

## **Numeracy Skills and the Numerate Environment: Affordances and Demands**

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### **Abstract**

In the 2012 PIAAC Survey of Adult Skills of 23 industrialised countries, the UK (England & NI) scored below average on adult numeracy. Several recommendations focus on the need for (some) individuals in the population to undergo training. Yet, even in “high-performing countries” like the Netherlands, many adults (1.5M) score at or below PIAAC Level 1 (sometimes designated as “functionally innumerate”). The question arises as to how all of these people manage in important domains of their lives. In this article we aim to consider the context of the exercise of numeracy by adults, drawing on earlier research in mathematics education. We examine a recent conception of an adult’s ‘literate environment’ (EU HLG on Literacy, 2012), and extend this to reflect on the idea of an adult’s ‘numerate environment’. We consider the range of practices that particular adults may engage in, and the demands that these may make on the adult, the affordances the practices may offer; the latter include the opportunities, and the supports and / or barriers produced within these practices, and in cultures more generally, that may foster or impede an adult’s ongoing numerate development. We give examples of each of these aspects of adults’ numerate practices, and consider implications for the teaching, learning and development of numeracy.

Key words: numeracy, assessment, PIAAC, skills

## Introduction

In the 2012 PIAAC Survey of Adult Skills of 23 industrialised countries, the UK (England & Northern Ireland) is one of ten countries which scored below average on Numeracy. (It scored above average on Adult Literacy and above average on “PSTRE” (“basic IT skills” or “digital literacy”).) The Numeracy results, in particular, were widely hailed in the media as “not good” (Yasukawa, Hamilton & Evans, 2016). Even in “high-performing countries” like the nearby Netherlands, many adults (1.5M, out of just over 11M aged 16-65) scored at or below PIAAC Level 1, and thus are seen as “functionally innumerate”. In spite of their different positions in the overall rankings, these two countries, and many others, appear to share a common policy problem, namely what is to be done about such apparently significant groups of adults?

Some of the remedies proposed focus on the lacks, or deficits, on the part of (at least some) adults in the population. On this view, the solution is training, mostly via formal learning such as in “basic skills courses” at college. However, we also know from sources such as the EU Adult Education Survey and PIAAC itself that adults who seem to have the most need are the least likely to engage in formal adult education courses.

We might ask: How do all these people manage in important domains of their lives? Perhaps they are more at ease than some policy makers allow (Grotlüschen et al., 2016)? This echoes earlier findings that respondents consistently self-rated their level on literacy and numeracy higher than they “should have”, given their scores on the previous OECD sponsored surveys, the International Adult Literacy Survey (IALS), and the Adult Literacy and Lifeskills Survey (ALL), as well as on national surveys like the Skills for Life assessments in the UK (e.g. Ekinsmyth & Bynner, 1994; Henningsen, 2006).

Perhaps adult skills policy makers and most adult citizens are living in different worlds?

How can we begin to characterise the worlds that most adults live in? We propose that an ecological perspective of the affordances and opportunities adults have for numeracy development may be fruitful (see for example Barton (2007) and van Lier (2000) for an ecological perspective on literacy, and on language learning).

## Understanding the Contexts of Adults’ Lives

Ecological issues have been taken up in mathematics education research, in long-standing discussions aiming to understand the notion of *context*; see e.g. Bishop (1988); Evans (2000); Lave (1988); Lerman (2000); Nunes, Schliemann & Carraher (1993); Walkerdine (1988); and many others. Studies in adult literacy and adult numeracy have also contributed to this research base.

One major strand of these broadly “sociocultural” approaches considers the world of adults to be “*constituted*” (framed materially, conceptually and socially) *by the practices the adults are engaged in* (e.g. Evans, 2000). How can we know about these practices?

It would appear that we can approach these practices in two ways: top-down (“generalising”, Evans, Wedege & Yasukawa, 2013) or bottom-up (“grounded”). For top-down (“generalising”) analyses, we can analyse hypothetical sets of practices that *adults in general* may engage in. For example, Bishop (1988) described six very general mathematical activities that he considered people in virtually all cultures to be engaged in: *counting, locating, measuring, designing, playing and explaining*. National and international assessments nowadays take a similar approach: for example, the PIAAC Numeracy framework postulates four *contexts* that its items can refer to: work-related, personal, social and community; education and training (PIAAC Numeracy Expert Group, 2009). These approaches assume that claims can be made about numeracy practices that apply across and beyond any particular local contexts; they seek to explain numeracy at a *global* level.

Alternatively, the analysis can be done in a bottom-up (“grounded”) way - by analysing the sets of practices that a particular group or community of adults may engage in. For example, Barton and Hamilton (2012) described the literacy practices of a community of adults in the northern English city of Lancaster. Street, Baker and Tomlin (2008) have studied numeracy practices, at home and at school, but mainly for school pupils. Marta Civil has explored the involvement of (bilingual) parents in mathematics education in the US state of Arizona (e.g. Civil, 2007). These approaches privilege the *local* meanings and practices of literacy and numeracy.

The tensions between the “generalising” versus “on-the-ground”, or the global versus the local, continue to be a source of frustration for ethnographic researchers who are concerned about the lack of traction in policy debates of their findings about the real, lived experiences of adults in their everyday contexts; on the other hand, policy makers struggle to see how policies can be based on research findings that are each so contingent on the particularities of the sites of the research. In their critique of a binary approach to literacy research, Brandt and Clinton (2002) argue the “limits of the local”, that is, “many human contexts are given to the activities of de-localizing meaning” (pp. 354-355): literacy “travels, integrates and endures” across different contexts (p. 337).

We can consider examples of different types of settings where adults might be expected to exercise their numeracy in contemporary industrial societies. For example, citizens are presented with statistics, often a plethora of statistics, during election (or referendum) campaigns in Western democracies. But what appear to be numerical riches are often less helpful than they seem. Political parties often fail to give the basic numerical (or other) information that any citizen would need, in order to be able to make informed decisions; e.g. the UK Conservative party’s refusal in the 2015 UK election campaign to specify where their £12 billion pounds of welfare cuts would be coming from over the next 3 to 5 years<sup>2 3</sup>.

Consumers are nowadays presented with much “choice”, e.g. in the decision about what energy tariff to take up with which company, whereas in earlier periods, they may have had little “choice”, especially if the sole provider was a nationalised industry. However, people have suspected many free-market firms of trying to obscure and confuse customers, by the complication or proliferation of pricing. In 2014 the UK Energy ombudsman responded by requiring energy firms to reduce the rich proliferation of tariffs ([https://www.ofgem.gov.uk/sites/default/files/docs/2014/03/assessment\\_document\\_published\\_1.pdf](https://www.ofgem.gov.uk/sites/default/files/docs/2014/03/assessment_document_published_1.pdf)). Since then, the UK Consumers’ Association has made a “super-complaint” to the Competition and Markets Authority (CMA), about supermarket retailers’ use of multi-buys and different pack sizes. “We’ve found retailers are confusing customers with tactics that exaggerate discounts and manipulate shoppers, so we’re using our legal powers to take the issue to the ... CMA” (*Which?*, 2015).

Another case of trying to aid consumers in understanding what is being offered in the market has been the passing of legislation regulating the use of data, in advertising ‘pay day loans’. These examples suggest that numerical proliferation *in itself* does not necessarily provide clear information, nor facilitate confident “choice”.

In workplaces, the power relations in the workplace can hinder or extend workers’ mathematical knowledge. In Williams and Wake’s (2007) study in an industrial chemistry lab, the workers were

<sup>2</sup> Nevertheless, we do not suggest that data can ever be presented in a way that the theoretical or policy “implications” are straightforward: there is always room for debate / controversy. For example, one of the authors (Creese) led a workshop where adult teacher-trainees were challenged to come up with different conclusions about immigration in the UK, after being provided with the same official data on immigration.

<sup>3</sup> We can nonetheless begin to think about the amount involved in this way: If over 3 years, that is “only” a cut of £200 pounds per citizen of the UK (population 60M+) *on average* ... But, if concentrated on the poorest 10% of the population, it is £2000 over 3 years! See the suggestions for making big numbers meaningful in Blastland & Dilnot (2008, p129).

responsible for providing data to their manager, but were completely “black-boxed”, or excluded from information about the detailed workings of the calculation process, because the managers controlled the models that produced the calculations and the resulting decisions themselves.

Thus, the lack of numeracy apparently exhibited by adults is produced by a range of social institutions and practices, and thus any “blame” should really be shared across society, and not attached only to the adults themselves. We need to acknowledge the role of the powerful – individuals, political parties / governments, media and corporations – in determining the availability and the shape of the *choices* that are available, and of the *information* that is available, whether in textual or numerical (or digital) form. In particular, free-market businesses seem intent above all on “persuading” the individual to “consume”.

Therefore, when studying adults’ use of numerical (or other) information, we must take account of the “information providers (and gatekeepers)”, their powers and their methods. So far, rather than providing *opportunities* to use numeracy in a thoughtful way, or *supports* for this, these examples suggest *barriers* to the development of adults’ numeracy, in society at large. This suggests ways in which we might begin to think about the context of an adult’s numerate practices – what we might call their “numerate environment”.

### The Literate Environment

In order to build up an understanding of what the numerate environment might entail, we now consider recent developments in the conception of the “literate environment”. In 2012 the European Commission convened a group of experts in the field of literacy (EU HLG) to carry out a review of literacy policy across Europe in response to what they termed Europe’s ‘literacy crisis’

...each year, hundreds of thousands of children start their secondary school two years behind in reading; some leave even further behind their peers. This has damaging consequences for their futures. And millions of adults across Europe lack the necessary literacy skills to function fully and independently in society.

(EU HIGH LEVEL GROUP OF EXPERTS ON LITERACY 2012: 11)

In their final report the EU HLG suggested that adults’ skills respond to and are shaped by the literate environment in which they act. The notion of the literate environment is drawn from the world of development education, in particular the work of Peter Easton for UNESCO. Easton uses the term literate environment as “...*a means of designating the contextual conditions and support required – both locally and externally – to make literacy fully sustainable.*” (Easton 2014, p20).

The EU HLG concludes that adults’ skills respond to and are shaped by the “literate environment” in which they act and proposed the creation of ‘a more literate environment’ as one precondition for success in tackling low levels of literacy among the European population. Their recommendations include:

- books and other reading materials should be easily available at home, in schools, libraries and beyond, on paper and online
- libraries should be set up in unconventional settings such as shopping centres or train stations
- parents “need help to improve their skills and confidence to engage their children in language development and reading for pleasure”
- reading promotion policies should stimulate reading and access to books, by organising media campaigns, book fairs, public reading events, competitions, and book awards”
- there is a “need to shift the mindset of all players in society – from parents to policy makers, from social and medical services to educational players, and from individuals

themselves to businesses – so that they see their engagement is crucial to promoting reading and writing (EU-HLG, 2012, p8).

The Report seems to offer mixed recommendations. On one hand, it wishes to encourage “adults to acknowledge their (sic) literacy problems”. Yet it also wants to encourage provision of “a variety of personalised learning opportunities” to “encourage providers of vocational education and training, and vocational teachers and trainers, to embed literacy instruction within their programmes [and to] recognise and validate non-formal and informal learning, putting a premium on adults’ achievements in experiential learning and tacit knowledge consolidation” (EU HLG, 2012, p12).

Nevertheless, the EU HLG argues that the responsibility for the literacy skills of adults (or the “lack” thereof) should be understood as *shared across society*, not as the individual responsibility of the adults themselves. And, in pointing to the *availability* of texts, the EU-HLG is emphasising the *opportunities* for exercising literacy skills in an adult’s everyday life.

### The Numerate Environment

The High Level Group considered mainly literacy, in a broad sense. But, for our purposes, it is worth considering the concept of the *numerate environment*. Here we might notice that the “stuff” of the literate environment envisaged by the EU HLG was a range of different *texts and opportunities and support to engage with them*. What might be the analogue of these texts for the case of numeracy?

One possible answer is *information*, particularly quantitative information, numbers, represented in various forms, such as tables – but also including visual forms such as graphs and maps, and dynamic forms of these available from the use of modern IT: information in a numerate environment, like texts in a literate environment, is multimodal (Street & Baker, 2006). Numeracy practices involve the production of information, as well as its interpretation, use and critique<sup>4</sup>.

If we note that information is becoming increasingly *available*, this could mean that *opportunities* to exercise numeracy are increasing. In this section, we give examples of opportunities (and supports) for numeracy mainly from the UK – but the work of these agencies is more widely accessible on-line, and we are confident that there are similar ones in many other countries. For example, the Open Data Institute (<https://theodi.org>) is an independent, non-profit organisation, based in London that aims to promote the availability and the use of many kinds of data, especially state statistics. The UK National Statistical Office (<https://www.ons.gov.uk/>) is the producer of a wide range of official statistics on the functioning of the UK economy and society, and has recently been working to make its website more user-friendly<sup>5</sup>.

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<sup>4</sup> While we focus on information as one possible analogue to literacy’s “texts”, it is important to acknowledge that there are other possible analogues; one is “tools”, for example those of carpenters, whose use requires an embodied learning of the angle and distance to position various parts of the body, and the amount of body weight to put on the tool or the material it is working on to achieve the desired result.

<sup>5</sup> But the story is somewhat mixed. For example, many people are excited by developments that are sometimes grouped under the title of “Big Data”; this includes previously unimagined streams of information, collected on peoples’ behaviours, choices, purchases and opinions, from surveillance cameras, loyalty cards, social media, etc. These data are often harvested by the state – but they are more and more gathered by private corporations – and both types of institutions often resell the data to other private bodies. This is the long-awaited *information society*! There are likely to be fierce struggles over the ownership of, access to, and control of data, e.g. medical records. Inquisitive citizens, who are concerned to understand better the workings of society, may have to struggle to maintain access to such data, even though they may have been among the original “producers” of it.

However, people will not necessarily find it easy to start using information, especially numerical information. Accordingly, we must investigate (and publicise) *supports* for ordinary citizens in exercising numeracy. We mention a number of these:

- Fact-checking agencies, which often offer free scrutiny of the statistics (and the logic) of claims about public policy or the achievements of political parties, e.g. Full Fact [<https://fullfact.org/>]
- Professional volunteers, which can be contacted in the UK, through the Royal Statistical Society (RSS) [[http://www.rss.org.uk/RSS/Get\\_involved/Volunteering\\_opportunities\\_at\\_the\\_society/RSS/Get\\_involved/Volunteering\\_opportunities\\_at\\_the\\_society.aspx?hkey=ad2eab87-9813-4274-bc8d-44f0751e827b](http://www.rss.org.uk/RSS/Get_involved/Volunteering_opportunities_at_the_society/RSS/Get_involved/Volunteering_opportunities_at_the_society.aspx?hkey=ad2eab87-9813-4274-bc8d-44f0751e827b)] or the Radical Statistics Group (Evans & Simpson, 2016), RSS; or in the USA, through Statistics without Borders [<http://community.amstat.org/statisticswithoutborders/home>]
- Broadcasters: e.g. BBC Radio 4 “More or Less” [<http://www.bbc.co.uk/programmes/b006qshd>]
- Books, journals and websites produced by campaigning organisations such as Radical Statistics [<http://www.radstats.org.uk/>]; for example, *Statistics in Society* (Dorling & Simpson, 1999) and *Visualising Information for Advocacy* [<http://visualisingadvocacy.org/>].
- the wider culture: norms about presentation / discussion of numerical information (Blastland & Dilnot, 2008).

There is one agency that may not be replicated in many other countries: the UK Statistics Authority, which in certain cases can be asked to rule on a tendentious claim about the meaning of government statistics made by the media or by a politician, even the Prime Minister [<https://www.statisticsauthority.gov.uk>]

The *opportunities* and *supports* to exercise numeracy go hand in hand; without adequate and appropriate supports, individuals may not be aware that there are opportunities for numeracy development. Information on its own doesn’t present itself as an affordance in the same way to all people; “[w]hat becomes an affordance depends on what the organism does, what it wants, and what is useful for it” (van Lier, 2000, p. 252). Thus, besides the opportunities and supports for exercising literacy and numeracy skills at work, at home, and in the community, we should also ask: what are the *demands* for exercising such skills? If they are few, and if adults are not required to do calculations, or read graphs, or think about tables of data – as a consequence their skills may fail to develop, or even *decline* (Murray, 2009; Reder, 2009). This would leave a large sub-class excluded from the numerate environment, and relying on others for interpretation and access to information.

To sum up: We see three key aspects to a literate or numerate environment:

- the *demands* that the practices may make on the adult.
- the *opportunities* the practices may offer to the adult engaged in them
- the *supports / resources* offered, or conversely the *barriers* existing (or put up) within these practices, and cultures more generally, that impede the adult’s numerate development

We might group *opportunities* and *supports* under the heading of *affordances*; see for example, Greeno (1994). Supports means ways in which purposeful engagement with numeracy is made more achievable; that is, there is scaffolding that enables the learning adult to build from what they already know to achieve something they had previously not been able to achieve. So, while a literacy support might be through the use of language that is comprehensible and making features of the particular text type and how they help to achieve particular social purposes visible,

a numeracy support could also involve clarifying the social purpose of the information, how it is constructed and how the different elements are serving the purpose. Thus social interactions, either with an expert / teacher or with peers are important aspects of the meaning-making that is involved in numeracy development.

So if we, as educationalists consider numeracy courses to be the best support we can provide, it is a matter of concern that take up of these courses remains surprisingly low (if we accept the findings of surveys such as PIAAC). This may be because learners do not see these courses as relevant supports for them. A recent research project conducted by NRDC at UCL Institute of Education, into the impact of low levels of basic skills in the workplace, found very few employers or employees who saw a great need for staff to embark on a functional skills qualification, but there would have been interest in short courses on, for example estimation or interest rates (Carpentieri, Litster & Mallows, 2016).

Moreover, in considering learning needs for workers, Worthen (2008) identifies two different objectives in the workplace: one that is linked to increasing productivity, and one that is linked to the workers' "earning a living". In other words, the learning opportunities that may be readily offered by the employer are likely to be linked to numeracy (and other skills) that would increase the company's profit margins. However, learning opportunities that help the workers to negotiate better conditions and pay are unlikely to be forthcoming from the employers, and in many contemporary de-unionised workplaces, unlikely altogether (Yasukawa, Brown & Black 2014). Similarly, those struggling to get by on low incomes may see little affordance from enrolling in a maths course – but may see the support offered by a short course on debt management. This obviously confirms standard theories of adult education, that adults engage with learning when they see a clear need for that education. The point here is that affordances need to be aligned to the individual's numerate environment.

At the same time, we also need to highlight the opportunities for collective numeracy – i.e. numeracy as practices and skills created and held by groups, e.g. through trade union organising (Bond, 2000; Yasukawa & Brown, 2013; Kelly (2016). This is particularly important - but also challenging - in many workplace contexts where the ability for workers to organise has been eroded with the decline in the role of trade unions, substantially diminishing workers' collective identity.

Within the home environment the most important actors in defining the numerate environment are parents. Their attitude to maths and numbers is crucial to setting norms to children. A household that values numeracy and how numeracy can enhance the family is likely to produce children and future adults who do not accept poor standards of numeracy (Civil, 2007). For this reason, Family Learning may be seen as having a potential impact, as it encourages children and parents together to build a better and more coherent numerate environment. However, such programs need to be sensitive to all of the dimensions that have constituted these family groups including the linguistic, cultural, historical, and economic (see for example Chodkiewicz, Johnston and Yasukawa, 2005).

### Conclusions

The idea of a literate environment offers a way to think about the context of literate thinking and literate acts, and we think these ideas can be extended to numeracy. Describing the numerate environment for adults in the ways suggested above, leads to better understanding of adults' uses of numeracy and how they can be supported. In this paper we have begun to construct a characterisation of the literate / numerate environment as including *opportunities*, *supports* (and *barriers*), and *demands* for workers and citizens to use their literacy and numeracy skills.

Our knowledge of the types of, or extent of, literacy and numeracy practices in which adults are encouraged/required to engage is currently inadequate for our purposes. Unless we fully



understand the demands on adults' numeracy skills we will not be able to design learning programmes that support adults in meeting those demands as well as credibly demonstrating to employers, and others, that they can meet those demands. Such learning programmes may encourage more adults to improve their numeracy. What's more, low demands on adults' numeracy may have serious long-term consequences for individuals and societies. We know from Reder's (2009) research, as well as PIAAC, that skills use and skills proficiency are linked:

adjusting for educational attainment and language status reveals that the positive relationship between practice and proficiency is strong. That is, adults who practice their literacy skills nearly every day tend to score higher, regardless of their level of education. This suggests that there might be practice effects (...) that influence proficiency (OECD 2013, p. 212).

It may be that the demands on many adults' numeracy skills are low, or that they have developed strategies to largely avoid the use of numeracy, leading to a vicious circle of underuse and consequent loss of skills.

To help us to understand these issues we need to bring to bear qualitative research (e.g. Barton & Hamilton, 2012; Street, Baker & Tomlin, 2008) on literacy and numeracy practices that adults are encouraged / required to engage in – and on the consequences of low demand / mismatch between adults' actual practices and those that are required for engagement in society.

At the same time, we need to develop our understanding of how learning and development unfolds in a numerate environment. To this end, our focus on affordances (Greeno, 1994), including opportunities and supports / barriers, and demands suggests that notions of learning as a goal-oriented activity, the zone of proximal development, and the role of mediating tools / people from Vygotsky's (1987) individual learner-focused, and later Engestrom's (2001) team-focussed, versions of cultural-historical activity theory may offer productive tools to pursue studies, both of individuals and groups within numerate environments.

Finally, we must highlight the opportunities for collective numeracy – that is, numeracy as practices and skills created and held by groups, as discussed above. From a more general perspective, Blastland and Dilnot suggest that some of the changes required have to do with what one might call *culture*: “A culture that respected data, that put proper effort into collecting and interpreting statistical information with care and honesty, that valued statistics as a route to understanding, and took pains to find out what was said by the numbers we have already got, that regarded them as something more than a political plaything ... would, in our view, be the most valuable improvement to the conduct of government and setting of policy Britain could achieve.” (2008).

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