

Numeracy - an underestimated domain of the basic education?

Selected research findings

Anke Grotlüschen

Klaus Buddeberg

Gabriele Kaiser

Abstract In this article, terms and the state of research on adult numeracy are compiled in a systematic way. The findings and theories are selected according to their relation to the German-language discourse of adult education and at the same time embedded in a historical context as well as in international discourse. Many recent findings confirm Jean Lave's approach in that numeracy differs from school mathematics in the high relevance of rules of thumb and estimates as well as in less formal procedures. Numeracy is therefore often not understood as mathematics and remains rather invisible. Numeracy practices are based on social power relations. The assertion of one's own interests is also based on numeracy—for example in financial literacy, in the health system or in the use of statistical data. Last but not least, numeracy skills and practices go hand in hand with better living conditions.

Keywords: Numeracy · Adult basic education · New literacy studies · Numeracy as social practice · PIAAC

1 Introduction and procedure

"Numeracy" is understood in the following, with reference to early works by Jean Lave, as a recourse to numbers and data in everyday life, whereby estimates and plausibility checks, simplifications and rules of thumb are also applied (Lave 1988). The research field of adult numeracy characterized in this way has not yet been highlighted as a topic of the "Zeitschrift für Weiterbildungsforschung", the "Hessische Blätter für Volksbildung" or the "Zeitschrift weiter bilden". In contrast, the objects of research have alphabetisation, Literalism or basic education of adults in various places to receive the status of a book topic.¹

Research and practice expanded since 2005 in the course of BMBF funding in this field also focuses mainly on literacy, but not on numeracy. There are only two practical projects within these funding lines: on the one hand the project "Curricular Networking - Debt Counselling" as a starting point for basic education (CurVe) for financial basic education under head of the German Institute for Adult Education (Mania und Tröster 2014). As well as the "Rahmencurriculum Schreiben und Rechnen" (framework curriculum for writing and arithmetic) of the German Volkshochschulverband.² The LEO study also focuses solely on literacy, not on numeracy (Grotlüschen et al. 2019b).

¹ For example in REPORT - Zeitschrift für Weiterbildungsforschung (Issue 3/2011 and 1/2012), in Hessische Blätter für Volksbildung (Issue 2/2014) or in DIE Zeitschrift für Erwachsenenbildung (Issue 1/2009 and 3/2014).

² <https://www.alphadekade.de/de/ein-lehrplan-fuer-die-grundbildung-1833.html>.

In England and France - two countries responsible for the development of the German literacy promotion - the literacy and numeracy of adults were surveyed in two population-representative studies each (ANLCI - Agence Nationale de la Lutte contre l'Illettrisme 2005; DfES 2003). The follow-up studies showed stagnation or slight improvement in literacy, however, the deterioration in numeracy (Harding 2011; Jonas 2012).

For Germany, data on adult numeracy since the PIAAC survey are available (Rammstedt 2013). A use of these data is, however, at least hardly available in German adult education and is most likely to occur in the future in Austrian adult education (Schlößl 2016). In addition, in German-language literacy research there is more of a reference on theories from the field of New Literacy Studies (comprehensive information on this can be found here: Linde 2008). This can be achieved by working on the basis of hierarchical competence models (Rammstedt 2013). Both theoretical approaches are also valid with regard to the numeracy of adults in international space and produced extensive Research activities (Evans et al. 2019; Gal et al. 2009; Tsatsaroni and Evans 2014), but they have hardly been received in Germany to date.

Due to this dominance of literacy research over numeracy research the first question to be asked is whether numeracy has a relevance for adults who is not already covered by literacy. Literacy seems to be indispensable. But is there a need for everyday mathematics in adult life? To answer this question will be presented in a historical excursus on Adam Ries' arithmetic book as well as questions of working-class education.

Furthermore, the question arises as to which specific subpopulations are to be found in better or worse, and in which manner there are participation restrictions with low numeracy. Such questions are typically asked by with population representative data sets. On the other hand there are questions the diversity of numerical practices better in the theoretical discourse of numeracy as Social Practices. This also favours qualitative-empirical Procedures. Both strands of theory and empirical approaches are increasingly being received (exemplarily for a special issue of the journal ZDM Mathematics Education, cf. Askew, 2015). In addition, work has been carried out on in the wake of the PIAAC studies and the Numeracy as Social Practice approach.

On the basis of these discussions, a research project was launched in Germany in 2014, consisting of six subprojects. This was completed in 2017 by the Hamburg State Research Fund and has been carried out since then. The six subprojects are staffed in such a way that a series of qualitative or secondary analytical-quantitative work on numeracy.³ The following overview now covers the following topics and research questions which have been discussed in the discussion contributions of the past years were brought to speech. In this process, the language learned from German adult education on the numeracy of adults. Embedded this discourse becomes part of the two discourse strands that originally influenced German literary research: on the one hand, competence research that is representative of the population; On the other hand, competence research that is representative of the population and New Literacy Studies.

A selection had to be made. On the one hand, we base our explanations on findings on Numeracy as Social Practice, which was already published in 2018 in an anthology, which also contains contributions from a wide range of different countries ("Numeracy as social practice. Global and local perspectives"). From these, those contributions have been selected in which the hegemony-critical theoretical

³ To anchor its own contributions, an interdisciplinary conference with around seventy lectures was held. (2018).

approach is particularly clear. On the other hand, passages are reported, which examine the history of research from the perspective of Numeracy as Social Practice report.

The selection from analyses of the PIAAC studies starts with the main results OECD publications concerning the relevance of numeracy. These findings are then differentiated by subgroup-specific differentiations from the adult education research in Germany. Findings from the international PIAAC Conferences of the OECD and the US PIAAC Conferences have been received, but postponed. They show, however, that numeracy has received a great deal of attention, and in the meantime has also been included in a thematic report of the OECD (Jonas 2018). Internationally, adult numeracy is certainly becoming more and more but in Germany it has so far been rather limited.

The discussion on financial literacy, on the other hand, has its place in of German-language adult education research is solidly established, as can be seen in the of the publication activity. Even if it is not in the narrowest sense about numeracy research the contributions are, in our opinion, to be appreciated, because they contribute to the pioneers of German numeracy research. The aim of this contribution is to explore the topics of numeracy research for a German-speaking audience in adult education on the basis of the above-mentioned to prepare discourses. Quantitative approaches meet qualitative ones. He benefits from the perspectives of mathematics didactics, social work and the Adult education.

First, we ask about the relevance of adult numeracy and thus place numeracy within the framework of normative, enlightened or humanistic Efforts. This is followed by conceptual classification and demarcation of other concepts. The following historical view shows less the humanist-normative efforts, but rather the corresponding findings. This is followed by the discourse on Numeracy as Social Practice. The financial literacy that bonds take in both discourses is then appreciated. Subsequently, secondary analyses from the competence research received. A special space is devoted to the bundled representation of the most recent Publication of assumed results from German numeracy research one. Since these analyses provide the basis and framework for the entire ZfW magazine, this summary takes up a little more space. It is about distributed publications that have not yet been aggregated at any point. In summary a need for action is indicated: This can be practical, political or in-depth research. Last but not least, research desiderata are reported, especially the need for theoretical clarification.

2 Does Numeracy Matter? On the Relevance of Numeracy

The meaning of numeracy is today officially equated with that of literacy, as in the Decade for Literacy and Basic Education in Germany (Federal Ministry of Education and Research and Standing Conference of the Ministers of Education and Cultural Affairs of the regions in the Federal Republic of Germany 2016) and in the Sustainable Development Goals of the United Nations. These include an area for education (Goal 4). In it on the literacy and numeracy of populations worldwide (Objective 4.6).

However, this parallelism of the meaning of literacy and numeracy is not reflected in the research is still in practice, adult numeracy has long been considered time as insufficiently researched and theorized (Coben 2003; Carpentieri et al. 2009). "Much of the research on numeracy is schools-based, the bulk on teaching the individual elements and operations of numeracy. Adult numeracy is a relatively new concern" (NRDC Institute of Education 2010, p. 5). Meanwhile the international numeracy research (Askew 2015).

The term "numeracy", used in adult education, is used by mathematical literacy", which is predominantly used in school research, to distinguish. For adults, everyday actions (estimates, rough calculations or measurements) to carry (Lave 1988). This is followed by the tradition of situated literacies, also known as Literacy as Social Practice (Grotlüschen et al. 2019c). And recently, theoretical references to and empirical studies on Numeracy as Social Practice (Yasukawa et al. 2018).

On the other hand, in the wake of large scale assessments, in particular with the International Adult Literacy Survey (IALS) since the mid-1990s, literacy and numeracy on the political agenda. Numeracy is in many countries a decided part of basic education or literacy strategies for adults (e.g. England, Australia, France, Germany). In international discourse, adult numeracy has been dealt with in various ways (Coben 2003; Gal et al. 2009; Carpentieri et al. 2009) and often to critical thinking (Askew 2015; Geiger et al. 2015a, 2015b).

3 Literacy, basic education, everyday mathematics, competencies and practices

3.1 From literacy to basic education

"Basic education" includes reading, writing, arithmetic and financial, health and social skills, digital and political basic education (Duncker-Euringer 2017; Tröster 2000) and successively solves the concept of "literacy" limited to the acquisition of the written language (Abraham and Linde 2010). Although 2011 is expected to be a National Strategy for literacy (Conference of Education Ministers Working Group on Continuing Education 2015) and, since 2015, a National Literacy Decade, but a broad canon of competence domains is already laid out in it, which is the term "basic education" corresponds more to that of "literacy".

In German-language adult education, everyday mathematics is a part of the canons of basic education, such as a qualitative-empirical dissertation on the term (Euringer 2016b, 2016a). As a result, everyday mathematics is used in many ministries of culture and among key players of the Decade for Literacy, unanimously as part of a basic education canon. In addition, there is a literature research institute that is crosswise to international literature research definition of basic education (Tenorth 2004). This sets "basic education" as a prerequisite for subsequent education. If one understands the term in this way, then the he doesn't subdivide into subdomains. This is precisely what the international discourse but was carried out and was introduced into the German discourse, e.g. to basic health education (Schaeffer et al. 2016), basic political education (Menke and Riekmann 2017), digital basic education (Wolf and Koppel 2017) or financial education (Wolf and Koppel 2017). Basic education (Mania and Tröster 2015). That we are not talking about simple basic adjustment formation, has been pointed out elsewhere (Grotlüschen 2018, p. 1269). Reading and arithmetic, as the historical review shows, were resolutely promoted for the purpose of reconnaissance.

3.2 Everyday mathematics as part of basic education

The terms "everyday mathematics", "numeracy" and "numeracy" are used in this contribution is used synonymously and distinguished from "school mathematics". Everyday Mathematics is distinguished from school mathematics by the fact that the precise calculations successively give way to the rollover (Lave 1988, 1993), and that the latter is often not perceived as mathematics (NRDC Institute of Education 2010). However, according to Coben (2003) and Tout (1997), numeracy is not about less than mathematics, but more than that, for it contained the use of Mathematics in all its facets, such as space and time, dimensions, data and statistics etc. in order to generate meaning from the practical

world: "That is why we can say that numeracy is not less than maths but more. It is why we don't need to call it critical numeracy - being numerate is being critical" (Tout 1997, p. 13).

The concept was developed in competence research in the OECD study Programme for the International Assessment of Adult Competencies (PIAAC) on Adults (to be understood with PIAAC as persons aged 16 to 64 years):

In PIAAC, (...) everyday mathematical competence refers to the ability to make mathematical information and ideas accessible, to apply them, to interpret and communicate, in order to be able to work with mathematical dealing with requirements in different everyday situations of adults (Zabal et al. 2013, p. 47).

The definition refers to competences that are reflected in contextualised practices.⁴

3.3 From (numerical) competences to (numerical) practices

The paradigm shift from competences to practices is also theoretically linked with the movement of New Literacy Studies (Street 2003). The adult concept of everyday mathematical practices is based on ethnological Studies, led by Jean Lave, which developed the approach of the Communities of Practice on the basis of West African field research (Lave and Wenger 1991; Lave 1993). One of her students, Stephen Reder, was able to US-american longitudinal section with young adults show that literary skills with and without teaching only slowly improve, while literary practices (Reder 2011).

"Competences" are action dispositions that can be used in a situation-specific way. They are also regarded as acquirable (Klieme and Hartig 2008). "Practices are competences used in a situation-specific way. A Practice is not understandable without the situation (Barton and Hamilton 2003).⁵ In the meantime, competence research in the PIAAC study has been expanded to include background questions the use of expertise has been expanded. In addition to the psychometric test of numeracy was also discussed in the background questionnaire after the use of numerical skills (these are referred to as "skill-use questions", as "questions the use of competence" or referred to as "numerical practices"). Independent empirical effects of the use of competence (under control of sociodemographic variables and the tested competences), Stephen Reder, among others, can be (Grotlüschen et al. 2016).

4 Gutenberg and Ries: Reading and Arithmetic for Popular Enlightenment

Reading competence from Luther's translation of the Bible to Gutenberg's book printing and to Wilhelm von Humboldt's language-oriented educational ideal as the core of the enlightenment and emancipation (Conrad et al. 1998), even though Humboldt in the Königsberg syllabus also emphasises the role of mathematics (Humboldt 1809). The history of reading by adults stretches from the reading

⁴ In the context of the PIAAC study, the following contexts are given: "In private everyday life, for example in the case of domestic repair measures or when determining a route. At work, for example at drawing up budgets or cost estimates, reading building plans or carrying them out of measurements. In the social context, for example to understand social issues through statistics such as crime and health statistics. In the context of education and training further training, for example for commercial courses" (Zabal et al. 2013, p. 48).

⁵ For example the writing down of food names in vertical order is a sign of written language competence, but only in the situational context does it become the practice of a shopping list.

circles of the bourgeoisie to the on the workers' movement (Conrad et al. 1998; Trumann 2009).⁶ As well as Gutenberg's Bible (1452-54) as a milestone in the history of popular enlightenment Adam Ries' second arithmetic book (1522) can be interpreted as a milestone in the history of arithmetic. And this is also true for Ries in the service of improving the living conditions of the ordinary population. He explains his book in the preface as follows: "So that the poor common man might bread purchase" (Deschauer 2013, p. 155). Instead of the Roman Numbers were spread so the decimal system, especially merchants and craftsmen benefited from this (ibid., p. 2).

Arithmetic is indispensable for coping with everyday life, just to combat wage fraud and to prevent overreaching. Mathematical didactics has been answering these questions since decades, essays in the field of "wage increases" were published. in mathematical treatment" by Getrud Effe and others (1976). Gabriele Kaiser was able in the 1980s (Kaiser-Meißner 1986) to show how factual calculations, i.e. applied arithmetic, are performed in the course of industrialization. was introduced. It became necessary for the rural population, who were increasingly worked or had to work in the factories, could deal with sizes, i.e. with money, weight and length measurements as well as time spans. The latter are particularly important, as is clear from the factory rules, which ensure compliance with the punctual the start of work for the former farm workers, who are attached to the natural environment. were accustomed to time rhythms, interspersed with draconian punishments.

In addition, there is the application orientation practiced at the grammar schools. With the beginning of the second industrial revolution, which was in particular a revolution of the optical industry, it became necessary to teach pupils (at that time there were only boys) as much as possible to train that they could take up an engineering study (so-called "Meran curricula" from 1904).

Under the title "An objective, but dangerous arithmetic lesson" Otto published Felix Kanitz already in 1924 from the perspective of the workers' movement on the necessity of arithmetic. This strand of development was discussed in the discussion of Adult education on everyday mathematics has not yet been taken into account. In the literacy of adults, the development of theory is going on, especially under UNESCO influence, on Paulo Freire back, the literacy in the service of the liberation from social oppression (Freire 1996). But the everyday mathematics are not taken into account - wrongly, because Adam Ries too saw his arithmetic book as a means to emancipate himself from illegitimate paternalism (Deschauer 2013). Everyday mathematics can be considered necessary to this extent, to understand political information, to deal with social distribution conflicts to act and to make informed decisions (to the contexts of the cf. Zabal et al. 2013, p. 48; on the state of research OECD and PIAAC Numeracy Expert Group 2009, p. 13).

Numeracy is also relevant in the workplace, as Yasukawa shows. She outlines first central insights from the early studies of Baker, Harris, Lave, Evans and Nunes published during the 1990s (Yasukawa 2018, p. 225). Firstly, this generation was able to show that mathematics in the workplace clearly looks different from the kind of mathematics that is practiced and valued in schools. will be. Secondly, it has already been shown here that mathematical practices at the workplace on the part of the employees

⁶ Under the title "People's Enlightenment", for example, from the perspective of historical scholarship the following is predominantly presented reading, not arithmetic. This is to be found exemplarily with Ernst Hinrichs, who evaluated the curricula in the Oldenburg area: around 1687 "singing, praying, reading the Bible, read in books and letters, repentance done, the Lection recited, after that is written, it follows Interpretation and Question Pieces" (Hinrichs 1998, p. 41), however, 1751 the recitation was a real But above all: reading, writing and - nota bene - calculating have developed themselves to veritablen curriculum" (ibid., p. 42).

not always as mathematical activities are perceived. Thirdly, the transfer of knowledge from the school to the workplace neither straightforward nor unproblematic (ibid.).

The more recent studies continued by Yasukawa since the 2000s years confirm that superiors act as "gatekeepers", the workers mathematical information and only implementation information to the people of this country. Furthermore, inaccurate deficit discourses on numerical practices have been of a younger employee. Last but not least, a dominant discourse on the of superior school mathematics, which is to be seen as a contrast to the numerical practices considered inferior. This again applies according to Yasukawa as a reason that adult workers do not consider themselves as persons to apply or practice mathematics, but only more than someone, who estimates, estimates and checks (loc. cit., p. 226).

5 Numeracy as Social Practice: Contexts and power relations

Yasukawa, Rogers, Jackson and Street (Yasukawa et al. 2018) recently published a collection of essays, which show the development of theory into an overarching concept Numeracy as Social Practice unfolds. The central assumption is that numeracy is not free of value or context, but embedded in power relations. They do not only refer to Street's life's work, but also to three generations of the Cultural-Historical Activity Theory (CHAT) since Vygotsky, Leontiev and Engeström and not least on Lave's early works on situational learning.

The findings first show the extent to which the respective environment of mathematical activities that influence the different numerical practices (Rogers and 2018 Street). Rogers and Street summarize individual studies on New Zealand Kiwifruit-growing, Mexican agricultural work, vocational preparation in Sweden and rice cultivation in the Philippines. In the studies it was worked out that estimates instead of calculations are perceived as faster and therefore more efficient will be. At the same time, it is confirmed that even those who have successfully practice rough calculations, consider themselves as mathematically little competent (Kane 2018, p. 34).

Mathematics is not free of power relations, e.g. between employers and employees. For example, the repayment of debt in a company-owned business in Mexico, precise control of wage slips and promissory notes, in order to avoid the risk of overreaching by the enterprise (Kalman and Solares 2018). This can also be seen in South Africa, where all the curricula apartheid, with the exception of mathematics, which is considered to be neutral was viewed. A South African contribution (Khuzwayo 2018) shows with the title "Occupation of our Minds", that previous curricula have been replaced by this discourse of neutrality are continued, even though they are not in the sense of this theorizing direction are to be understood as neutral.

Khuzwayo argues that under apartheid Regime was by no means intended to teach coloured people mathematics. Thus the power of the white minority should be prevented from being questioned, and would eventually resist. The fact that mathematics is linked to the social context is also evident in Botswana (Nthogo Lekoko et al. 2018). Here numeracy is used in courses for social empowerment, in which everyday numerical practices can be brought up. However, as Australia has shown, improved recognition of numerical practices does not yet result in demand for wage increases, although this process will lead to cost savings for operation (Yasukawa 2018). In this respect, the socio-critical Element of recognition of numerical practices still to be developed. Leave it (cf. Yasukawa et al. 2018):

- Mathematics is invisible in everyday practices.

- Numerical practices are variable and contingent.
- Numerical practices are always related to local circumstances and global discourses (e.g. UNESCO).
- Human beings and objects are linked in numerical practices.
- Numerical practices contain a political element and are therefore not neutral.

In the following step we want to look at research work from the German-speaking area. These relate both to more emancipatory approaches and to large scale assessments. The latter are essentially to highlight unequal opportunities and vulnerability of specific population groups.

6 Financial literacy: The core of financial literacy

Numeracy has overlapping areas with financial literacy. Exemplary is the project "Curricular Networking - Debt Counselling" (CurVe) for basic education, from which a competence model is derived. (Mania and Comforter 2015). The model is explicitly based on more comprehensive financial education. Financial literacy can be seen as part of more comprehensive economic education and forms part of consumer education. (Remmele 2016). Financial literacy, however, explicitly concerns "the existentially basal and directly life-practical requirements of everyday life and the way of life in monetary matters" (Mania and Tröster 2014). These are described in the model in the form of a matrix that identifies both domains of basic financial education (households, money and payments, spending and buying, etc.) and specific dimensions (knowledge, reading, writing, arithmetic). This follows the assumption that financial literacy cannot be limited to arithmetic alone, but also to reading and writing practices and knowledge.

The study LEO 2018 - Living with Low Literality, a Large-Scale Assessment Study, recorded the literacy in the sense of reading and writing competence of German-speaking adults (Grotlüschen et al. 2019b). Although the study does not include a numeracy assessment, the subject area of financial practices and however, basic competences were covered by a number of questions. These questions are mainly based on the theoretical preparatory work of the CurVe project and represent the competence domains described there. On the basis of self-assessments, statements on financial practices and basic competences are thus possible. With regard to finance-related practices, literacy-related limitations are particularly evident when they imply the use of the Internet, for example when using online banking or searching for information in advance of major acquisitions. With regard to the self-assessed functional-pragmatic and above all critical-questioning basic competencies, systematic differences between low-literalized adults can be seen and the total population: Low literalized adults write themselves even significantly lower competencies in the selection of suitable services (telephone provider, electricity provider, retirement provision) or in tax matters. This also applies to the critical and reflective handling of online banking or Installment buying.

7 Results from the Hamburg Numeracy Project

The Hamburg Numeracy Project (2017-2020) provides secondary analyses on the basis of population representative competence studies (TIMSS, IALS and PIAAC), supplemented by UNESCO studies (RAMAA, GAML) and the work of the World Bank (STEP). This serves to develop numerical competencies (Klieme and Hartig 2008) and numerical practices (Lave 1988). Furthermore, numerical practices of vulnerable groups in qualitative analyses (in the case of the of flight and asylum, over-

indebtedness, old age, limited health or disability). The historical dimension will be discussed with eyewitness interviews of the post-war generation.

7.1 Inadequate and declining numerical competences

England and France, which tested both literacy and numeracy in their respective population representative IVQ and Skills for Life studies, report a deterioration in everyday mathematics while improving reading skills (Jonas 2012; Department for Business, Innovation and Skills (BIS) 2012). The PIAAC study published in 2013 (Rammstedt 2013) differentiates the picture. Overall, German adults achieve the following numerical results in an international comparison better performance than reading. The good performance of adults are, however, caused by the most powerful part of the population (Zabal et al. 2013, p. 57). The share of Germans at and below competence level I is 18% of the population (ibid., p. 54f.). In addition, these competences go beyond lost easily due to misuse (Bynner and Parsons 1998; NRDC Institute of Education 2010, p. 35).

It is precisely this practical use of literary and numerical competences that seems to be declining in the context of the International Adult Literacy Survey (IALS) in the mid-1990s (Desjardins 2017; Redmer and Dannath, in print).

7.2 Unequal returns of numerical competences

Overall, basic competences such as literacy and numeracy lead to outcomes, for example in the area of income and job security (OECD 2013; Vogtenhuber 2014) as well as so-called wider benefits of learning, such as health and socio-political participation (Bynner et al. 2003; Schuller 2017). Numeracy also correlates more closely with income than literacy (Schleicher 2013).

Complement and differentiate this comprehensive and recurrently documented finding various of individual studies (Redmer et al. 2018; Liu et al. 2019). The findings are inconsistent: OECD shows high returns of numeracy across the board in terms of incomes, but income yields are not less for women than for men (Heilmann, in print). Within those who have high school-leaving qualifications, there are no effects of numeracy on the admission to studies. In addition to numerical competences, a correlation between of motivation and determination with income. The general the income from numeracy are to be differentiated by the individual studies in this respect - not everyone benefits equally from high numeracy, on the other hand are relevant in addition to numeracy, determination and motivation.

7.3 Importance of numerical practices

A milestone in research is the expansion of the PIAAC survey beyond competence measurement. Since the first round of PIAAC in 2012, various numerical practices have been surveyed. According to Technical Report (OECD 2016) this will be done through the following questions:

How often do you usually have ...

... Have you read bills, bank statements or the like?

... Have you read diagrams, plans, maps or diagrams?

... Prices, costs or budgets calculated?

... fractions, decimals or percentages used or calculated?

... uses a calculator, whether as a stand-alone device or in the Computer?

... diagrams, charts or tables?

... simple formulas or the like?

... higher mathematics or statistics, such as analysis, complex Algebra, trigonometry or regression analysis?

A series of complex analyses on the role of (literal and) numerical practices have been published in the meantime. So Nienkemper and others created with the help of a latent class analysis, three competence usage profiles, which, in addition to the written language practices also include computer use and - within limits - numerical practices. It becomes clear that the latent class of the so-called ubiquitously writing adults also calculated ubiquitously⁷ (Nienkemper and Grotlüschen 2019), and both professionally and privately. In other words, adults in this group are involved in to communicate permanently and everywhere in writing. This may also be the case for numerical practices, for example regarding the assessment of time and financial resources, efficient procedures and relevant orders of magnitude.

While many surveys emphasize the importance of numerical practices (Reder 2017), the trend comparison of numerical practices with the help of the German IALS data and selected, comparable PIAAC data, a decrease in numerical practices over the last thirty years (Redmer and Dannath in print). The analyses were differentiated according to occupational groups and show a polarisation of the labour market in almost all countries considered. This means that middle occupational groups divide into higher-qualified occupational groups in favour of larger proportions and also in low-skilled professions (Redmer and Dannath in print). At the same time, all three groups show lower values for occupationally related numerical practices.⁸

This result can be seen against the background of the disappearance of mathematics in technology with simultaneous dominance of mathematics in all to interpret areas of life and the continuing devaluation of mathematics in everyday life. The fact that mathematics is becoming increasingly invisible can also be explained by Niss (2002, p. 371). The disappearance of mathematics in technology Gellert, on the other hand, uses the term "demathematization" (Gellert and Jablonka 2007).

In summary, it can be stated that the quantitative secondary analyses representative datasets, which process numerical competencies, both the merits higher competences (Liu et al. 2019) as well as inequality and to show processes of repression (Heilmann in print). The findings on numerical practices, in turn, shows that they are used in both higher and medium and low-skilled occupational groups since the mid-1990s have declined (Redmer and Dannath in print). At the same time, it becomes apparent that not all groups is dealt with ubiquitously with numeracy (Nienkemper and Grotlüschen 2019).

7.4 Vulnerability and numeracy

"Vulnerability" can on the one hand mean the vulnerability of societal groups which, although still participating, are in increased danger of becoming of exclusion (strike 2009). In feminist discourse,

⁷ The variables used were those with the highest dispersion within the low literalized adults. In fact, however, the evaluation did not take into account the intrinsic value of numerical practices to bring out the best in you. The two variables used are the use of calculator or calculation program at the workplace and the calculation of prices and budgets in everyday life. Interestingly these broadly scattering variables are also meaningful in other analyses (Grotlüschen et al. 2019a).

⁸ As these are two data sets (IALS and PIAAC), and also the formal formation data and the as a result of which the competency data of the German IALS dataset are defective, it is only possible to values side by side. Significance tests would require integration of the data record. Of which the author and the author have refrained for the reasons mentioned.

vulnerability on the other hand as *conditio humana* (Butler 1998); however there are groups, which are more precarious to a greater extent and therefore have a higher vulnerability (Janssen 2017).

7.4.1 Mathematical needs and self-confidence in fledglings

The situation of refugees, both young people and adults, occupies both the educational research and practice. So far, little has been said about the numerical competences and practices to Germany. However, there are in (school) mathematics international benchmarking studies (TIMSS) from the years 2007, 2011 and 2015, in which countries of origin such as Syria and Iran, among others (Lüssenhop and Kaiser in print, p. 8). Furthermore, neighbouring countries are (Turkey, Lebanon, Jordan) and host countries (Italy, Germany, Sweden).

The studies focus first of all on mathematical competences and show, that the lower level of funding for education systems in the countries thus affected is Middle East and North African countries with below-average school mathematical competences (*ibid.*). This also means that no one from the group of Syrian and Jordanian students who has reached the highest level in TIMSS with representative surveys (*ibid.*, S. 20). In principle, these now adult persons have a knowledge of integers and decimal numbers, operators, and basal graphics, but no mathematical knowledge beyond this (*ibid.*).

It is therefore necessary to provide subsequent educational opportunities here. This can fall on very fertile ground, because the attitudes and appreciation for learning mathematics, as well as the reported self-confidence in mathematics in Iran, Jordan, Lebanon and Syria, are even higher than in the comparative countries (*ibid.*). Those questioned in 2011 would now be in their early twenties and fall into the largest age group of refugee migration after 2015 (*ibid.*, p. 8). Especially for the mouth of the river in vocational education and training and the labour market is a corresponding qualification is necessary.

7.4.2 Low skilled employment: Denumeralisation at work?

Redmer and Dannath (in print) show workers in low-skilled sector and show that the labour market share of this group are not disappearing. They also show that over three decades this group systematically used (a) diagrams and tables less often. Also (b) invoices, bank statements or budget tables are used less often than in other professions. Conversely, low-skilled employees calculate somewhat more frequently today compared to medium qualifications in the workplace (c) budgets or costs. Employees in low-skilled jobs have the following in two out of three segments (a-b), rather to do with "denumeralization", in the the third segment (c) is the time comparison, not the occupational group comparison. (*ibid.*).

7.4.3 Tight Budget Control? The less money, the more you calculate

In fact, it can also be seen in other places that the handling of everyday budgets is more widespread in the vulnerable segment of the population than in better-off groups. Looking at unemployment, homelessness or over-indebtedness, the more vulnerable monetary group shows a more frequent activity for budgets and price comparisons. Tight budgets are becoming more common ("tight control") (Grotlüschen et al. 2019a) than by the comparison population.

These results are based on PIAAC data and supplementary surveys in the field of debt counselling and homeless assistance. Also at the transition in the retirement age, higher numerical activities can be observed in phases, as Redmer shows on the basis of PIAAC and CiLL data (Redmer and Grotlüschen 2019). Older women are more familiar with the day-to-day management of the while older men are

increasingly concerned with banking matters (ibid.). The existence of children increases the intensity of numerical practices, even if they no longer live in the household (ibid.).

7.4.4 Numeracy Avoidance? The view of counselling over-indebted people

If one now focuses on the side of the advisors in the case of over-indebtedness, a contradiction arises. Qualitative group interviews show that consultants have a "numeracy avoidance" (Angermeier and Ansen in print) of their advisors and I'll find out. They rarely have an overview of their income and expenditure (ibid., p. 10). According to debt counselling, over-indebted people were seeking advice, "they wouldn't even have to start adding something up; it wouldn't do any good" (ibid.).

Contradictions in the findings could possibly be clarified by the fact that such avoidance statements are to be regarded as statements of protection, which, although dislike but not with the real avoidance of numeric practices. So anyone who says they need their monthly repayment obligations not to count them together in the first place, can still be very accurate. Keep an eye on your budget and compare prices daily. In addition, it can be that the counsellors have an inaccurate picture of their addressees, and that addressees is articulated. This requires further research.

The advisory staff in the over-indebtedness advisory service continue to point out that that suppliers provide a type of product description that allows price comparisons between made more difficult. Credit offers, instalment purchases and debt collection offers are mentioned here, telephone and power supply. Evans also expresses this criticism, Yasukawa, Mallows and Creese (Evans et al. 2017). Complex financial decisions (old-age provision, tax returns) dare to be less literalised adults is correspondingly rarer than the average (Grotlüschen et al. 2019b).

7.4.5 Habitus and Numeracy in Elderly: Economy as a virtue

The statistically visible way of dealing with retirement (Redmer and Grotlüschen 2019) can also be seen in the qualitative interview with 64- to 93-year-olds (Zeuner et al. in print). Retirement poses new challenges. This leads to private accounting and systematic saving (for new lenses or unforeseen items). The generations and social groups surveyed say that economy and a livelihood without debt are part of their value system (ibid., p. 7): "In their view, the virtue of the old days was not to spend more money than one has" (ibid., p. 8). This "virtue" can be described with Bourdieu as an integrated part of the habitus (Bourdieu 1987); according to the habitus theory, however, it is not only generation-specific but also social status-specific.

In addition, health concerns generate probability considerations (chances of cure and risks of an operation), scaled self-observations (pain protocols) and dosing tasks. In addition, costs and bonuses for health insurance (Zeuner et al. in print). Playing time questions especially when care services enter the house at agreed times.

The combination of financial and health vulnerability has consequences for social inclusion or feelings of loneliness. Numeracy can, therefore at least to a certain extent, have a positive influence on financial performance and health well-being, thereby increasing the quality of life and the chance of social integration at an advanced age. Exactly this causal relationship gives the results of analyses outlined below from cross-sectional representative surveys. Conversely the representative data confirm the qualitative results.

7.4.6 Numerical practices and subjective perception of health

Higher age leads to more comprehensive health challenges. Health-related actions and decisions are based in part on numerical competencies, including medical dosage, as well as the ability to concerning health-relevant information on food packaging, or in diet tables. Understanding the opportunities and risks of treatment requires the ability to comprehend percentages or probabilities.

The state of research meanwhile states that literary abilities do not sufficiently explain the connections with subjective health perception and behaviour (Heilmann in print). In this respect, the term "health numeracy" is now used. A health numeracy of this kind represents the degree to which persons who have the ability to identify themselves numerically, quantitatively, graphically, biostatistically and probability-theoretical health information are available to process them, to interpret them, to communicate them and to orientate them towards them (Golbeck et al. 2005, p. 375).

Based on the PIAAC-L extension study, regression analysis of the relationship between numerical competences, practices and subjective health status secondary analysis (Heilmann in print). The relationship between health behaviours (non-smoking, physical activity, health-conscious people nutrition) and numerical practices also under the control of socio-demographic variables confirmed. So-called "complex numerical practices" (ibid., p. 13) how the interpretation of statistical data correlates with all three variants healthy behavior. Rather "basic numerical practices", such as estimating of measurements and the calculation of simple average values, correlate each with some of the three variables of healthy behaviour (ibid.). The data show that extending data and statistics to all areas of life, including health, poses new challenges to people.

7.4.7 Creating visibility: Numerical practices among disabled people

Zeuner, Pabst and Benz-Gydat (Zeuner et al. in print) quote a 92-year-old interview partner with the words:

Today I am handicapped and [...] if I could still get out now [...] things would be different. Then I could take part in life outside and go there, go to a concert. But all that doesn't work anymore.

The interviewee is dependent on outpatient care. His age restrictions are usually not considered a disability. In contrast, Hirschberg advocates a human rights-based approach (2014; Hirschberg et al. 2019). According to this, age-related disabilities would also be covered by the Convention on the Rights of Persons with disabilities. An exclusion from participation, as reported above, would then even be unlawful (Article 3, para. 3, GG).

Independently of this, Schreiber-Barsch, Curdt and Gundlach (Schreiber-Barsch et al. in print) were able to ascertain that eleven persons with learning difficulties in all dimensions of numerical practices were accompanied by participants. The authors reflect the experienced numerical practices against established competence systems from the field of adult numeracy as well as from the field of school mathematics. This includes the competence framework of the German Adult Education Association, the KMK and the numeracy theory concept of the PIAAC study.

They show that the study participants work on and master questions of space and form, numbers and calculation, sizes and measures, aids (lists, computers, navigation systems), patterns and structures, probabilities, frequencies and chances. People with learning difficulties are under-represented in large

scale assessments. Schreiber-Barsch et al. argue that practices of people with disabilities only find visibility and social recognition when they also appear in measurements. Hirschberg also calls for a correspondingly improved data situation (Hirschberg 2014).

7.4.8 Adult numeracy across the globe? Sustainable Development Goal

The Sustainable Development Goals were adopted by the United Nations in 2015. The fourth of the seventeen sustainability goals demands

Ensuring inclusive, equitable and high-quality education for all and opportunities for lifelong learning.

This goal is subdivided into seven subgoals, which aim at school education, early childhood education, vocational and higher education, competencies for good work, genetic justice and inclusion, universal literacy and numeracy as well as global citizenship. Numeracy can claim the same relevance as literacy:

By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy.

This is where the monitoring initiative of the UNESCO Institute for Statistics and the UNESCO Institute for Lifelong Learning (Objective 4.6.1), entitled "Global Alliance for Monitoring Learning", comes in. This process uses available education statistics for the reports on indicator achievement. In the process, OECD studies are increasingly producing derivatives that focus on countries of the global South, e.g. PISA and PISA for Development as well as PIAAC and STEP (World Bank 2014). However, this now raises the question of which surveys can be sensibly used or recorded in low or middle-income countries.

There's a dilemma here: Educational data are necessary to aggregate resources, including for notoriously underfunded lifelong learning (Singh 2019). At the same time, a test monopoly is emerging based on globally accepted definitions, scales and instruments (Addey 2018; Grotlüschen et al. 2019c). Two groups of experts have submitted corresponding recommendations. Following a consultation on the UNESCO Strategy on Youth and Adult Literacy 2020-2025 held in 2019, the approach to be taken is to support the diversity of assessments rather than an extended monopoly of assessments.

8 High relevance, decreasing use, high vulnerability

A synopsis of the findings clearly shows that numeracy has its own effects on gainful employment, income, management positions and participation in further training. Numeracy is therefore of great importance, but is researched much less frequently than literacy (Carpentieri et al. 2009). The relevance of the sustainability goals to the same extent is also not reflected in equally intensive consultations on numeracy. Nevertheless, the development of basic competences should pay off for the individual and society, as the quantitative analyses show. However, an unequally distributed vulnerability of social groups can also be seen here. Over-indebted and homeless people, job seekers, fugitives and low-skilled workers can also be considered vulnerable groups. In addition, there are gender, age, migration background, health, disability and the socio-economic status of the family of origin.

Qualitative data indicate the importance of numerical practices for the enforcement of one's rights and availability in professional and social life. This result can be replicated in a wide variety of social contexts and countries. At the same time, the finding of a successive numeracy behind the technology, disappearing or already invisible, is confirmed - both in terms of competences and practices.

If, however, the relevance of numeral competences and practices is now well documented, then the decline in numeral competences (yo- nas 2012) and practices (Redmer and Dannath in print) appears problematic. This gives rise to a mandate for education policy and practice to contribute to the improved numeracy of adults. Particularly in times of increasing quantification and datafication, there may be educational needs here.

9 Desiderata

The need for scientific action is initially evident in the improved theoretical exploration and modelling of numeracy in the context of basic adult education. If numeracy is to have a similar relevance to literacy not only because of humanistic normative assumptions but also because of the findings, then it must also be conceptually anchored and differentiated in the constructs of basic education. The question then arises as to whether, in addition to financial literacy, digital literacy, health literacy and political literacy, there should also be relevant approaches to numeracy.

Initial approaches to this are available, for example the Curve project talks about "calculating in the area of basic financial education".⁹ A transition to the term "financial numeracy" would be obvious. Parallel to health literacy, there is already a concept of health numeracy, as discussed above. In times of data processing and algorithmization, digital numeracy is probably more appropriate than digital literacy. And political numeracy would have to take as its starting point the approaches of critical numeracy (Geiger et al. 2015a) or statistical literacy (Ridgway et al. 2019).

Furthermore, stereotyping and stigmatisation, deficit orientation and "blaming the victim" have long been discussed in literature research (Belzer and Pickard 2015; Bittlingmayer 2008). In contrast, the construction of the addressees of low-numbered adults is only recognizably addressed in debt counselling research.

In addition, the German and international quantitative data on adult numeracy have not yet been fully exhausted. Longitudinal section data, international comparative data, data on digital and numerical competences have been available since 2013. LEO data on financial and digital literacy - which at least overlap with numeracy - have been available since 2018. Increasingly, qualitative data are also being made available for secondary analysis. Here, interview and observation transcripts assigned to literacy research can be re-analysed with regard to unidentified numerical practices.

The previous findings show: Numeracy is not perceived as such by adults, it disappears in technology and is nevertheless important for political and professional processes. Algorithmization, datafication, digitization and quantification in a so-called data or control society are discussed with reference to numeracy and literacy (Evans et al. 2019; Smythe 2018) and framed in a new way. This opens up a variety of research perspectives that are not yet foreseeable.

⁹ www.die-curve.de.

Literature

- Abraham, E., & Linde, A. (2010). Alphabetisierung/Grundbildung als Aufgabengebiet der Erwachsenenbildung. In R. Tippelt & A. von Hippel (Hrsg.), *Handbuch Erwachsenenbildung/Weiterbildung* (4. Aufl. S. 889–903). Wiesbaden: Springer.
- Addey, C. (2018). Assembling literacy as global: the danger of a single story. In M. Milana, J. Holford, S. Webb, P. Jarvis & R. Waller (Hrsg.), *The Palgrave international handbook of adult and lifelong education and learning* (S. 315–335). London: Palgrave Macmillan.
- Agence Nationale de la Lutte contre l'Illettrisme (2005by). *Illiteracy: the statistics: analysis by the national agency to fight illiteracy of the IVQ survey conducted in 2004–2005 by INSEE*. Lyon: ANLCI.
- Angermeier, K., & Ansen, H. (im Druck). Value and understanding of numeracy practices in German debt counselling from the perspective of professionals. *ZDM Mathematics Education*, 52(2).
- Askew, M. (2015). Numeracy for the 21st century. A commentary. *ZDM Mathematics Education*, 47(4), 707–712. <https://doi.org/10.1007/s11858-015-0709-0>.
- Barton, D., & Hamilton, M. (2003). Literacy practices. In D. Barton (Hrsg.), *Situated literacies. Reading and writing in context* (S. 1–6). London: Routledge.
- Belzer, A., & Pickard, A. (2015). From heroic victims to competent comrades. Views of adult literacy learners in the research literature. *Adult Education Quarterly*, 65(3), 250–266. <https://doi.org/10.1177/0741713615580015>.
- Bittlingmayer, U. H. (2008). Blaming, producing und activating the victim. Materialistisch inspirierte Anmerkung zu verdrängten Dimensionen sozial bedingter gesundheitlicher Ungleichheit. In G. Hensen & P. Hensen (Hrsg.), *Gesundheitswesen und Sozialstaat. Gesundheitsförderung zwischen Anspruch und Wirklichkeit* 1. Aufl. Gesundheit und Gesellschaft. (S. 239–258). Wiesbaden: Springer.
- Bourdieu, P. (1987). *Die feinen Unterschiede. Kritik der gesellschaftlichen Urteilskraft*. Frankfurt am Main: Suhrkamp.
- Bundesministerium für Bildung und Forschung (BMBF) & Kultusministerkonferenz (2016). Grundsatzpapier zur Nationalen Dekade für Alphabetisierung und Grundbildung 2016–2026. Den funktionalen Analphabetismus in Deutschland verringern und das Grundbildungsniveau erhöhen. www.alphadekade.de/files/01_GrundsatzpapierzurNationalenDekadeAlphabetisierungundGrundbildung_final.pdf. Zugegriffen: 24. Sept. 2019.
- Butler, J. (1998). *Haß spricht. Zur Politik des Performativen*. Berlin: Berlin-Verlag.
- Bynner, J., & Parsons, S. (1998). *Use it or lose it? The impact of time out of work on literacy and numeracy skills*. London: Basic Skills Agency.
- Bynner, J., Schuller, T., & Feinstein, L. (2003). Wider benefits of education: skills, higher education and civic engagement. *Zeitschrift für Pädagogik*, 49(3), 341–361.
- Carpentieri, J.D., Litster, J., & Frumkin, L. (2009). Adult numeracy: a review of research. www.nationalnumeracy.org.uk/sites/default/files/carpentieri_et_al_2009_bbc_adult_numeracy_a_review_of_research.pdf. Zugegriffen: 24. Sept. 2019. London: National Research and Development Centre for Adult Literacy and Numeracy (NRDC).
- Coben, D. (2003). Adult numeracy: review of research and related literature. https://dera.ioe.ac.uk/22487/1/doc_2802.pdf. Zugegriffen: 24. Sept. 2019. London: NRDC Institute of Education.
- Conrad, A., Herzig, A., & Kopitzsch, F. (Hrsg.). (1998). *Das Volk im Visier der Aufklärung. Studien zur Popularisierung der Aufklärung im späten 18. Jahrhundert. Tagung „Popularisierung der Aufklärung im späten 18. Jahrhundert“*. Hamburg: LIT.
- Department for Business, Innovation and Skills (BIS) (2012). 2011 skills for life survey: a survey of literacy, numeracy and ICT levels in England. London (BIS research paper, 81). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/36000/12-p168-2011-skills-for-life-survey.pdf. Zugegriffen: 24. Sept. 2019.
- Deschauer, S. (2013). *Das Zweite Rechenbuch Von Adam Ries: Eine moderne Textfassung mit Kommentar und metrologischem Anhang und einer Einführung in Leben und Werk des Rechenmeisters*. Wiesbaden: Vieweg und Teubner.
- Desjardins, R. (2017). Is literacy and the practice of literacy on the decline? In A. T. de Matos, G. d'Oliveira Martins & P. Hanenberg (Hrsg.), *The future within reach* (S. 761–766). Lissabon: Catholic University of Portugal.

- DfES (2003). The skills for life survey: a national needs and impact survey of literacy, numeracy and ICT skills. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/36000/12-p168-2011-skills-for-life-survey.pdf. Zugegriffen: 24. Sept. 2019. London: DfES Research Brief RB490.
- Duncker-Euringer, C. (2017). Was ist Grundbildung? In B. Menke & W. Riekman (Hrsg.), *Politische Grundbildung. Inhalte – Zielgruppen – Herausforderungen* (S. 13–33). Schwalbach/Ts.: Wochen- schau Verlag.
- Effe, G., Fuchs, P., & Kaiser, G. (1976). *Lohnerhöhungen in mathematischer Behandlung. Unterricht im Konflikt, Konflikt im Unterricht*. Bamberg: Schwarz.
- Euringer, C. (2016a). Grundbildung im Spannungsfeld bildungspolitischer Ein- und Abgrenzungsinter- essen. *Zeitschrift für Weiterbildungsforschung*, 39(2), 241–254. <https://doi.org/10.1007/s40955-016-0066-9>.
- Euringer, C. (2016b). *Was ist „Grundbildung Erwachsener“? Das Grundbildungsverständnis der öffentli- chen Bildungsverwaltung im Kontext von Interessen und Machtverhältnissen. Dissertation*. Bielefeld: W. Bertelsmann.
- Evans, J., Ruane, S., & Southall, H. (Hrsg.). (2019). *Data in society: challenging statistics in an age of globalisation*. Bristol, UK: Policy Press.
- Evans, J., Yasukawa, K., Mallows, D., & Creese, B. (2017). Numerical skills and the numerate envi- ronment: affordances and demands. *Adults Learning Mathematics. An International Journal*, 12(1), 17–26.
- Freire, P. (1996). *Pädagogik der Unterdrückten. Bildung als Praxis der Freiheit*. Reinbek bei Hamburg: Rowohlt.
- Gal, I., Alatorre, S., Close, S., Evans, J., Johansen, L., Maguire, T., Manly, M., & Tout, D. (Hrsg.). (2009). *PIAAC numeracy. A conceptual framework*. OECD Education Working Paper, Bd. 35. Paris: OECD Publishing.
- Geiger, V., Forgasz, H., & Goos, M. (2015a). A critical orientation to numeracy across the curriculum. *ZDM: The International Journal on Mathematics Education*. <https://doi.org/10.1007/s11858-014-0648-1>.
- Geiger, V., Goos, M., & Forgasz, H. (2015b). A rich interpretation of numeracy for the 21st century. A survey of the state of the field. *ZDM Mathematics Education*, 47(4), 531–548. <https://doi.org/10.1007/s11858-015-0708-1>.
- Gellert, U., & Jablonka, E. (2007). Mathematisation – demathematisation. In U. Gellert & E. Jablonka (Hrsg.), *Mathematisation and demathematisation. Social, philosophical and educational ramifications* (S. 1–18). Amsterdam: Sense.
- Golbeck, A.L., Ahlers-Schmidt, C.R., Paschal, A.M., & Dismuke, S.E. (2005). A definition and operational framework for health numeracy. *American Journal of Preventive Medicine*, 29(4), 375–376. <https://doi.org/10.1016/j.amepre.2005.06.012>.
- Grotlüschen, A. (2018). Grundbildung von Erwachsenen. In R. Tippelt & B. Schmidt-Hertha (Hrsg.), *Handbuch Bildungsforschung* (S. 1261–1278). Heidelberg: Springer.
- Grotlüschen, A., Buddeberg, K., Ansen, H., & Redmer, A. (2019a). Vulnerable subgroups and numeracy practices. How poverty, debt and unemployment relate to everyday numeracy practices. *Adult Edu- cation Quarterly*. <https://doi.org/10.1177/0741713619841132>.
- Grotlüschen, A., Buddeberg, K., Dutz, G., Heilmann, L.M., & Stammer, C. (2019b). LEO 2018. Li- ving with low literacy. Hamburg. <http://blogs.epb.uni-hamburg.de/leo/files/2019/05/LEO-2018-first- results.pdf>. Zugegriffen: 24. Sept. 2019.
- Grotlüschen, A., Mallows, D., Reder, S., & Sabatini, J. (2016). Adults with low proficiency in literacy or numeracy. *OECD Education Working Papers*. <https://doi.org/10.1787/5jm0v44bnmxx-en>.
- Grotlüschen, A., Thériault, V., Nienkemper, B., & Capstick, T. (2019c). Critical viewpoints on adult li- teracy practices at the time of PIAAC. *International Journal of Lifelong Education*, 38(4), 361–365. <https://doi.org/10.1080/02601370.2019.1614105>.
- Harding, C. (2011). 2011 skills for life survey: headline findings (BIS research paper, 57). [https:// assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/623399/ 11-1367-2011-skills-for-life-survey- findings.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/623399/11-1367-2011-skills-for-life-survey- findings.pdf). Zugegriffen: 24. Sept. 2019.
- Heilmann, L. (im Druck) Health and numeracy. The role of numeracy skills in health satisfaction and health-related behaviour. *ZDM Mathematics Education*, 52(2).

Hinrichs, E. (1998). Zur Erforschung der Alphabetisierung in Nordwestdeutschland in der Frühen Neuzeit. In A. Conrad, A. Herzig & F. Kopitzsch (Hrsg.), *Das Volk im Visier der Aufklärung. Studien zur Popularisierung der Aufklärung im späten 18. Jahrhundert* (S. 35–56). Hamburg: LIT.

Hirschberg, M. (2014). Ethische Richtlinien für Forschung und Wissenschaft. In E. Mührel (Hrsg.), *Perspektiven sozialpädagogischer Forschung. Methodologien; Arbeitsfeldbezüge; Forschungspraxen* (S. 347–380). Wiesbaden: Springer.

Hirschberg, M., Bonna, F., & Stobrawe, H. (2019). Gelingensbedingungen zur Umsetzung eines Menschenrechts: Professionalisierung in der inklusiven Erwachsenenbildung. *weiter bilden*, 1, 21–23. von Humboldt, W. (1809). Ueber die mit dem Königsbergischen Schulwesen vorzunehmende Reformen Auszug aus: Der Königsberger und der Litauische Schulplan. In A. Flitner & K. Giel (Hrsg.), *Werke in fünf Bänden*, Band IV, (S. 168–173). Darmstadt: Wissenschaftliche Buchgesellschaft.

Janssen, A. (2017). *Verletzbare Subjekte. Dissertation*. Opladen: Budrich Uni Press.

Jonas, N. (2012). Pour des générations les plus récentes, les difficultés des adultes diminuent à l'écrit, mais augmentent en calcul. www.insee.fr/fr/themes/document.asp?ref_id=ip1426. Zugegriffen: 24. Sept. 2019. Hrsg. v. INSEE. Paris (INSEE PREMIERE, 1426 Décembre 2012).

Jonas, N. (2018). *Numeracy practices and numeracy skills among adults*. Education working papers, Bd. 177. Paris: OECD.

Kaiser-Meißner, G. (1986). *Anwendungen im Mathematikunterricht. Dissertation*. Bad Salzdetfurth: Franzbecker.

Kalman, J., & Solares, D. (2018). Tear it out and rip it up or you might get charged again: Paying debts at the company store in a farm workers' camp in Mexico. In K. Yasukawa, A. Rogers, K. Jackson, & B. V. Street (Hrsg.), *Numeracy As Social Practice: Global and Local Perspectives* (S. 59–75). Milton: Routledge.

Kane, P. (2018). Estimation by kiwifruit orchard managers and urban refuse/recycling operators within their situated horticultural or civic workplace practices: case studies from New Zealand. In K. Yasukawa, A. Rogers, K. Jackson & B.V. Street (Hrsg.), *Numeracy as social practice. Global and local perspectives* (S. 21–39). Milton: Routledge.

Khuzwayo, H. (2018). "Occupation of our minds": a metaphor to explain mathematics education in South Africa in the apartheid era. In K. Yasukawa, A. Rogers, K. Jackson & B. V. Street (Hrsg.), *Numeracy as social practice. Global and local perspectives* (S. 171–186). Milton: Routledge.

Klieme, E., & Hartig, J. (2008). Kompetenzkonzepte in den Sozialwissenschaften und im erziehungswissenschaftlichen Diskurs. In M. Prenzel, I. Gogolin & H. Krüger (Hrsg.), *Kompetenzdiagnostik* (S. 11–32). Wiesbaden: VS.

Kultusministerkonferenz Arbeitskreis Weiterbildung (2015). *Nationale Strategie Alphabetisierung – Bericht 2015*

Lave, J. (1988). *Cognition in practice. Mind, mathematics, and culture in everyday life*. Cambridge, New York: Cambridge University Press.

Lave, J. (1993). Textaufgaben im Mathematikunterricht. Mikrokosmos der Widersprüche zwischen schulischem Lernen und außerschulischer Lebenspraxis. *FKP (Forum Kritische Psychologie)*, 31, 5–28.

Lave, J., & Wenger, E. (1991). *Situated learning. Legitimate peripheral participation*. Cambridge, New York: Cambridge University Press.

Linde, A. (2008). *Literalität und Lernen. Eine Studie über das Lesen- und Schreibenlernen im Erwachsenenalter*. Münster: Waxmann.

Liu, H., Fernandez, F., & Grotluschen, A. (2019). Beyond literacy and numeracy skills – examining self-directedness in learning in Yunnan, Vietnam, Germany, and the United States. *International Journal of Educational Development*, 70(Article 102088). <https://doi.org/10.1016/j.ijedudev.2019.102088>

Lüssenhop, M., & Kaiser, G. (im Druck) Numeracy in the context of forced migration – a secondary analysis of TIMSS data. *ZDM Mathematics Education*, 52(2).

Mania, E., & Tröster, M. (2014). Finanzielle Grundbildung: Ein Kompetenzmodell entsteht. *Hessische Blätter für Volksbildung*, 2, 136–145.

Mania, E., & Tröster, M. (2015). Finanzielle Grundbildung. Konzepte, Förderdiagnostik und Angebote. In A. Grotluschen & D. Zimper (Hrsg.), *Literalitäts- und Grundlagenforschung* (S. 45–60). Münster: Waxmann.

Menke, B., & Riekman, W. (Hrsg.). (2017). *Politische Grundbildung. Inhalte – Zielgruppen – Herausforderungen*. Schwalbach/Ts.: Wochenschau Verlag.

Nienkemper, B., & Grotlüschen, A. (2019). Using PIAAC data to learn more about the literacy practices of adults. *International Journal of Lifelong Education*, 38(4), 393–405. <https://doi.org/10.1080/02601370.2019.1596171>.

Niss, M. (2002). Mathematics in society. In R. Biehler, R. W. Scholz, R. Strässer & B. Winkelmann (Hrsg.), *Didactics of mathematics as a scientific discipline* (S. 367–378). Dordrecht: Kluwer.

NRDC Institute of Education (2010). BBC raw numeracy literature review May 2010. http://downloads.bbc.co.uk/learning/learningoverview/impact_of_low_numeracy.pdf. Zugegriffen: 24. Sept. 2019.

Nthogo Lekoko, R., Mompoloki Suping, S., & Pitso, O. (2018). Critical humanistic pedagogy in the context of adult basic education: making sense of numeracy as social empowerment. In K. Yasukawa, A. Rogers, K. Jackson & B. V. Street (Hrsg.), *Numeracy as social practice. Global and local perspectives* (S. 204–224). Milton: Routledge.

OECD (Hrsg.). (2016). *Technical report of the survey of adult skills (PIAAC)*. Paris: OECD Publishing. OECD (2013). *OECD skills outlook 2013: first results from the survey of adult skills*. Paris: OECD Publishing. <https://doi.org/10.1787/9789264258051-en>.

OECD and PIAAC Numeracy Expert Group (2009). *PIAAC numeracy: a conceptual framework*. OECD education working paper, Bd. 35.

Rammstedt, B. (Hrsg.). (2013). *Grundlegende Kompetenzen Erwachsener im internationalen Vergleich. Ergebnisse von PIAAC 2012*. Münster: Waxmann.

Reder, S. (2011). *Some thoughts on IALS measurement validity, program impact, and logic models for policy development. Fall Institute 2011*. Montreal: The Centre for Literacy.

Reder, S. (2017). *Adults' engagement in reading, writing and numeracy practices*. Applied linguistics faculty publications and presentations, Bd. 22. Portland: Portland State University.

Redmer, A., & Grotlüschen, A. (2019). Alltagsmathematische Praktiken im höheren Lebensalter. *Zeitschrift für Weiterbildungsforschung*. <https://doi.org/10.1007/s40955-019-0135-y>.

Redmer, A., & Dannath, J. (im Druck) Changes in employment since the 1990s – trend of numeracy practices at work. *ZDM Mathematics Education*, 52(2).

Redmer, A., Heilmann, L., & Grotlüschen, A. (2018). Grundkompetenzen und Hochschulzugang. Zur Rolle von Literalität und Numeralität beim Zugang zur Hochschule. *Magazin erwachsenenbildung.at. Das Fachmedium für Forschung, Praxis und Diskurs* (34). https://erwachsenenbildung.at/magazin/18-34/meb18_34.pdf. Zugegriffen: 24. Sept. 2019.

Remmele, B. (2016). Ökonomische Kompetenzen. Was sie umfassen und wie man sie misst. *DIE Zeitschrift für Erwachsenenbildung*, 1, 22–25.

Ridgway, J., Nicholson, J., Sutherland, S., & Hedger, S. (2019). Critical statistical literacy and interactive data visualisations. In J. Evans, S. Ruane & H. Southall (Hrsg.), *Data in society. Challenging statistics in an age of globalisation* (S. 349–358). Bristol: Policy Press.

Rogers, A., & Street, B. V. (2018). Part I: Using case studies to expose the significance of what “surrounds” mathematics in numeracy practices. In K. Yasukawa, A. Rogers, K. Jackson & B.V. Street (Hrsg.), *Numeracy as social practice: global and local perspectives* (S. 19–20). Milton: Routledge.

Schaeffer, D., Vogt, D., Berens, E., & Hurrelmann, K. (2016). Gesundheitskompetenz der Bevölkerung in Deutschland. Ergebnisbericht. Bielefeld: Universität Bielefeld. www.uni-bielefeld.de/gesundhw/ag6/downloads/Ergebnisbericht_HLS-GER.pdf. Zugegriffen: 24. Sept. 2019.

Schleicher, A. (2013). Skilled for life? Key findings from the survey of adult skills. <https://www.slideshare.net/OECD/edu/skilled-for-life-key-findings-from-the-survey-of-adult-skills-andreas-schleicher-special-advisor-to-the-secretary-general-on-education-policy-27212444>. Zugegriffen: 24. Sept. 2019.

Schlögl, P. (2016). Kompetent! Aber wofür genau? *Kulturkontakt Magazin*, S. 6–9. (Winter 2016/2017) Schreiber-Barsch, S., Curdt, W., & Gundlach, H. (im Druck) Whose voices matter? Adults with learning difficulties and the emancipatory potential of numeracy practices. *ZDM Mathematics Education*, 52(2).

Schuller, T. (2017). What are the wider benefits of learning across the life course? Future of skills & lifelong learning. http://dera.ioe.ac.uk/29773/1/Skills_and_lifelong_learning_-_the_benefits_of_adult_learning_-_schuller_-_final.pdf. Zugegriffen: 24. Sept. 2019.

- Singh, S. (2019). New Horizons for the Development Education in the Context of Sustainable Development Goals. *International Journal of Research in Social Sciences*, 9, 3(1), 326–341. http://www.ijmra.us/project%20doc/2019/IJRSS_MARCH2019/IJRSSMarch19.pdf
- Smythe, S. (2018). Adult learning in the control society: digital era governance, literacies of control, and the work of adult educators. *Adult Education Quarterly*. <https://doi.org/10.1177/0741713618766645>.
- Street, B. (2003). What's "new" in the New Literacy Studies. Critical approaches to literacy in theory and practice. *Current Issues in Comparative Education*, 5(2), 77–91.
- Streich, W. (2009). Vulnerable Gruppen: „Verwundbarkeit“ als politik-sensibilisierende Metapher in der Beschreibung gesundheitlicher Ungleichheit. In K. Hurrelmann & M. Richter (Hrsg.), *Gesundheitliche Ungleichheit. Grundlagen, Probleme, Perspektiven* (2. Aufl. S. 301–307). Wiesbaden: Springer.
- Tenorth, H. (2004). Stichwort: „Grundbildung“ und „Basiskompetenzen“. Herkunft, Bedeutung und Probleme im Kontext allgemeiner Bildung. *Zeitschrift für Erziehungswissenschaft*, 7(2), 169–182.
- Tout, D. (1997). Some reflections on adult numeracy. In D. Coben (Hrsg.), *Adults learning maths-3: proceedings of the third international conference of adults learning maths*. London (S. 13–15).
- Tröster, M. (Hrsg.). (2000). *Spannungsfeld Grundbildung*. Bielefeld: W. Bertelsmann.
- Trumann, J. (2009). Bibliotheken als kommunale Lernzentren. In P. Faulstich & M. Bayer (Hrsg.), *Lernorte. Vielfalt von Weiterbildungs- und Lernmöglichkeiten* (S. 47–64). Hamburg: VSA.
- Tsatsaroni, A., & Evans, J. (2014). Adult numeracy and the totally pedagogised society. PIAAC and other international surveys in the context of global educational policy on lifelong learning. *Educ Stud Math*, 87(2), 167–186. <https://doi.org/10.1007/s10649-013-9470-x>.
- Vogtenhuber, S. (2014). Die berufliche Nutzung mathematischer Kompetenzen: Determinanten der Utilisierung und Effekte auf das Einkommen. In Statistik Austria (Hrsg.), *Schlüsselkompetenzen von Erwachsenen – Vertiefende Analysen der PIAAC-Erhebung 2011/12* (S. 354–374). Wien: Statistik Austria.
- Wolf, K. D., & Koppel, I. (2017). Digitale Grundbildung: Ziel oder Methode einer chancengleichen Teilhabe in einer mediatisierten Gesellschaft? Wo wir stehen und wo wir hin müssen. *erwachsenenbildung.at*, 30, 1–11.
- World Bank (2014). STEP Skills Measurement. Snapshot 2014. [www.worldbank.org/content/dam/Worldbank/Feature%20Story/Education/STEP%20Snapshot%202014_Revise_June%202014%20\(final\).pdf](http://www.worldbank.org/content/dam/Worldbank/Feature%20Story/Education/STEP%20Snapshot%202014_Revise_June%202014%20(final).pdf). Zugegriffen: 24. Sept. 2019. Unter Mitarbeit von A. Valerio, M. L. Sanchez Puerta, P. Gäelle, T. Rajadel & S. Monroy Taborda. World Bank.
- Yasukawa, K. (2018). The workplace as a site for learning critical numeracy practice. In K. Yasukawa, A. Rogers, K. Jackson & B. V. Street (Hrsg.), *Numeracy as social practice. Global and local perspectives* (S. 225–240). Milton: Routledge.
- Yasukawa, K., Rogers, A., Jackson, K., & Street, B. V. (Hrsg.). (2018). *Numeracy as social practice. Global and local perspectives*. Milton: Routledge.
- Zabal, A., Martin, S., Klaukien, A., Rammstedt, B., Baumert, J., & Klieme, E. (2013). Grundlegende Kompetenzen der erwachsenen Bevölkerung in Deutschland im internationalen Vergleich. In B. Rammstedt (Hrsg.), *Grundlegende Kompetenzen Erwachsener im internationalen Vergleich. Ergebnisse von PIAAC 2012* (S. 31–59). Münster: Waxmann.
- Zeuner, C.; Pabst, A. & Benz-Gydat, M. (im Druck) "I have to do something for my body and also for my mind": Numeracy practices as a strategy against vulnerability in old age. First results of an explorative study. *ZDM Mathematics Education*, 52(2).

