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Introduction to TWG07 Adult Mathematics Education

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This paper is a summary paper of the Thematic Working Group (TWG) on Adult Mathematics Education (AME). The theme AME made its first appearance on CERME11 and in this paper we provide an overview of the growing and blossoming field of AME and the results of the working group. The main themes associated with AME are: the definition, scope, and assessment of numeracy, the role of language and dialogue, the role of affect, including motivation, and the role of societal power structures, including subthemes like equity, inclusion, vulnerable learners, agency and self-efficacy. We conclude with the opportunities and challenges for this theme from both scientific and societal perspective.

Keywords: Adult Mathematics Education, Numeracy, PIAAC, Language, Agency.

Introduction

Adult mathematics education is a fast growing tree in the mathematics education forest. Many countries have in recent decades adopted policies on lifelong learning and, in most cases, mathematics and numeracy are included in these policies (see for instance the Lifelong Learning Platform, llplatform.eu). This is a consequence of the rising awareness that the current society is rapidly changing due to technological, digital and environmental developments, and that citizens need a broad repertoire of mathematical knowledge, skills, and confidence to deal with those changes, both in work situations as in daily life.

This idea is not completely new. An increasing interest in the relevance of mathematics needed for a well-functioning citizen started in the late 1950s in the UK with the Crowther report (DES Department of Education, and Science, 1959) but really blossomed two decades later with the Cockcroft report (DES Department of Education and Science, 1982), the foundation of Adults Learning Mathematics – an international research forum (ALM) established in 1993 with a strong European input (see e.g., Safford-Ramus, Keogh, O’Donoghue & Maguire, 2018), and the start of the Adults Numeracy Network (ANN) established in 1994 with a main focus on the USA. Numeracy was at that time defined in the Crowther report (1959) as scientific understanding and thinking quantitatively and in the Cockcroft report (1982) as the capacity to understand and use basic principles of mathematics and science presented in mathematical terms.

With the rapid growth of adult education in the 1970s (Milana & Nesbit, 2015) we witnessed a rise in formal mathematics education for adults, as a result of growing opportunities for adults to take another chance in getting mathematics certificates for further study or new careers. During this time, a large part of adult numeracy and mathematics education took place in informal and non-formal education environments, for instance in community centres or in the workplace, or was

hidden in vocational or literacy courses for adults, which made it hard to get a complete overview of the field. Therefore, the mathematics referred to in AME has many appearances. It ranges from formal mathematics for advanced technological careers, to typical school mathematics content supporting the attainment of formal certificates and diplomas, and to the multifaceted concepts of mathematical literacy and numeracy, which deal with the use of numbers, patterns and structures in daily activities. This last appearance can also be described as *Numeracy as a social practice* (Yasukawa, Rogers, Jackson, & Street, 2018). This makes the concept of numeracy relevant to large segments of the populations in many countries; Indeed, the results of the Programme for the International Assessment of Adult Competencies (PIAAC), discussed in the next section, found that many adults have their optimal functioning in daily life hampered by numeracy problems.

In this paper we show the subthemes raised by the participants in the TWG on AME. We consider this TWG as new platform for scientific discussion to push AME towards a more recognized position within the scientific international community. We present a brief summary of each of the contributions presented in the TWG during the conference. Finally, we conclude with some remarks on new avenues and challenges for the research in AME in the forthcoming years.

Emerging themes in Adult Mathematics Education

In TWG07 on AME the breadth and depth of the emerging field of AME is mirrored. Contributions come from various backgrounds, cultures, and experiences. In the first working group discussion the various themes of the contributions were made explicit and put into categories.

These are the categories covered by the contributions of the participants in this TWG:

- The definition, scope, and assessment of numeracy;
- The role of language and dialogue;
- Affect, including motivation;
- Special groups and vulnerable learners;
- Teaching and learning activities, including vocational education;
- The role of power structures, inclusion, agency and self-efficacy.

These themes more than anything else make clear that AME is a multi-layered phenomenon and much more than just mathematics education for a special target group. Mathematics education for adults intertwines the learning of mathematics with language and dialogue, affect, and dealing with learners' reality, but also with societal power structures and sociological concepts like equity, inclusion, and agency.

Regarding the definition, scope and assessment of numeracy

“Adults’ numeracy and literacy practices matter” (p. 75) is the opening line of the chapter by Coben and Alkema (2018) in the ICME13-monograph series title *Contemporary Research in Adult and Lifelong Learning of Mathematics – International perspectives* (Safford-Ramus, Maaß, & Süss-Stepancik, 2018). This brief sentence summarizes in the shortest possible way the importance of the theme numeracy in the field of AME.

The results of the last PIAAC survey show that in all but one participating country, at least 10% of the adults are proficient below level 1 of the 6-point scale in literacy or numeracy (OECD, 2013;

PIAAC Numeracy Expert Group, 2009). In other words, significant numbers of adults do not possess the knowledge, skills and confidence to succeed in today's society regarding quantitative matters. These results on numeracy give rise to serious concern for the economic development of Europe. This is an even more pressing issue since the amount of numerical data that needs to be interpreted and used is rapidly rising and all pervasive due to technological developments and the prevalence of (big) data. To gain a better insight in these trends a second cycle of PIAAC will be starting in 2021, which is now in preparation (Tout et al., 2017).

David Kaye, chair of ALM, made a contribution to the discussion in the group on the development of the definition and historical development of the concept of numeracy, based on his earlier publications in an ICME13 monograph (Kaye, 2018). In the Crowther report (1959), numeracy was closely related to understanding science and developing technologies in society. In the next twenty years, the meaning changed to basic operations, whereby the association with science was no longer present and the level of mathematical understanding to which numeracy refers became much lower and not much more than "able to perform basic arithmetic operations". The persistence of the latter definition makes it hard to develop, disseminate, and implement a concept of numeracy which better equates to an ability to cope confidently with the mathematical demands of adult life. For that purpose this latter definition is much too restricted because it refers only to more mechanical and lower-order skills like performing arithmetic operations and not 'mathematizing', which is the skill of translating an encountered problem into an adequate operation so that the mathematics can be used with confidence to cope with practical everyday situations. What is so significant about these shifting definitions is that the debate about what numeracy might include was already twenty years old in 1982, and that the tension between numeracy being little more than arithmetic versus being a significant part of everyone's social practice is still being repeated in debates on numeracy policy development. The continuing tension can most likely be explained by the fact that it is not just an academic and educational debate, but rather a political one. In many countries we see a reoccurring 'back-to-the-basics'-movement as a simple answer to the complex issue of how to prepare children and adults to deal with situations in everyday life which involve numbers, patterns, and structures.

Two contributions especially address this issue too. Diez-Palomar, Hoogland, and Geiger are members of the PIAAC Numeracy Expert Group, which is responsible for the development of an assessment framework and the items in the next PIAAC international comparative assessment, which is happening from 2021 onwards. They performed a limited literature review to explore which concepts from mathematics education theories could enrich the numeracy framework to make it more appropriate to adults functioning adequately in our number-drenched society (Tout et al., 2017). The most relevant concepts taken into account are number sense, big ideas in mathematics, and embeddedness and authenticity. Common in these concepts is that they all acknowledge the richness and multifaceted aspects of adults' cognitive processes in dealing with numeracy situations.

Furthermore, Hoogland, Auer, O'Meara, Diez-Palomar and Van Groenestijn report in their contribution on the first steps towards creating a *Common European Numeracy Framework (CENF)* for adults. These steps are made in an Erasmus+ project with the same name, which started in 2018, and is aims to broaden the perspective on numeracy, foremost by considering numeracy as a social

practice, focusing on numerate behaviour and numeracy practices. For a much more sophisticated discussion on seeing numeracy as a social practice, we further refer to the work of Coben and Alkema (2018) and Yasukawa (2018).

Regarding the role of language and dialogue.

The importance of the role of language and dialogue in AME was emphasised by no less than three contributions by Griffiths, Wessel, and Diez-Palomar & Anagnostopoulou respectively.

Griffiths report on his investigations into discussions that took place during and following a particular small group activity in which a scene is read aloud and a mathematical task is undertaken. In his research, the concept of ‘thinking as communication’ is utilised and employs an overarching framework for analysis. To understand what happens when the ‘reading aloud’ activity is undertaken, it is important to investigate what happens when learners undertake related activities. Griffiths describes the key elements to the research with some initial analysis drawing on data from an exploratory phase along with observations from the main study.

Wessel gives an overview of an Erasmus+ project that aims to empirically identify the potentials and challenges of language-responsive teaching designs for low-achieving students in vocational contexts. Using topic-specific designs the research delivers first insights into developing and experimenting with two teaching units (percentages and proportional reasoning) and summarizes the questions that come up when adapting design principles for language-responsive mathematics to the teaching and learning in vocational education. The empirical investigations are carried out with young adult pre-apprentices in lower level vocational education in Germany in the technical sector. These young adults often struggle with mathematics and have only limited proficiency in the language of instruction.

Diez-Palomar and Anagnostopoulou discuss the effectiveness of dialogic learning as an adults’ learning theory. Their paper specifically focuses on how so-called *Mathematics and Physics Dialogic Gatherings* can enhance the critical thinking of adult learners and hence develop their learning in both topics. Two studies were considered where the participants engaged in dialogic reading activity reading classics in mathematics or physics. The former study took place in Barcelona, Spain and involved adult women of above 40-years-old with low literacy skills engaging in mathematics. The latter took place in Kendal, UK and involved two groups of adults. Although the samples were extremely diverse, the results indicate that using classical readings can significantly improve critical thinking and dialogic talk in all groups and provide the potential to create further learning opportunities.

Regarding affect, including motivation

In various contributions, attention is given to the role of affect as an important factor influencing the outcomes of AME in the classroom. It acknowledges that learning mathematics involves not only cognitive processes, but also, to a substantial level, an array of psychological and affective factors.

Kelly undertook extensive doctoral research on the role of motivation in AME. Her research is based on interviews with adults about their motivation to study mathematics in the workplace, through classes organised and funded by trade unions in the UK. The findings point to motivation

as a function of individual's emotions and cognition that are influenced by social experiences. The research identifies a difference between the initial motivation to re-engage with learning and that required to continue, or persist. Continuing learning relies on a socially and emotionally supportive learning environment which adults identify as 'different' from previous learning experiences. The term 'Affective Mathematical Journey' is developed to describe the positive emotional changes experienced by adults, which helps them overcome negative memories. The adults' resultant increase in confidence and motivation encourages them to successfully develop and use their mathematical skills both inside and outside the classroom.

Regarding special groups and vulnerable learners

Engaging in mathematics education as well as trying to improve the management of various numeracy situations, such as finances, is a big step for many adults, especially when their past experiences with education are negative.

Redmer used PIAAC data to get a better insight into the numerate behaviour of older people. Demographic changes render basic numeracy skills increasingly important in older age. Among them, skills in financial matters are increasingly relevant. The skills measured in PIAAC and Competencies in Later Life (CiLL) represent comprehensive cognitive abilities that can be seen as the basis for successful participation in social and economic life. In a secondary analysis, Redmer shows that financial practices continue to be important for older people, although their numeracy skills proficiency may be lower than those of younger people. The analysis clearly indicated a gender difference in dealing with financial matters: men handle bills and bank statements, whereas women manage the household, although there was some discussion about whether this distinction would continue in following generations.

Byrne did research on a very special group. Her exploratory study is part of a larger study on assessment and teaching in mathematics classrooms in Irish prison education centres. Her purpose is to enhance knowledge in this field, to enhance practice and to enable better learning and teaching through research. A so-called Mathematics Teaching Triad is used as a theoretical construct for the study. This triad looks at management of learning, sensitivity to students, and mathematical challenges. When finished, the research project will present data derived from a wider investigation, including data from teachers in the secure sector across Ireland and data from prisoners attending mathematics classes. In this paper Byrne analyses the data gathered from a survey on small sample of teachers, covering the time available for mathematics classes, class composition, teacher satisfaction and teacher's identities through metaphor.

Regarding teaching and learning activities

Keogh reports on developing and validating an instrument to let people recognise their own numerate behaviour. His reasoning is that adults know more about mathematics than they think and use it more often than they realise. Despite their apparent self-perception of being a 'non-maths' person, they behave in mathematics-informed ways, which are dismissed, routinely, as common sense or something other than mathematics. The doctoral research found that given the opportunity to reflect on their own behaviour at work, through a mathematics-sensitive lens, people readily recognise their numerate behaviour even if they talk about it in different ways. This work introduces

a set of tools and a methodology to harvest real tangible benefits for the learner. The tools explore the locus of a person's expertise in increasing granularity, building a platform from on which to capture a learner's mathematics knowledge, skills and competence, to help revise possible mistaken self-perceptions and to inculcate confidence in his/her learning of mathematics.

Hoogland, Heinsman and Drijvers report on conducting a literature review on how numeracy is used in vocational education and whether there are effective practices identified in peer-reviewed literature of the last five years. The rationale for this study is that numeracy and mathematics education in vocational education is under pressure to keep up with the rapid changes in the workplace due to developments in workplace mathematics and the ubiquitous availability of technological tools. Vocational education is a large component of education for 12- to 20-years-olds in the Netherlands and the numeracy and mathematics curriculum is on the brink of a reform. Preliminary results show that in most of the articles the concept of numeracy was not clearly explained, however when specified the PIAAC definition is used. In the search for articles on numeracy education practices which also reported on effects of those practices, only four such articles could be found out of more than 600 publications on numeracy and vocational education. Discussion in the group suggests a wider search of publications which includes practices involving problem solving, motivation, and math-anxiety.

Regarding the role of power structures, inclusion, agency and self-efficacy

Last but certainly not least is the notion of the use of numeracy in society, including the importance of being numerate, equity in access to relevant numeracy education and the perception of gender issues around mathematics and numeracy, all of which are never value-free. In her research Heilmann uses adults' numeracy skills in the PIAAC data to analyse the issue of power. She states that theoretical discussions increasingly view numeracy as embedded in power relations, and if this is the case, these power relations should be visible in the results. She gives an overview of the underlying theories, 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. The value of numeracy skills is analysed using the example of gender relations in the labour market. The analyses explores how gendered hegemony might influence the way numeracy skills matter in terms of monthly wages and the probability of getting into leadership positions.

Forwarding the field

Although there is a broad acknowledgment that an array of psychological and sociological factors are important in (the results of) adult education, there is not yet a well-researched set of examples how in practice this can be taken into account in a more systematic and effective way. The practice of adult numeracy education is still a plethora of different content descriptions and goals that vary from very back-to-the-basics to very sophisticated higher-order skills. Reported teaching practices and lesson materials for adults are quite often not very different from those used in primary schools. Research-validated practices explicitly addressing the psychological and sociological issues are still very rare. The twin goals of trying to establish a firm definition of numeracy which acknowledges

the multifaceted nature of adult's mathematical practices while identifying consistent teaching approaches should be of concern to the global AME community.

Currently in Europe there are some developments which are promising to come to a more common definition of numeracy and identify effective teaching approaches. The ALM organisation is strongly anchored in Europe and functions through its yearly conference in July as a community of practice for researchers in the field of AME in Europe and beyond. The European Basic Skills Network (EBSN) in combination with the EPALe-website of the European Union provides a platform where practitioners, policy makers and researchers can share their ideas, thoughts and results. Furthermore, in 2018 an Erasmus+ project started, which originated in The Netherlands, Austria, Ireland, and Spain, and is aiming to involve all European countries in an attempt learn from each other experiences to find some common ground for terminology, perspectives, development and practice, and policy making .

In the future, it could be helpful if national and regional level policy documents explicitly define and openly discuss the chosen definitions of numeracy in relation to the European or world-wide used definitions, like the one by OECD in the PIAAC programme. Especially when societies become globalised, as Safford-Ramus, Misra and Maguire (2016) advocate, numeracy must remain a dynamic concept that recognises and responds to changes in society.

Conclusion

AME plays a vital role in empowering individuals to fulfil their full potential, enriching their repertoire to cope with situations and problems in daily life and the demands made by a globalised world, increasing reliant on technology. In the second cycle of PIAAC, which will be conducted from 2021 onwards, a large body of data will become available, which will for the first time provide a longitudinal comparison with the results of the first cycle of PIAAC. To some extent, this will also point to trends in the development of give aspects of the field of AME

Despite the relevance of numeracy in our society, the role that AME plays in the field of research into mathematics education is still rather small. There are international research associations in AME, but the main educational mathematics conferences that are referents in the field do not usually include AME as working group. We have over seventy years of “numeracy” as research topic devoted in national and international reports and studies. In the last decade, results of important large-scale surveys such as PIAAC have becoming available. However, there are still numerous gaps in terms of research understanding how adults learn and use mathematics, develop their quantitative understanding of everyday facts or situations, understand particular mathematical objects (proportions, functions, big numbers, shapes, etc.), and their properties, relationships and representations. The themes identified in this CERME working group layout a possible research agenda. The discussion will continue on the scope and definition of numeracy. Furthermore, sociological aspects will remain in the foreground of discussions on AME, such as its relationship with societal power structures and promoting individual inclusion, agency and self-efficacy for special groups and vulnerable learners. Another important aspect in AME is that adults bring their own life experiences to the learning environment, which implies that teaching and learning is influenced by a broad range of factors including the recognition that motivation to learn is

developed through social and emotional experiences, while teaching activities need to be sensitive to the role of language and dialogue as well as relevant to the context of learners' lives.

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