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Reproducing social difference in the concept of ‘numeracy skills’

Lisanne Heilmann

University of Hamburg, Germany; Lisanne.heilmann@uni-hamburg.de

This paper is concerned with adult numeracy skills as these are presented within the Programme for the International Assessment of Adult Competencies (PIAAC). It will focus on what we can learn from PIAAC results about adult skills, about the assessment and about societal structures. Theoretical discussions increasingly view numeracy as embedded in power relations. If so, these power relations should be visible in the results. This paper will provide a brief overview of underlying theory in the field, focusing on three elements of numeracy skill proficiency: the distribution of skills in society, the process of defining a hegemonic view of numeracy skills and finally, the value of numeracy skills in the context of power relations. This value of numeracy skills can be analysed by the example of gender relations in the labour market. The analyses will use PIAAC-data to indicate how gendered hegemony might influence the way numeracy skills matter in terms of monthly wages and the probability of getting into leadership positions.

Keywords: Basic skills, gender bias, labour market, adult education, PIAAC.

Introduction

Educational research often looks at skills as something to acquire. Once acquired, it is anticipated that skills bring benefit to their possessor by transforming skills into success. Following that line of argument, a common aim is to make education available and suitable for more people; assuming, that if education would only find a way to convey knowledge more efficiently, this would bring direct benefit to people in terms of happiness, health, or success in the labour market (Grotlüschen, Mallovs, Reder, & Sabatini, 2016; Kittel, 2016; OECD, 2016a). Craig (2018) argued – in a paper called ‘the promises of numeracy’ - that numeracy education is largely associated with empowerment and seen as relevant for social participation, while innumeracy is connected to “personal, social, and cultural costs” (Craig, 2018, p. 64). This paper is a reflection on PIAAC results with this perspective in mind. The OECD assessed via PIAAC the literacy and numeracy skills of 16-65 year-olds. In 2011/12, 24 countries participated in the first round of assessment. Nine other countries followed in a second round in 2014/15 (OECD, 2016a).

There is a variety of definitions and concepts around numeracy, mathematics, quantitative literacy used in international contexts. (e.g. Karaali, Villafane-Hernandez, & Taylor, 2016; Vacher, 2014). For this paper, the terms *numeracy* and *numeracy skills* refer to PIAAC’s definition:

PIAAC defines numeracy as the ability to access, use, interpret and communicate mathematical information and ideas, in order to engage in and manage the mathematical demands of a range of situations in adult life. (OECD, 2012, p. 34)

An alternative view on skills focusses more on their embeddedness in society and in power relations. Being embedded in social constructs means being greatly influenced by power structures. Thus, it is worth asking, whether Craig’s ‘promises’ are equally true for those who acquire them.

Using the example of gender to look at a concrete representation of societal power relations, PIAAC results offer the potential to analyse the intersection of gender and numeracy empirically and with quantitative methods. In this paper, I choose a regression analysis to test the value of numeracy skills in terms of income and the chance of getting into a leadership position. The scope of difference between these values for men and women will also be explored.

Numeracy in relations of power

Distributing numeracy

How do people acquire numeracy skills and why do some attain higher skill proficiencies than others? Focusing on gender differences, the achievement of young boys and girls has received much attention for the past decades and continues to be of high importance (OECD, 2016b). Surveys such as PISA¹ and TIMSS² test students at the ages of 10 (TIMSS) and 14/15 (TIMSS, PISA). These assessments show that boys tend to perform higher on numerical and science-related tests. The difference is small, but nevertheless significant (Mullis, Martin, Foy, & Hooper, 2016; OECD, 2016b). A comparison between these and further assessments of numeracy and mathematical competencies from the years 1994 to 2007 show that gender differences increase with age and grade. The performance of boy's on numeracy and mathematical proficiency increases from the seventh grade on. The difference between boy's and girl's performance on such assessments can be related to stereotypes and expectancies. Not only do teacher seem to expect and (unconsciously) support different skills and interests of boys and girls, but also, students expectations of themselves have been shown to align with their interests and their self-concept to what they think is expected from them (Budde, 2009).

Regarding the adult population, results from PIAAC show men scoring higher on the numeracy scale than women with the gender gap greater in older age cohorts (OECD, 2016a). The presented findings on young students and adults show differences in how numeracy skills are distributed among genders.

Determining numeracy

In a comprehensive look at the social aspects of numeracy, Street, Baker and Tomlin (2008) transferred insights from the New Literacy Studies to the field of numeracy and argued that numeracy is a social practice. This idea of a multiple of skill interpretations originates in the New Literacy Studies (Street, 1993). Contemplating the great variety of numerate practices – numeracy itself has to be seen as *multiple numeracies*. The relativity of numeracy is not only evident in the social distribution of skills but also in determining what constitutes as mathematics or as numeracy. As such, all numeracies are embedded in power relations and subject to the societal hegemony. A variety of studies have demonstrated how numeracy skills and practices are embedded in economic outcomes (Grotlüschen et al., 2016) or how values, beliefs and power relations determine the idea and the relevance of numeracy and mathematical education (c.f. Ares & Evans, 2014). The

¹ Programme for International Student Assessment (by OECD)

² Trends in International Mathematics and Science Study (by IEA, International Association for the Evaluation of Educational Achievement)

relativity of numeracy is not only evident in the social distribution of skills but also in determining what constitutes as mathematics and as numeracy. Different studies showed how skills and practices are embedded in economic outcomes (Grotlüschen et al., 2016) or how values, beliefs and power relations determine the construct of numeracy and mathematical education (Ares & Evans, 2014). Following postmodern theories, some researchers view mathematics and numeracy to as constructed in discourse in every aspect (Ernest, 2004). Velero (2004) suggests this perspective allows us “to perform a very fine grained analysis of how mathematics and mathematics education are used by people in particular discourses and of the effects of those discourses on social practices and, consequently, on people's lives” (p. 11).

Rewarding numeracy

Continuing from the perspective of that power relations shape numeracy conceptualizations and acquisition, the following analyses will show empirically that gender relations affect the value of numeracy skills on the example of labour market outcomes. Regression analyses of PIAAC data will be used to show how numeracy proficiency does not have the same value for everybody. Looking at two labour market outcomes (wages and leading positions), the analyses that follow will reveal how the effect of numeracy skills changes with gender.

Method: Data and sample

The presented research was carried out with PIAAC datasets for 13 European countries. The analysis disregarded those European countries whose PIAAC data did not disclose all variables employed. It therefore includes the following thirteen European countries: Belgium, Czech Republic, Denmark, Spain, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway and Poland.

PIAAC scales its numeracy test items based on item response theory (IRT) to account for differences in item difficulties. Based on the IRT scaling of the items and a population model, plausible values are drawn. This approach increased the measurement accuracy (Yamamoto, Khorramdel, & Davier, 2013). PIAAC views numeracy skills on a scale from 0 to 500, which it sections into five levels³ (OECD, 2013).

To exclude a possible bias arising from any gendered occupational segregation, different areas of work were included as control variables in the regression analyses. To exclude any effects of women working part-time, those participants who are unemployed, out of the workforce or work part-time⁴ were not incorporated in the analysed data.

Method: Variables and analyses

Variables on monthly income and leadership positions⁵ serve as indicators of labour market outcomes. The income variable indicates the monthly income exchanged into US-Dollars and

³ The score boundaries for numeracy in PIAAC are: 0-175 points (below level 1); 176-225 points (level 1); 226-275 points (level 2); 276-325 points (level 3); 326-375 points (level 4); 376-500 points (level 5).

⁴ Excluding all participants who work less than 31 hours in an average week (D_Q10).

⁵ Variables names are EARNMTHALLPPP for monthly wages and J_Q07a and J_Q08a for leading positions.

transformed as purchase power parity (PPP). This way, all outcomes are given on the same scale. Both income and leadership variables include employees as well as self-employed workers.

The effect on monthly income was regressed with a multinomial linear model. Logistic regressions were used for the leadership positioning. On both occasions, three models were employed: Model 1 regressed against male gender and numeracy; model 2 added background variables (b.v.)⁶ and model 3 regressed against the interaction term between numeracy and male gender. For the analysis on monthly income, the average work hours per week (h/w) were also controlled for in the first model.

Result: Same numeracy, different wages

Table 1 shows the result of the first two models on the monthly wages; showing significant results⁷.

Country	adjusted for h/w	adjusted for b.v.	Average equivalent of income differences in numeracy points
Belgium	718 ***	977 ***	61
Czech Republic	719 *	756 **	n.s.
Finland	493 ***	664 ***	58
France	304 ***	385 ***	44
Germany	516 ***	686 ***	30
Greece	330 ***	395 ***	60
Ireland	565 *	905 ***	32
Italy	614 ***	703 ***	88
Norway	748 ***	994 ***	59

Table 1: Difference of monthly income of men and women with the same numeracy proficiency

The results indicate how much higher men’s monthly wages are when having the same average numeracy proficiency as women. A comparison of the two models suggests that structural differences cannot explain men’s higher wages, as in most countries the differences in income rise in the further adjusted model. In Norway, for example, women on average earn almost 1.000 USD (PPP) less than men despite having the same level of skill proficiency.

⁶ Background variables include: Age (AGE_C), educational qualifications (EDLEVEL3), the parent’s educational background (PARED), native language (NATIVELANG), different fields of work (ISCO1C) and the average hours of work per week (D_Q10)

⁷ Significant results are marked as follows: *** (p < 0.001); ** (p < 0.01); * (p < 0.05). n.s. (not significant).

The last column in Table 1 shows how many points on the numeracy scale are the equivalent of the gender difference in income. Men in these European countries seem to score from 30 (Germany, Ireland) to 60 (Finland, Norway, Greece, Belgium) to 88 (Italy) points lower on the 500 scale when earning a similar income to women. There are no significant differences in Denmark, Spain, Netherlands, and Poland.

Result: Exchanging numeracy into wages at different rates

Table 2 presents the third model of regression on the monthly income. The analysis tested for the increase of income against numeracy proficiency – again, not for individuals but structurally. The table indicates how much additional skill points relate to higher income for men in comparison to women. For all genders, higher numeracy scores relate to higher income. However, for men higher numeracy points relate to a higher increase in income. The difference is smallest in Ireland (with Germany as a close second). Here, a man’s increase equals 117 percent (118 percent) of women’s. In Italy, men’s income increase equals more than 140 percent of the average woman’s increase in income.

Country	Men’s increase in income compared to women’s increase
Belgium	138 %
Finland	130 %
France	122 %
Germany	118 %
Greece	122 %
Ireland	117 %
Italy	141 %
Norway	129 %

Table 2: Average value of men’s numeracy in relation to women’s

There are no significant differences in Denmark, Spain, Netherlands, Poland and the Czech Republic. For all thirteen European countries, higher numeracy scores relate to an increase of income by 123 percent of women with equivalent scores.

Result: The probability of leadership

Regarding the probability of men and women of getting into a leading position, we found similar results, which are shown in Table 3. These results show the effect coefficient of the binomial logistic regression analyses. The effect coefficient is the exponent of the regression results. In both models, men show a higher probability of being in a leadership position. In the unadjusted model, men in Italy and Germany are between 14 and 20 percent more likely to be in a leadership position when having equal numeracy skills as women. In Finland and Belgium, men are 81 and 89 percent more likely to be in a leadership position.

In the adjusted model, men in Spain and Finland are almost twice as likely to be in a leadership position as women with similar numeracy proficiency, educational background, in the same field of work, and with further background variables controlled. In the Czech Republic they show a more than two and a half times higher probability.

Women in Finland or Spain are almost half as likely to get into a leading position with the same numeracy proficiency, education and further background variables. There are no significant results in Ireland.

Averaged for all analysed European countries, men's probability to be in a leadership position is 148 percent of that of a woman with equivalent numeracy skills. When controlled for background variables, the overall average for men is 59 percent higher in relation to women.

Country	not adjusted	Adjusted for b.v.
Belgium	1.89 ***	1.62 ***
Czech Republic	1.75 ***	2.60 ***
Denmark	1.77 ***	1.52 ***
Spain	1.75 ***	1.93 ***
Finland	1.81 ***	1.95 ***
France	1.68 ***	1.65 ***
Germany	1.21 *	<i>n.s.</i>
Greece	1.52 **	<i>n.s.</i>
Italy	1.14 ***	1.61 ***
Netherlands	1.57 ***	1.37 **
Norway	1.55 ***	1.26 *
Poland	1.40 **	1.72 ***

Table 3: Odds ratios of logistic regression results: average probability of men getting into a leading position compared to women with equal numeracy skills

Discussion

As a consequence of the use of IRT, plausible values and the nature of our calculations, these results cannot be interpreted at the level individual case. In addition, countries' results can't be compared because of the different economic positions and related purchasing power within countries. However, the strong and significant correlation in at least nine of the 13 analysed countries indicate strong gender differences in the way (numeracy) skills can be transformed into labour market outcomes.

Furthermore, it seems numeracy does not correlate (strongly) with all job-specific skills. In contrast, there is no reason to assume that the gender difference in numeracy is bigger than in other job-specific skills.

In this paper I have argued that numeracy is embedded in hegemonic structures of society in (at least) three specific ways: (1) influencing what is recognised in definitions of numeracy, (2) selecting who acquires numeracy, and (3) determining the societal value of numeracy skills. The analyses of PIAAC data could show women's numeracy skills relate to a lower income and to lower probabilities of being in a leadership position. On a scale of 500, men score between 32 and 88 point lower than women while having a similar income. With the same numeracy proficiency, men on average earn between 300 and 750 USD more than women. Similarly, men's probability of getting into a leadership position is around one and a half times that of women with the same numeracy proficiency.

In some cases, the adjustment of the model for various background variables increased the respective coefficients. This might indicate, that part of the gender differences in the labour market are intensified by (some of) those background variables, like different fields of work or educational attainments. This result, however, cannot be explained by the first model.

In conclusion, this study provides evidence that numeracy skills are entwined in power relations. A multitude of factors, which - in some way or another - appear to be influencing women's opportunities along gender lines, accumulate to different outcomes in the labour market. My analysis indicates that higher levels of numeracy skills relate to an increase in labour market outcomes - but it is not an equal increase for everybody. This might suggest a deeper reflection on our concepts of numeracy and skills and our willingness to use real-life outcomes as promises for numeracy education.

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