case studies, often based on small samples of teachers, providers and learners. Impact assessments of specific interventions were usually based on surveys and interviews with participants, administrative data from courses and completion and qualification attainment data. While such methods are useful for understanding the success of a programme based on stakeholders' views, they cannot inform us on what would have happened without the intervention and thus they cannot provide an estimate of the total impact. Across all themes, there are a few studies that used high-quality experimental or quasi-experimental methods to test hypotheses and the impact of specific interventions. However, those studies are in the minority. They also refer to interventions that are very specific in nature, and the studies are sometimes based on very small samples – an issue very pronounced in the literature on additional support. There are also a few studies which evaluate larger initiatives, follow groups of learners over time, or consider

national data. Overall, the evidence discussed in this review is of mixed quality. In many cases, the context is vital for understanding the strength and generalisability of results.

A few evidence gaps were identified across all themes. Within the area of motivation and engagement of adult learners, there was limited evidence on the use of incentives and rewards to motivate learners, effective communication approaches in the classroom and online, and compulsory attendance. No studies were found to explore the use of social media for engagement of adult basic skills learners. The literature on workplace training was the richest across all delivery channels, but it lacked robust evaluations of the impact of specific programmes. The smallest body of evidence within delivery channels referred to community-based training and family learning. Only a limited number of studies were identified on these topics and most of the evidence available was based on small case studies.

Although the evidence base on teaching practices was the largest of all themes, home learning and practice between sessions and dual classroom teaching were not assessed by any study reviewed. The theme of additional support for adult learners with specific needs was the area with the smallest evidence base, with some key evidence gaps identified. Firstly, there was no study addressing the needs of adults with dyscalculia. Additionally, evidence on support for adult learners with SEND and learning difficulties focused on the most severe levels of learning difficulties. Finally, the number of papers on support for learners with maths anxiety was extremely small.

Future research applying experimental or quasi-experimental approaches to establish the impact of interventions would be welcome, as such studies were limited within the literature reviewed. Additionally, future research could focus on informing policymakers and the public on the areas where there was a gap in the evidence base, prioritising the areas with the most limited research available (e.g. support for adults with dyscalculia, family support for adult learners, home learning, and dual teaching). Furthermore, the impact of the COVID-19 pandemic on delivery methods, teaching practices and the outcomes of learners could also be explored as it can provide valuable lessons on the effect of digital learning. Finally, ideas and evidence from other parts of the education and training academic literature may support the design of provision and research in adult basic skills learning, e.g. practices for young people (aged 16-19) or children, or lessons learned from other topics in adult learning (e.g. ICT training), taking into consideration the expected differences across the populations of interest.

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Torgerson, C., Brooks, G., Porthouse, J., Burton, M., Robinson, A., Wright, K., & Watt, I. (2004). Adult literacy and numeracy interventions and outcomes: A review of controlled trials. Quality score: 8

Tout, D. (2020). Evolution of adult numeracy from quantitative literacy to numeracy: Lessons learned from international assessments. International Review of Education, 66(2), 183–209. https://doi.org/10.1007/s11159-020-09831-4 Quality score: 7

Tunstall, S. L. (2020). Measuring Numeracy: Validity and the Programme for the International Assessment of Adult Competencies (PIAAC). Numeracy, 13(2), 1–37. https://doi.org/10.5038/1936-4660.13.2.1348 Quality score: 6

UIL. (2012a, January 9). Prison Family Learning Programme, United Kingdom of Great Britain and Northern Ireland | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/prison-family-learning-programme-united-kingdom Quality score: 7

UIL. (2012b, July 3). The Manukau Family Literacy Project, New Zealand | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/manukau-family-literacy-project-new-zealand Quality score: 6

UIL. (2014, November 25). Maths Everywhere, United Kingdom Of Great Britain and Northern Ireland | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/maths-everywhere-united-kingdom-great-britain-and Quality score: 7

UIL. (2015a, July 16). ABCami (Literacy and Adult Education in the Mosque), Germany | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/abcami-literacy-and-adult-education-mosque-germany Quality score: 7

UIL. (2015b, August 28). Family Literacy Programmes, Turkey | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/family-literacy-programmes-turkey Quality score: 6

UIL. (2015c, November 30). Clare Family Learning, Ireland | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/clare-family-learning-ireland Quality score: 7

UIL. (2015d, December 9). Alphabetizing People Deprived of Liberty, Chile | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/alphabetizing-people-deprived-liberty-chile Quality score: 6

UIL. (2017a). Literacy and Numeracy from a Lifelong Learning Perspective. UIL Policy Brief 7. In UNESCO Institute for Lifelong Learning. UNESCO Institute for Lifelong Learning. https://uil.unesco.org/literacy/achieving-literacy-and-numeracy-lifelong-learning-perspective-uil-policy-brief-7 Quality score: 6

UIL. (2017b, July 18). AlphaRoute, Canada | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/alpharoute-canada Quality score: 7

UIL. (2017c, July 18). Challenges of the Countryside – a Rural Literacy Programme for Adults in Slovenia, Slovenia | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/challenges-countryside-rural-literacy-programme Quality score: 6

UIL. (2017d, July 21). Education Model for Life and Work, Mexico | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/education-model-life-and-work-mexico Quality score: 7

UIL. (2017e, July 24). Fight Against Illiteracy, France | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/fight-against-illiteracy-france Quality score: 7

UIL. (2017f, July 24). Information and Communication Technologies (ICTs) in Andragogical Mediation, Costa Rica | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/information-and-communication-technologies-icts Quality score: 6

UIL. (2017g, July 25). Literacy Alberni Society, Canada | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/literacy-alberni-society-canada Quality score: 7

UIL. (2017h, July 26). Basic Competence in Working Life, Norway | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/basic-competence-working-life-norway Quality score: 7

UIL. (2017i, July 26). The Lifelong Learning and Training Project, Chile | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/lifelong-learning-and-training-project-chile Quality score: 7

UIL. (2017j, July 26). Virtual Assisted Literacy Programme, Colombia | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/virtual-assisted-literacy-programme-colombia Quality score: 6

UIL. (2017k, July 26). Web-Based Literacy Programme (WBLP), Turkey | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/web-based-literacy-programme-wblp-turkey Quality score: 5

UIL. (2017l, July 26). Words and Numbers in Everyday Life, Ireland | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/words-and-numbers-everyday-life-ireland Quality score: 7

UIL. (2018a, January 18). Learning Basic Skills while Serving Time, Norway | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/learning-basic-skills-while-serving-time-norway Quality score: 6

UIL. (2018b, April 4). Cell-Ed: Innovative education through cell phones, United States of America | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/cell-ed-innovative-education-through-cell-phones Quality score: 6

UIL. (2018c, June 8). Letters for Life, Portugal | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/letters-life-portugal Quality score: 7

UIL. (2019a, November 25). ESPERE: Schools of Forgiveness and Reconciliation, Colombia | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/espere-schools-forgiveness-and-reconciliation Quality score: 6

UIL. (2019b, November 26). Students and Parents In Cooperative Education (SPICE) Family Literacy Programme, United States of America | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/students-and-parents-cooperative-education-spice Quality score: 5

UIL. (2021, May 21). Parents as Literacy Supporters in Immigrant Communities (IPALS) | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/parents-literacy-supporters-immigrant-communities Quality score: 6

UIL. (2022, January 12). Sistema Interactivo Transformemos Educando, Colombia | UIL. https://uil.unesco.org/case-study/effective-practices-database-litbase-0/sistema-interactivo-transformemos-educando-1 Quality score: 6

University of Exeter. (2002). Adult basic skills in the workplace. Quality score: 9

Vorhaus, J., Litster, J., Frearson, M., & Johnson, S. (2011). Review of research and evaluation on improving adult literacy and numeracy skills. Quality score: 8

Waite, E., Evans, K., & Kersh, N. (2014). The challenge of establishing sustainable workplace 'Skills for Life' provision in the UK: Organisational 'strategies' and individual 'tactics'. Journal of Education and Work, 27(2), 199–219. Quality score: 6

Warner, J. R., Vorhaus, J., Appleby, Y., Bathmaker, A.-M., Brooks, G., Cole, P., Pilling, M., & Pearce, L. (2008). The Learner Study: The impact of the Skills for Life strategy on adult literacy, language and numeracy learners. Institute of Education. Quality score: 7

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Wilkin, A., Hart, R., Halsey, K., & Kinder, K. (2010). Adult basic skills development and family learning. CfBT Education Trust. Quality score: 8

Windisch, H. C. (2015). Adults with low literacy and numeracy skills: A literature review on policy intervention. In OECD Education Working Papers (No. 123; OECD Education Working Papers). OECD Publishing. https://ideas.repec.org/p/oec/eduaab/123-en.html Quality score: 8

Windisch, H. C. (2016). How to Motivate Adults with Low Literacy and Numeracy Skills to Engage and Persist in Learning: A Literature Review of Policy Interventions. International Review of Education, 62(3), 279–297. https://doi.org/10.1007/s11159-016-9553-x Quality score: 9

Wolf, A., Aspin, L., Waite, E., & Ananiadou, K. (2010). The rise and fall of workplace basic skills programmes: Lessons for policy and practice. Oxford Review of Education, 36(4), 385–405. Quality score: 6

Woodhouse, J., & Stevenson, A. (2018). Workplace Basic Skills Case Studies. https://learningandwork.org.uk/resources/research-and-reports/workplace-basic-skills-case-studies/ Quality score: 7

Yamashita, T., Cummins, P. A., Millar, R. J., Sahoo, S., & Smith, T. J. (2019). Associations between motivation to learn, basic skills, and adult education and training participation among older adults in the USA. International Journal of Lifelong Education, 38(5), 538–552. Quality score: 7

Yasukawa, K., Brown, T., & Black, S. (2014). Workplace Literacy and Numeracy Learning: An Opportunity for Trade Union Renewal in Australia? International Journal of Training Research, 10(2), 94–104. https://doi.org/10.5172/ijtr.2012.10.2.94 Quality score: 7

Yasukawa, K., Lo Bianco, J., Osmond, P., & Iles, V. (2020). Weaving a richer narrative of adult literacy and numeracy: Policy position proposal for ACAL https://www.voced.edu.au/content/ngv:88484 Quality score: 6

Appendix A: Research protocol

This section sets out the research questions, the search strategy and the inclusion criteria that were used to decide if retrieved studies would be included in the literature review. We also include a technical note on the regression analysis reported in our analysis of secondary data.

Once the research protocol was agreed upon, the next step was to search the literature and arrive at a "long list" of relevant studies. The studies included in the long list were then subject to a review of titles and abstracts and were screened based on the inclusion criteria. The screening process led to a "short list" of studies that were read in detail. While reading the papers in the short list, we recorded the relevant information using a Research Extraction Sheet (RES). The information recorded was used to synthesise and summarise the evidence related to the research questions.

Research questions

The three guiding research questions for this piece of work were:

- What lessons can be learnt from numeracy-focused adult skills policy over the past 20 years?
- What is known about adults in the UK who have limited numeracy skills?
- Which approaches appear to be the most and least successful in supporting different groups of adults to improve their numeracy skills, up to and including Level 2 (GCSE Grade 4+ or equivalent)?

The research questions were further broken down into four sub-themes, or chapters. For this reason, the most and least successful approaches in supporting adults include:

1. Engagement with learners – how to identify numeracy problems, barriers to engagement, and motivations to learn.
2. Delivery channels – how best to implement flexible learning programmes, digital and blended provision, community learning and classroom-based teaching.
3. Effective teaching practice – which includes actions to assess difficulties, approaches to embed numeracy, dual teaching, use of digital content, review of specific interventions, and progress monitoring.
4. And any additional support that learners might need, including adults with special educational needs or disabilities (SEND), adults with low maths confidence. We also reviewed approaches to build peer, and family support, as well as interventions for specific sub-populations.

Search strategy

This protocol was set to obtain the most relevant pieces of literature to address the research questions. Based on the scope of the review, we built the search strategy through targeting keywords present in the title and the abstract. We applied our search strategy into 11 search engines: ABI/Inform, SAGE, IDEAS, ERIC, Google Scholar, VOCEDplus, JSTOR, Science Direct, SpringerLink, and SSRN. Table A illustrates the keywords that were used to identify relevant sources of evidence.

Search terms

Table 1 contains the keywords that were used to identify relevant sources of evidence. During the scoping review, we tested different combinations of words to arrive at these keywords based on a desk-based review of related studies including earlier literature reviews and key papers. We targeted three groups of keywords; studies were added to the long list if they had a group 1 & group 2 keyword in the title and at least one keyword from group 3 in the abstract.

Table 1: Search Keywords

Group	Criteria	Keywords
1: Main subject	One keyword present in title	Numeracy, math*, “basic skills”, “Skills for Life”
2: Target population	One keyword present in title	Adult*, post-16, post-18, lifelong, life-long, work, workplace
3: Type of intervention	One keyword present in abstract	skills, course*, learn*, teach*, intervention*, programme*, project*, curriculum, policy, policies, approach*, practice, train*

Not all databases allowed this level of nuance in search terms and the box below includes a list of all search strings used. Search terms were combined into search strings using Boolean operators (AND/OR) and other database-specific search operators.

Search strings used

ABI/Inform - ProQuest.
TI(numeracy OR math OR "basic skills" OR "Skills for Life") AND TI(adult* OR "post-16" OR "post-18" OR lifelong OR work OR workplace) AND TI,AB(skills OR course* OR learn* OR teach* OR intervention* OR programme* OR project* OR curriculum* OR policy OR policies OR approach* OR practice)*

ERIC. Institute of Education Sciences.

(title:numeracy OR title:math OR title:"basic skills" OR title:"skills for life") AND (title:adult OR title:"post-16" OR title:"post-18" OR title:lifelong OR title:"life-long" OR title:work OR title:"workplace") AND (abstract:skills OR abstract:course OR abstract:learn OR abstract:teach OR abstract:train OR abstract:intervention OR abstract:programme OR abstract:programme OR abstract:project OR abstract:curriculum OR abstract:policy OR abstract:policies OR abstract:approach OR abstract:practice)

IDEAS

(numeracy OR math OR maths OR "basic skills" OR "skills for life") AND (adult OR adults OR adulthood OR lifelong OR life-long OR work OR workplace)

JSTOR

(1) (numeracy OR math OR "basic skills" OR "Skills for Life") [item title] AND (adult* OR "post-16" OR "post-18" OR lifelong OR work OR workplace) [item title] AND (skills OR course* OR learn* OR teach* OR train*) [abstract]*

(2) (numeracy OR math OR "basic skills" OR "Skills for Life") [item title] AND (adult* OR "post-16" OR "post-18" OR lifelong OR work OR workplace) [item title] AND (intervention* OR programme* OR project* OR curriculum*) [abstract]*

(3) (numeracy OR math OR "basic skills" OR "Skills for Life") [item title] AND (adult* OR "post-16" OR "post-18" OR lifelong OR work OR workplace) [item title] AND (policy OR policies OR approach* OR practice*) [abstract]*

SAGE

[[Title numeracy] OR [Title math] OR [Title "basic skills"] OR [Title "skills for life"]] AND [[Title adult*] OR [Title "post-16"] OR [Title "post-18"] OR [Title lifelong] OR [Title work] OR [Title workplace]] AND [[Abstract skills] OR [Abstract course*] OR [Abstract learn*] OR [Abstract teach*] OR [Abstract train*] OR [Abstract intervention*] OR [Abstract*

programme] OR [Abstract project*] OR [Abstract curriculum*] OR [Abstract policy] OR [Abstract policies] OR [Abstract approach*] OR [Abstract practice]]*

Google Scholar

allintitle: (numeracy OR math OR mathematic OR "basic skills" OR "skills for life") (adult OR adulthood OR lifelong OR "life-long" OR work OR workplace) (skills OR course OR learn OR teach OR train OR training OR intervention)

allintitle: (numeracy OR math OR mathematic OR "basic skills" OR "skills for life") (adult OR adulthood OR lifelong OR "life-long" OR work OR workplace) (programme OR project OR curriculum OR policy OR policies OR approach)

Science Direct

1. *Title:(numeracy OR math OR mathematic OR "basic skills" OR "skills for life") AND (adult OR adulthood OR lifelong OR life-long) AND Title, abstract, keywords:(skills OR course OR teach OR train OR learn OR intervention OR programme OR project OR curriculum) AND Year: 2002-2022*
2. *Title: (numeracy OR math OR mathematic OR "basic skills" OR "skills for life") AND (adult OR adulthood OR lifelong OR life-long) AND Title, abstract, keywords:(policy OR policies OR approach OR practice) AND Year: 2002-2022*
3. *Title:(numeracy OR math OR mathematic OR "basic skills" OR "skills for life") AND (work OR workplace) AND Title, abstract, keywords:(skills OR course OR teach OR train OR learn OR intervention OR programme OR project OR curriculum) AND Year: 2002-2022*
4. *Title: (numeracy OR math OR mathematic OR "basic skills" OR "skills for life") AND (work OR workplace) AND Title, abstract, keywords:(policy OR policies OR approach OR practice) AND Year: 2002-2022*
5. *Title:(numeracy OR math OR mathematic OR "basic skills" OR "skills for life") AND ("post-16" OR “post-18”) AND Title, abstract, keywords:(skills OR course OR teach OR train OR learn OR intervention OR programme OR project OR curriculum) AND Year: 2002-2022*
6. *Title: (numeracy OR math OR mathematic OR "basic skills" OR "skills for life") AND (“post-16” OR “post-18”) AND Title, abstract, keywords:(policy OR policies OR approach OR practice) AND Year: 2002-2022*

Springer Link

1. *Where the title contains: adult numeracy*

(2) Where the title contains: “basic skills” adult

(3) Where the title contains: “skills for life”

(4) Where the title contains: math adult

SSRN

(1) Title Only: numeracy

(2) Title Only: skills for life

VOCEDplus

tm_metadata.title:(numeracy OR math OR "basic skills" OR "skills for life") AND tm_metadata.title:(adult* OR "post-16" OR "post-18" OR "lifelong" OR "life-long" OR work OR workplace) AND tm_metadata.abstract:(skills OR course* OR learn* OR teach* OR intervention* OR programme* OR project* OR curriculum* OR policy* OR policies* OR approach* OR practice* OR train*) AND sm_metadata.yearpublished:(2002 2022)*

Using these strings, we arrived at a long list of studies, which were then screened to see if they met the inclusion criteria.

Inclusion and Exclusion Criteria

We set inclusion and exclusion criteria to decide if the materials identified from our search were suitable for answering the core research questions of this project. If studies met the inclusion criteria, they were included in our short list and reviewed in full.

Table 2: Inclusion and Exclusion Criteria

Theme	Inclusion Criteria	Exclusion Criteria
Population characteristics or context	Adults aged 19 and over with numeracy skills up to and including Level 2	Individuals under-19 Adults with numeracy skills above Level 2
Target skills	Targeted at least in part at numeracy skills	Numeracy skills not a target
Country of the case study	OECD	Non-OECD

Theme	Inclusion Criteria	Exclusion Criteria
Language of publication	English – included Any other language – reviewed and referred to DfE to decide on translation if relevant	
Methods	All (experimental, quasi-experimental, descriptive, qualitative etc.)	No quantitative or qualitative methods used
Impact and outcomes	Improvement in numeracy skills/higher level qualifications attained Impact on engagement/attendance of courses	Impact/outcomes unrelated to numeracy skills, attendance, engagement, and completion of relevant courses Broader impact of higher numeracy skills
Date of research	After 2002	Before 2002
Type of studies	Peer reviewed journal articles; non-peer reviewed academic outputs (reports, working papers, etc.); government commissioned research; book chapters and publications by other research organisations. Evidence reviews and original studies	Whole books or other work of equivalent length. Newspaper articles, blog posts, editorials/opinion pieces, magazine articles. Theses and dissertations.

Additional literature

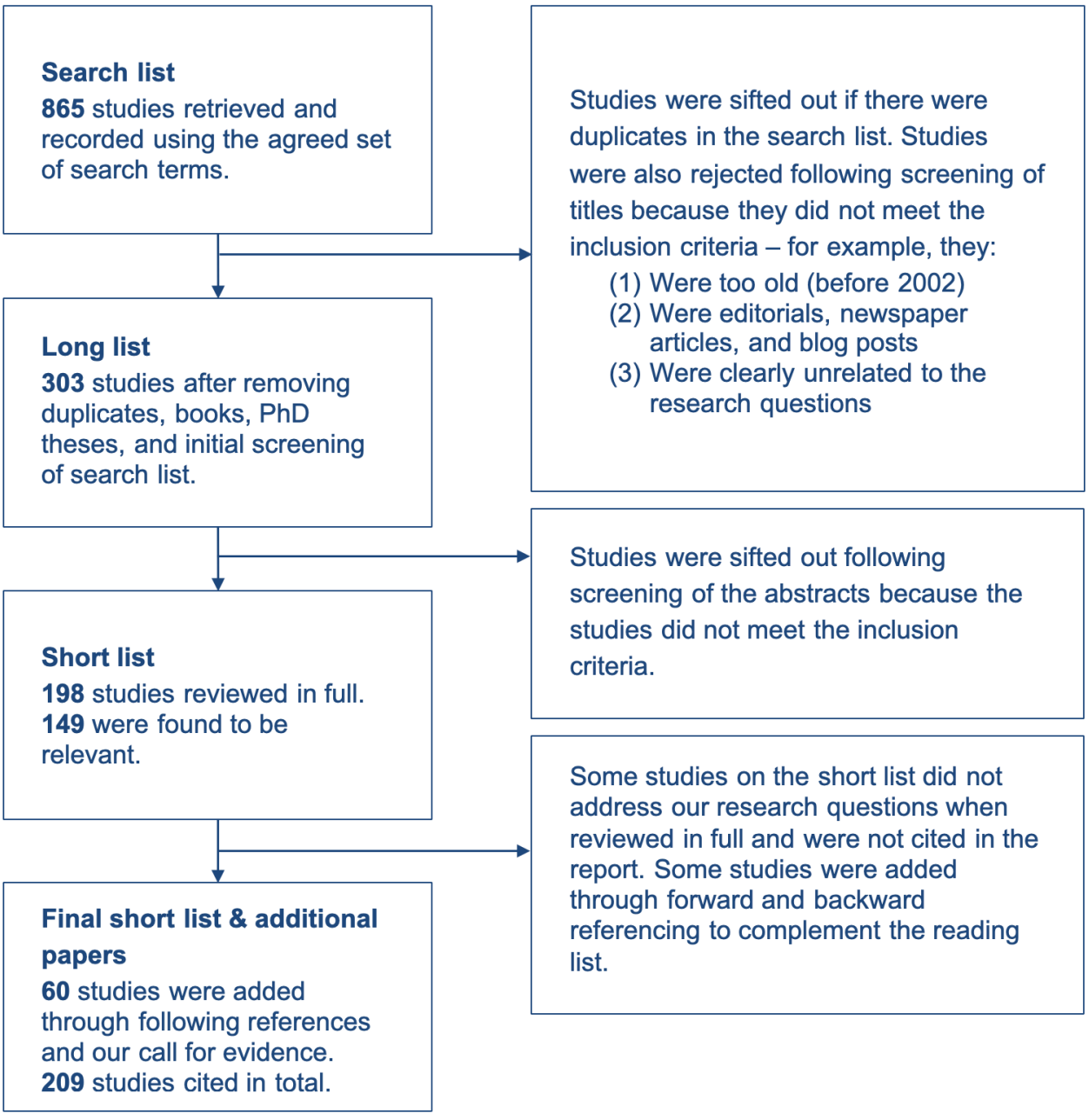
In addition to our systematic literature searches, we also added other studies through responses to a call for evidence and through forward and backward referencing from other short list studies. We issued a call for evidence to a number of relevant organisations. We also carried out searches of these organisations' websites for relevant material. We screened these materials using the inclusion & exclusion criteria described above and reviewed materials that met those criteria.

In addition, where evidence gaps emerged, we also included papers that were referenced in studies in our short list. This ensured that we covered as much of the relevant evidence base as possible.

Protocol results

The evidence selected, based on the inclusion criteria, are studies that review approaches to support adult numeracy. We carried out the systematic search between

July and August 2022. Our systematic search yielded 198 studies that were reviewed in full of which 149 were relevant to the research questions of the systematic review. Additionally, 28 sources were included through following references from shortlisted studies. We received a further 32 relevant publications following our call for evidence. The diagram below shows the stages of the systematic review, the number of studies identified at each stage, and the criteria for which papers were excluded or included.



Recording evidence

Data management

To ensure the search process was comprehensive and transparent, we used a Research Activity Sheet (RAS) to record all searched terms, accessed sources, the date of the search and the number of search results.

We recorded and maintained a list of the retrieved references in a specialist software package, Zotero. Zotero is a free, open-source reference management tool that stores citation information (e.g. author, title, and publication fields) and has the ability to organise, tag, and perform advanced searches. We captured the key findings of each study included in the short list in a Research Extraction Sheet (RES) that included the following details for each study:

- Title
- Author(s)
- Type of publication
- Publication date
- Source
- Country/Region of focus
- Abstract/Executive summary
- Methodology (e.g. focus groups, interviews, survey, observational data)
- Population of interest (e.g. all pupils, LGBTQ+ pupils, pupils with SEND, pupils from minorities, parents, teachers)
- Relevant chapter
- Relevant research question – primary
- Relevant research question(s) – additional
- Summary of findings
- Limitations
- Quality score

The information was recorded in MS Excel.

Assessing the quality and relevance of evidence

To assess the quality of the evidence included in the short list we used the criteria listed in Table 3 below. The quality assessment of the evidence was based on (i) credibility, (ii) methodology, and (iii) relevance of the study and is a judgement, not on the quality of any single piece of research, but of the quality and relevance of a piece of evidence for answering the research questions of this report. For each category, we assigned a score from 1-3 (where 1 is the lowest score and 3 is the highest). This scoring guides the

synthesis of the evidence produced in the full report where we emphasise the highest quality evidence. The methodology score draws on the Maryland Scientific Methods Scale (*The Maryland Scientific Methods Scale (SMS) | What Works Centre for Local Economic Growth*, n.d.) but has been adapted to allow us to deal with the large number of qualitative and mixed-methods papers in the literature.

Table 3: Quality appraisal criteria

Category	Description	Score
Credibility	Is the study coherent? Can findings be trusted? Does the author consider study limitations or alternative interpretations of the analysis? Has the study been peer-reviewed? 1 = Study has not been peer-reviewed, with conclusions drawn from limited data or theoretical discussion. Lack of transparency around data and no discussion of data quality. No discussion around assumptions made. 2 = Study is unpublished, or study is informally published as a working paper/research report by a reliable source. Limited discussion around sources, information and data quality, or alternative interpretations of research findings. Study focuses on an ongoing intervention with adequate discussion around assumptions made. 3= Study is published in a peer-reviewed academic journal. Study discusses information quality, sampling decisions and other aspects of the methodology. Study focuses on a completed initiative.	1-3
Methodology	How robust is the evidence to contribute to our review? 1 = Methodology is not fit-for-purpose and relies on before-and-after or cross-sectional comparisons with no use of control variables. (very similar to Maryland Level 1). This score will also be given to qualitative studies with unclear/inadequate sampling strategies. No discussion of why the chosen design and method are well-suited to answering the research question. 2 = Methodology is fit-for-purpose and relies on adequate control variables, though important unobserved differences may be remaining (Maryland Level 2). This score will also be given to high-quality qualitative studies (surveys, focus groups, case studies) with robust sampling strategies. Some	1 - 3

Category	Description	Score
	discussion of why the chosen design and method are well-suited to answering the research question. 3 = Methodology exploits quasi-randomness in treatment or explicit randomisation into treatment and control groups[38]. The study provides clear evidence on comparability of treatment and control groups. Extensive discussion of why the chosen design and method are well-suited to answering the research question. Literature reviews and meta-analyses will also receive this score.	
Relevance	Does the study help to answer the research question? 1 = The research question or hypothesis is not directly related to the proposed research questions or considers interventions in non-OECD countries. 2 = The research question or hypothesis is only somewhat related to the proposed research questions or considers interventions in OECD countries. 3 = Study addresses an intervention in the UK and/or the research question or hypothesis is directly relevant to the proposed research questions.	1-3
Overall judgment	Considering the above categories, what is the overall judgment?	3-9

Regression analysis

We include in the report an analysis of correlations between a number of individual characteristics and the likelihood of having low numeracy skills as reported in the Understanding Society survey. To conduct this analysis, we developed a regression model, a form of statistical analysis seeking to establish which factors are associated with a particular outcome variable of interest (also known as the dependent variable), whilst controlling for relevant factors. Specifically, we used a logistic (logit) regression model for this analysis given its ability to analyse associations with our variable of interest (splitting the sample into high and low achievers in numeracy). All variables included in the descriptive statistical analysis were initially included in the model specification, although

[38] As described in Section 3.5 of the HMT Magenta Book

due to multicollinearity (high correlation between predicting factors) some variables were subsequently removed from the model. In early versions of the model, literacy attainment had a very high positive association with numeracy attainment, but it was removed from the model because it was effectively proxying for numeracy attainment. The variables included in the final model specification were:

- Numeracy attainment level (Numeracy attainment of Level 2 of above OR below Level 2)
- Age (in years)
- Sex (Female OR Male)
- Ethnicity (black, Asian, or another ethnic minority OR white ethnicity)
- Self-reported satisfaction with life (proxy for health and wellbeing, on a 7-point scale)
- Frequency of using online banking (proxy for digital literacy)
- Housing tenure (social housing, privately rented, owner-occupier)

Estimates can be interpreted as the percentage point (ppt) change in the likelihood of having low numeracy skills for a change by one unit in the value of the predicting variable, taken at the sample average. For categorical variables, the effect is estimated with reference to a comparison group.

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