NUMERICALL

Numeric[All] Methodological Guide

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Contents

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Chapter 1: Introduction to the concepts of transformative and experiential learning in Non-formal Mathematics for Inclusive Adult Learning

In this chapter, the intersection of non-formal education, mathematics, and transformative and experiential learning is explained and discussed to provide a basic understanding of the Numeric[all]'s Methodological Guide approach to Inclusive Adult Learning. We provide definitions of the afore-mentioned concepts and introduce their interrelated nature and relevance to attaining today's basic skills. In addition, Inclusive Adult Learning is viewed through the lens of basic education competencies and content creation that can facilitate learning for all adults, inclusive of Specific Learning Disorders (SLDs) and other disabilities and migrant and refugee backgrounds.

Initially, this Methodological Guide intended to use gamified museum methodologies as its primary method to create learning content for adults. However, after much deliberation and research, the Numeric[All] project partners decided to use a combination of transformative and experiential learning as their core methodology to relate better to the target group, adults aged 35 to 65. This change stems from the fact that adults do not respond so well to playful and competitive content as expected with gamified methodologies but instead use their prior knowledge and experiences to acquire and develop their knowledge, attitudes, and skills.

1.1. Non-formal mathematics, transformative and experiential learning

The definition of non-formal education, provided by the Council of Europe (2022), is situated outside the formal educational setting and curriculum and aims to improve skills and competencies through structured programmes and processes. Such environments include youth organisations, sports clubs, or other community-based

activities (Council of Europe, 2022). Some core characteristics of non-formal education are “the learner's intrinsic motivation, voluntary participation, critical thinking and democratic agency” (Council of Europe, n.d., paragraph 1). In this way, non-formal education can occur in diverse environments that are not actively focused on assessing learning outcomes based on formal education standards. Such environments or spaces have become increasingly popular amongst learners of different ages, from youth to older adults. As illustrated by statistical data, the EU average rate of adults participating in non-formal education and training reached 41%, compared to only 5% of adults participating in formal education and training (European Commission/EACEA/Eurydice, 2021). This demonstrates the importance of putting our efforts into non-formal education as a space for learning.

Spaces of non-formal education allow individuals of any age to learn in a more relaxed and enjoyable environment where their opinions, knowledge and skills are not formally assessed but rather applied and improved. Such spaces put the needs of their learners first and encourage their improvement and learning through problem-solving scenarios and critical thinking (Spiteri, 2016). Thus, non-formal education provides greater flexibility, values each learner's diverse experiences, and motivates them to achieve their goals in a safe and comfortable space where discussion is open. This is a significant distinction from formal education settings, where learners are constantly assessed and may feel more restricted in expressing their opinions and thoughts. Generally, individuals are more open to learning when they can relate new knowledge to their lives and improve their skills through hands-on activities.

In the context of mathematics, a considerable number of studies argue that formal education contexts and curricula limit students’ perceptions and learning to understand and apply mathematics in real-life properly (as cited in Simpson & Kastberg, 2022; Nicol, 2002; Stevens, 2013; Nasir and Hand, 2008). Still, traditional school settings have a distinct set of goals and curricula that must be followed in order to correspond to national, and sometimes international, standards and assessments. This rigid structure is also relevant to students’ typical misconceptions of mathematics as ‘boring’ with no concrete relation to everyday life practices. Even though these misconceptions might start from negative school experiences, they still manifest when adults attempt to engage in this subject (Swain et al., 2005). However, we, in our project, are not confined by narrow views or fixed structures found in

formal education. Instead, we have the freedom to use any method or approach that suits our target group.

As a way to challenge existing negative perceptions of mathematics, non-formal spaces that facilitate the exploration and application of the subject in diverse scenarios emerged. There are several examples of such spaces that materialised as mathematics museums, such as MOMATH in New York (USA), MMACA Museum of Mathematics in Cornellà (Spain), Mathematikum in Giessen (Germany), Museum of Mathematics in Seoul (Korea), The Garden of Archimedes in Florence (Italy), Haus der Mathematik in Vienna (Austria), or NAVET in Borås (Sweden). Even though mathematics museums are still developing their own “language” separate from formal education settings and science popularisation, they represent a creative, stimulating and problem-solving environment that translates mathematical concepts into relatable everyday practices through hands-on objects. As such, mathematics museums are places where users are not taught in the formal sense but learn through their senses, cognitive stimulation, collaboration, and prior experiences. This creates a virtuous circle of the “Hands-on, Minds-on, Hearts-on and Talk-on” experience.

The concept of non-formal mathematics presents similarities with experiential and transformative learning. These approaches toward education are highly relevant to adults since the learner actively acquires and develops knowledge, skills, and attitudes from direct experiences. These experiences allow learners to either inform prior knowledge and associations or be introduced to entirely new fields. Therefore, the complementary nature of the two learning approaches works to reframe preconceived ideas and enact the transformation through hands-on activities and experiences. In other words, it simultaneously provides learners with direct experiences to inform and construct their knowledge and skills to transform their potentially negative perceptions into positive.

Transformative learning is best understood as a process of becoming aware of and challenging one’s existing misconceptions (Mezirow, 1997). Adults develop a series of different associations, notions, principles, feelings and habituated responses throughout their lifespan, which creates their understanding and perceptions of the world around them and largely influences their actions (Mezirow,1997). Accordingly,

adult learners might have had negative prior experiences in school, particularly in mathematics (see Swain et al., 2005); thus, their preconceived notions can be challenging to change but not impossible. In the context of adult education, Mezirow's (1997) words echo: "The key idea is to help the learners actively engage the concepts presented in the context of their own lives and collectively critically assess the justification of new knowledge" (p. 10). To put it differently, learners are called to critically evaluate and comprehend the potential usage of the new knowledge they are presented with.

Mezirow (1997) underlines the importance of relating new information to learners' existing frames of reference. This does not imply that the new information should reflect or validate learners' points of view, but rather be used as a vehicle to provoke discussion among a group of diverse individual perspectives. The instructional materials used by educators should allow learners to engage in collaborative problem-solving based on their experiences (Mezirow, 1997). Educators also need to adjust the learning content to match their learners' level of understanding. Some examples of transformative learning include group projects, case studies, and simulations. In this direction, experiential learning provides the experience or actions needed to stimulate the learner. The first person to coin the term 'experiential learning' was Kolb (1984), expressed as a continuous process of experiencing an event, acquiring knowledge from it, evaluating it, and improving it based on previous experiences. It is primarily based on interactions that occur between individuals and their environments as a way to construct knowledge and meaningful learning experiences. Therefore, the action becomes the means to question their existing knowledge and experiences to provoke or foster positive change.

1.2. Inclusive Adult Education and basic education competencies

The issue of illiteracy is not a new phenomenon, even though a common belief is that only developing countries are still struggling with this issue, which is largely untrue. The importance of a literate society is also emphasised in the Sustainable Development Goal (SDG) 4.6. of UNESCO, which states that "by 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy" (UIL, 2019, p.4). Based on this goal, literacy and numeracy form the basis of creating a literate society. Even though the conceptualisations and

definitions of literacy and numeracy are constantly evolving as the world changes, they are considered core competencies developed throughout a person's lifespan. The descriptions of literacy and numeracy ascribe to different competencies. However, they also emphasise their importance in ensuring social cohesion and full participation in various aspects of everyday life.

With this in mind, the definition of literacy provided by UNESCO reads: "the ability to identify, understand, interpret, communicate and compute, using printed and written materials associated with varying contexts. It involves a continuum of learning in enabling individuals to achieve their goals, to develop their knowledge and potential, and to participate fully in their community "(as cited in UIL, 2019, p. 4). The fundamental understanding of literacy goes beyond the simple idea of reading and writing into consolidating, analysing and critically assessing written information. Similarly, numeracy is defined 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" (as cited in UIL, 2019; OECD, 2012, p. 4). This definition also emphasises the function of numeracy as a set of life skills, attitudes and knowledge that are essential to everyday life practices.

Both definitions incorporate different proficiency levels, starting from baseline or basic level needed to a functional level and finally, to a more advanced level of these competencies (UIL, 2019). Thus, the baseline level of literacy and numeracy is considered to be based on memory retention and comprehension. In contrast, a functional level allows for applying and interpreting different life situations. The level of proficiency is also addressed in the PIAAC (OECD, 2019b) Survey of Adult Skills, where there are four proficiency levels for literacy and numeracy. The dichotomisation between low and high levels of these competencies is below Level 2 and above Level 2, respectively (OECD, 2019b).

Moreover, the correlation found between literacy and numeracy is further illustrated in both international assessment programs PIAAC (OECD, 2019b) and PISA (OECD, 2019a), and in academic research (e.g., Liu, 2019), where they explain that the higher the level of literacy the higher the level of numeracy and vice versa. In other words, literacy competencies can be developed and strengthened through numeracy.

Reder et al. (2020) noted that higher proficiency in numeracy and literacy demonstrate positive associations with employment, income, political and civic engagement, health condition, and social trust. Therefore, acquiring and developing higher numeracy skills contributes to increased proficiency in literacy and better social and economic outcomes for individuals.

It is essential to consider that policy frameworks and research primarily seek to prevent youth illiteracy and early school leaving. Even though this is highly important to ensure future adult proficiency and participation in society and the labour market, an often-neglected portion of the population is adults with low proficiency levels who are no longer part of school education (Reder et al., 2020). Many scholars agree that adults with low proficiency levels in numeracy are now vulnerable to the omnipresence of mathematics (e.g., Liu, 2019; Gal et al., 2020). The current demands of even low-skilled jobs require a variety of complex mathematics and technological knowledge, which leads to the exclusion of adults that do not possess them. Thus, low numeracy skills constrain active participation in economic and civic aspects of everyday life (Lui, 2019).

Apart from high numeracy skills, employers and governments alike require soft or transversal skills that focus on problem-solving, critical thinking and communication skills (Karpinski et al., 2021). The emergence of problem-solving skills as one of the most desired in the labour market stems from the increased value and importance of building a mathematically-oriented society. This is also demonstrated in the PIAAC Survey (OECD, 2019b), where a distinct section was dedicated to measuring the level of problem-solving skills of the adult population. Additionally, the key competencies framework created by the European Commission (2019) includes transversal skills (e.g., problem-solving, critical thinking, teamwork), literacy and numeracy, amongst others. As such, the core or basic education competencies that an adult must possess to succeed in today's world are numeracy, literacy, and transversal skills.

The acquisition and development of these basic education competencies are realised through adult education. As mentioned in the previous section, participation rates of adults in non-formal education are significantly higher than in formal education. Based on the correlations found between numeracy and literacy, non-formal

mathematics can create a stimulating environment for adult learners to develop these competencies through collaboration and hands-on experiences to foster a positive mindset towards learning. The role of transformative and experiential learning in non-formal mathematics is also vital for inclusive adult education.

Inclusive education entails adapting the learning and social environment based on the capabilities and needs of the individual in order to create an equitable and participatory experience (European Disability Forum, n.d.; UNICEF, n.d.). Several legal and regulatory frameworks were established on both an international and European level to ensure the implementation of inclusive education. These frameworks include the Universal Declaration of Human Rights (1948) and the UN Convention on the Rights of Persons with Disabilities (2006), among others. In 2017, Europe adopted the European Pillar of Social Rights, which declared as its first principle the right to quality and inclusive education, training and lifelong learning (European Commission, n.d.; COM, 2020). Following that, the European Education Area (EEA) is set to materialise by 2025 as a way to support and enhance both the economy and societies (COM, 2020). This also led to the reinforcement of inclusive education as one of the six dimensions incorporated in the EEA initiative. As such, inequalities linked to socio-economic status and educational attainment should be dissociated, and the UN Convention on the Rights of Persons with Disabilities and inclusive lifelong learning strategies should be implemented across education systems (COM, 2020).

Accordingly, combining non-formal mathematics with transformative and experiential learning can offer new quality learning opportunities to all adults. Some commonalities presented across different studies regarding the learning efficacy of mathematics for the above groups are manipulative-based objects (e.g., Bouck et al., 2021), contextual learning (e.g., Gal et al., 2020) and collaboration (e.g., Civil et al., 2020). In this view, content creation needs to include these components to encourage and increase adult learners' engagement, motivation, and progress. In the following chapter, empirical data will be collected and analysed to help understand better the needs and peculiarities of adult learners with low proficiency in basic education competencies.

Chapter 2: Characteristics and traits of the adult population with low proficiency in basic education competencies in selected European countries

The second chapter of this Methodological Guide aims at uncovering the characteristics of the adult population with low proficiency in basic education competencies through empirical research collected from selected European countries. The first section provides a general picture of the European adult population based on available statistical data. The second section discusses current adult education and training policies, gaps, and best practices in Europe and selected European countries. The third and final section is dedicated to analysing the empirical data collected from Belgium, Cyprus, Greece, Portugal, and Spain to provide an accurate picture of the adult population, their needs and peculiarities.

2.1. Descriptive account of the adult population with low proficiency in basic education competencies in selected European countries

The growing interest in human capital from the 1990s contributed to the creation of international assessment surveys of the adult population. The skills and knowledge that adults gain through different stages of their lifespan were acknowledged as measurable outcomes for individuals, societies (Kirsch & Lennon, 2017) and economic success (Martin, 2018). As such, the conceptualisations of literacy and numeracy became key areas of concern that acquired diverse definitions over the years (see Chapter 1). In the following paragraphs, we will explore the proficiency of the European adult population in basic education competencies based on typically used proxies such as educational attainment, age, gender, socioeconomic status, migrant and parental background (e.g., OECD, 2019b; European Commission/EACEA/Eurydice, 2021). These proxies are also interrelated and affect one another at different stages of a person's life.

The Programme for the International Assessment of Adult Competencies (PIAAC) is one of the most known large-scale surveys used to measure adults' proficiency in literacy, numeracy and problem-solving capabilities based on digital skills (OECD, 2019b). It should be mentioned that some countries from the EU Member States have either never taken part in the PIAAC Survey or have only taken part in some rounds (e.g., in 2011, but not in 2019). A typical pattern shown among EU-20 Member states is that low performance in numeracy is always greater than literacy. According to the European Commission/EACEA/Eurydice (2021) report on Adult Education and Training, 4.4% of adults have low performance in literacy, whereas 7.7% of adults demonstrate a low performance in numeracy. Numeracy proficiency is also closely interlinked to labour market outcomes such as employment and salary (OECD, 2019b). This is a notable distinction, reflecting the necessity to strengthen adults' numeracy skills.

The European countries participating in this project[1] have varying performances in literacy and numeracy. Data derived from the PIAAC Survey of OECD (2019b) demonstrates that Spain and Greece show higher figures of low performance in both competencies ranging from 22.5% to 19.5%. On the other end of the spectrum are Belgium (Flanders)[2] and Cyprus, where the proportion of low-performing adults in literacy and numeracy is 10.1% and 8.9%, respectively (OECD, 2019b). The situation in Portugal is not as well documented in terms of literacy and numeracy, but several OECD (2020;2021) documents and country-specific initiatives (e.g., New Opportunities Initiative, Qualifica Programme) focus on raising the level of educational attainment, which demonstrates the significant gap that exists.

Within the European context, there is a common understanding that completing upper secondary education is considered the basic level of education a person can have (European Commission/EACEA/Eurydice, 2021). Based on statistical data from 2019, 21.6% (i.e., 51.5 million) of adults aged 25-64 have not completed upper secondary education, and around one-quarter of these adults (12.5 million) abandoned their education system without completing lower secondary education (European Commission/EACEA/Eurydice, 2021). Within the latter, approximately

[1] Data for Portugal was not available from the PIAAC Survey of OECD (2019) or earlier publications.
[2] It should be noted that data available for Belgium in the PIAAC Survey (OECD, 2019) only represents the Flanders region of Belgium.

20.3% are individuals with disabilities in comparison to 10.8% that are individuals without disabilities (European Disability Forum, n.d.). This further indicates perpetuating inequalities that hinder individuals with disabilities' participation and access to education.

The majority of countries participating in the Numeric[All] project register proportions higher than the EU-27 average (21.6%) of adults who have not completed upper secondary education. Portugal registers the highest proportion of adults who have not completed upper secondary education (47.8%), followed by Spain (38.7%) and Greece (23.2%) (European Commission/EACEA/Eurydice, 2021). On the end of the spectrum, lower proportions are found in Belgium (21.3%) and Cyprus (17.5%) (European Commission/EACEA/Eurydice, 2021). Nevertheless, all partner countries register proportions higher than the EU-27 average (5.3%) for adults who abandoned their education system without completing lower secondary education, as shown in Figure 1 below.

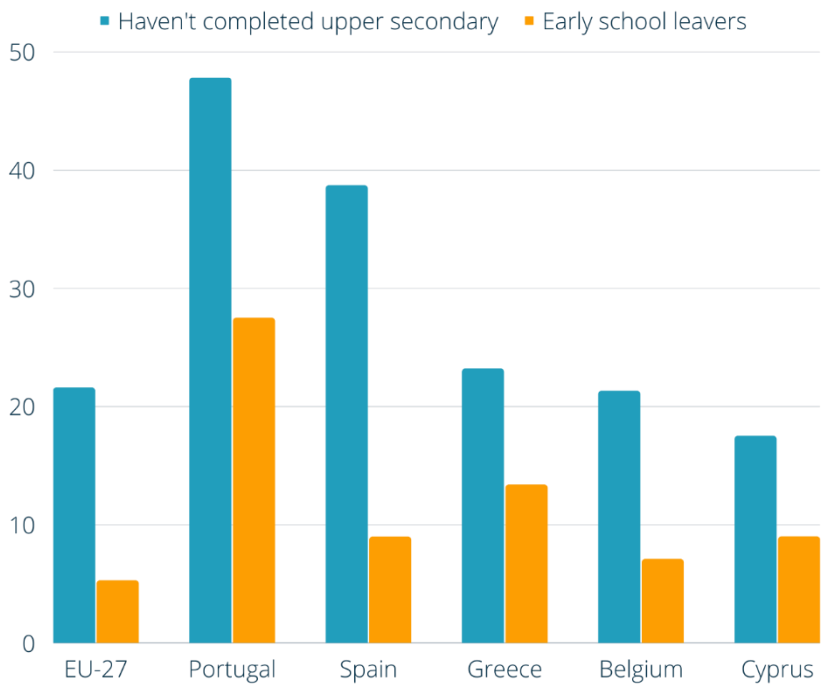

Figure 1. Educational attainment in EU and partner countries in % (Adapted from European Commission/EACEA/Eurydice, 2021, p.30)

Disparities between native-born and foreign-born are also apparent in educational attainment (European Commission/EACEA/Eurydice, 2021), numeracy and literacy proficiency levels (OECD, 2019b; Levels et al., 2017). In Europe, it has been

observed that higher proportions of adults born in a foreign country have not completed secondary education (34.1%) in comparison to those born in the country (19.6%) (European Commission/EACEA/Eurydice, 2021). This seems to be the case in Belgium (33.7% vs 18%), Greece (39.1% vs 21.5%) and Cyprus (19.2% vs 16.9%). However, this is not the case for Portugal and Spain, where 50% and 38.7% were born in the reporting country without completing secondary education, respectively. It should be noted that the difference in Spain between foreign-born adults and adults born in the country is only 0.2%, whereas it reaches as high as 20% in Portugal.

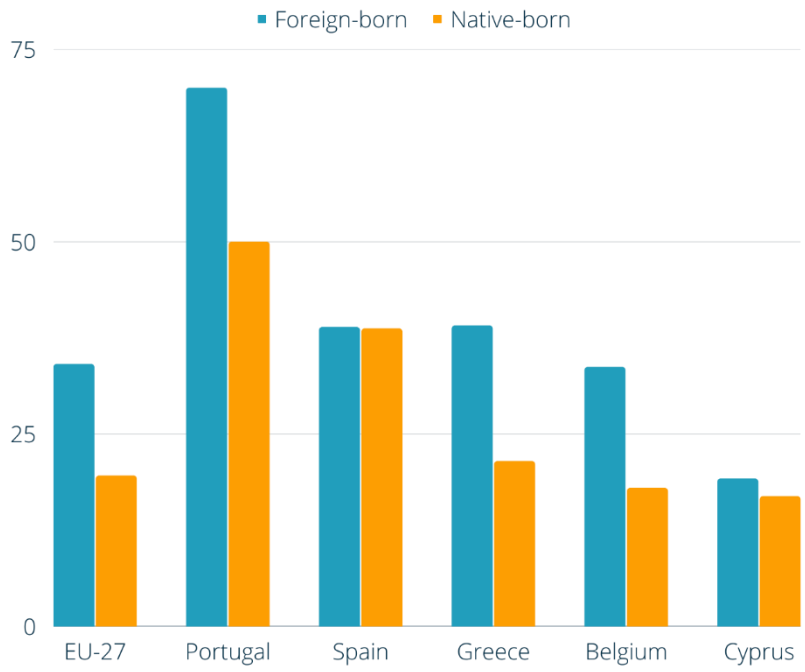

Figure 2. Educational attainment according to the place of birth in % (Adapted from European Commission/EACEA/Eurydice, 2021, p.32)

However, the proficiency levels in literacy and numeracy are also affected by the time spent in the host country since recent migrants demonstrate lower proficiency levels compared to adults who migrated five years ago (OECD, 2019b). It is essential to mention that adults with a migrant or refugee background are not a heterogeneous group (Jurdak, 2020). Socioeconomic, demographic and institutional factors affect their proficiency levels, such as language proficiency, employment status, country of origin and country-specific labour market policies (Levels et al., 2017). Thus, the intersection of these factors can create additional barriers for adults with a migrant or

refugee background to access and effectively participate in society and the labour market.

Even though educational attainment is a strong indicator of numeracy and literacy proficiency, disparities in age and gender are also significant to investigate further. According to the EU-27 average, 25-34 year-old adults who have not completed secondary education report a 15.5%. In contrast, an increase is observed from ages 35 to 64, ranging from 13.3% to 29% (European Commission/EACEA/Eurydice, 2021). Educational attainment, literacy and numeracy proficiency differences are also more pronounced in 55 to 64 year-old adults (European Commission/EACEA/Eurydice, 2021), especially between men and women (OECD, 2019b). This can be explained by the fact that women did not have as many opportunities to educate themselves and typically made, and still make, different occupational choices from men (OECD, 2019b). As such, intersections between age and gender are also related to educational attainment outcomes and proficiency in literacy and numeracy.

In line with the study of Haraldsvik & Strøm (2022), the labour market conditions and educational decisions made by adults during their adolescent years reflect their current living conditions. These decisions are also not free from sociocultural constraints and standards enforced during adults' lifespan (e.g., Judak, 2020). Similarly, Kean et al. (2022) noted the significance of early mastery of numeracy, which can predict children's math scores and further education in later stages of life. Furthermore, parents' educational attainment and perceived notions of mathematics also play a role in their children's numeracy proficiency in later life and their attitudes towards mathematics (Vanbinst et al., 2020). This is also demonstrated in the PIAAC Survey (OECD, 2019b), where adults with at least one parent who had completed tertiary education received a higher average score of 40 points on average in literacy than adults whose parents had not completed secondary education. Thus, an intergenerational effect becomes apparent and can act as a barrier to future generations developing and achieving high proficiency in literacy and numeracy.

This intergenerational effect typically follows in the socioeconomic background of adults, which is usually measured by their employment status. As underlined by Grotlüschen et al. (2019), adults with low proficiency in basic education

competencies are more likely to be unemployed or work in low-income jobs based on PIAAC and basic national skills surveys. Yet, they emphasise that unemployment and low proficiency in basic education competencies can coincide, but they are not equivalent. Adults with low proficiency in numeracy or literacy still participate in the labour market and use their skills frequently. Nevertheless, work-related tasks involving numeracy skills vary between countries even if high qualifications are required (OECD, 2019b). Therefore, adults might be excluded in certain instances due to low educational attainment.

However, a different picture is painted for adults with visible and invisible disabilities. As explained by WHO (n.d.), “disability refers to the interaction between individuals with a health condition (e.g., cerebral palsy, Down syndrome, and depression) and personal and environmental factors (e.g., negative attitudes, inaccessible transportation and public buildings, and limited social supports)” (paragraph 1). Disability does not come in one form, but various forms and types of disabilities can affect individuals’ quality of life and access to education and healthcare, among others. According to statistical data from Inclusion Europe (2021), 87 million people in the EU have some form of disability and only around half (50.8%) are employed compared to 75% without disabilities. Furthermore, only 29.4% of people with disabilities complete tertiary education and 28.4% are at risk of poverty or social exclusion. Over half (52%) of the people with disabilities feel discriminated against.

Additionally, statistical data on adults with Specific Learning Disorders (SLDs) is not as well-documented due to the difficulty of recognising learning disorders. This also means that the approximate numbers provided are not as accurate, especially for adults who might not have been diagnosed during their school years and might be unaware of this. A general estimate of the European population, including youth and adults with SLDs, amounts from 9% to 12% (European Dyslexia Association, n.d.). SLDs have a neurobiological cause that affects the way the brain processes information. They can disturb the cognitive development of a learning ability such as reading, writing, speaking, doing mathematics, or planning and coordinating motor tasks. They emerge in different ways and at different ages from one learner to another. SLDs are commonly known as “Dys” disorders, including dyslexia, dyspraxia, dyscalculia, dysgraphia and dysphasia. It is important to remember that

SLDs are not unitary disorders and affect each learner differently, at different ages and stages of development, and to different degrees.

Thus far, we have discussed some indicators used to assess adults' proficiency in basic education competencies within the European region and, more specifically, the partner countries participating in the Numeric[All] project. Through the statistical data collected, a descriptive account of the European adult population demonstrates the need to develop numeracy-related skills and educational material that can be adjusted to the needs of different groups. However, as we have seen, statistical data about adults with migrant or refugee backgrounds, SLDs and other forms of disabilities and their proficiency levels are not as well-documented or non-existent in certain instances. Therefore, exploring the policy coverage offered on an EU and national level in the selected European countries is highly relevant to identifying potential difficulties and opportunities for improvement in Inclusive Adult Education.

2.2. Policies and best practices to strengthen basic education competencies

The most effective way to enforce change is to implement new policies and provide the necessary support to the groups affected by these policies. Regarding Adult Education and Training, the policies implemented across the EU vary greatly and depend on the decentralisation or centralisation of the education system and the stakeholders participating. The responsible stakeholders of adult learning are usually overly complex and include national-level authorities, regional authorities, and other social actors such as non-governmental organisations (European Commission/EACEA/Eurydice, 2021). It is, thus, vital to ensure that policy development is framed within a coherent and complementary framework that uses coordination mechanisms (OECD, 2019b).

In general, strategic policy documents generated between 2015 to 2020 in the EU include three categories: support provided to adults with low basic education competencies or qualifications; broader education strategies such as the promotion of lifelong learning; and alignment of adult learning systems and their skills with the needs of the labour market (European Commission/EACEA/Eurydice, 2021). It

should be noted that the partner countries participating in this project have significant differences in their education systems and the levels of centralisation. Belgium and Spain are highly decentralised systems, whereas Cyprus and Greece are highly centralised. Portugal is found somewhere in the middle, where certain parts of the education system are more decentralised than others.

According to the European Commission/EACEA/Eurydice (2021) report, concerning the countries participating in the project, Greece is the only one that does not have any strategy supporting adults with low basic education competencies or qualifications up to 2020. The French-speaking region of Belgium has developed specific strategies for adults with low basic education competencies and qualifications. It also has a strategy for aligning adult learning with labour market needs. Portugal focuses on supporting adults with low basic education competencies and qualifications. Spain only has alignment policies for adult education and the labour market. Finally, Cyprus has incorporated broader adult education strategies.

2.2.1. Belgium

Flanders

Adult literacy provision in Flanders is provided by the Centres of Basic Education and the Centres for Adult Education which are both publicly funded by the Ministry of Education and Training, as well as a wide range of other publicly funded provisions, private provisions and provisions in the social-cultural sector (publicly funded). There are different types of provision: Dutch Level 1 – to improve literacy skills; basic math – to enhance numeracy skills; introduction to Belgian society; ICT; foreign languages.

Moreover, in 2017 new Strategic Plan for Literacy was approved. This is the third plan through which the Flemish Government aims to implement a sustainable literacy policy and address literacy gaps. The first plan was approved in 2005 and the second plan followed in 2012. This Literacy Plan is based on the involvement of all relevant policy areas of the Flemish Government and organisations in the field of literacy, representatives of the centres for adult education, and the low-literate persons. The main aim of the Strategic Plan for Literacy is to ensure that all learners achieve adequate literacy levels to ensure equity and equality in society (VLOR, 2017).

Furthermore, between 2008 and 2011, the Centre of Language and Education (CTO of the Catholic University of Leuven) and CITO (The Netherlands) developed a standardised test for low-literacy screening to enable easier identification (ELINET, 2016a)**.** Furthermore, libraries and local cultural organisations promote and raise awareness about literacy and reading. The promotion is done through different media sources and also through the organisation of dedicated thematic events such as the Reading race, the Book race, 'Everybody reads', the Day of Poetry, and 'Reading together' (ELINET, 2016a).

Francophone Belgium: Wallonie - Bruxelles

In Francophone Belgium, there is a large variety of literacy projects and consequently a large variety of provisions, which also influences methodologies (Lire et Ecrire Communauté française, 2013a)

Among other provisions and training, we can mention:

- Training organised by non-profit organisations aims to acquire competencies to enable access to continuing training or employment.
- Training organised by non-profit organisations recognised under the framework of Continuing Education, Social Cohesion, and/or Social Action, which aim at citizen participation, the reduction of exclusion, and a more inclusive society
- Aside from formal and informal training programmes, informal approaches also exist in locations such as libraries, cultural centres, etc. (ELINET, 2016b)

Lire et Ecrire ("Reading and Writing") movement is an association committed to providing access to basic education and skills and offers courses in reading, writing, arithmetic and computer science. It aims to draw attention to and raise awareness about literacy and its importance, promote the right of individuals to quality literacy and develop literacy as a tool for emancipation and positive societal change (Lire et Ecrire, n.d.).

For many years, Lire et Ecrire has published “Questions sur l'literacy... et reponses aux questions les plus frequentes” (“Questions on literacy... and answers to frequently asked questions”) (ELINET, 2016b). Through this, they aimed to raise awareness about low-literate adults who are not always encouraged to speak about

their situation. Recognising illiterate adults is not easy as the signs can often be invisible. Lire et Ecrire also periodically publishes the Journal de l'alpha, which covers a wide range of topics related to adult literacy (Lire et Ecrire, n.d.).

Moreover, before the Covid-19 pandemic, every year, Lire et Ecrire would organise an event Le Printemps d'Alpha ("The spring of Alpha"), to promote reading and overall literacy.

2.2.2. Cyprus

The Cypriot education system is highly centralised and allows limited or no autonomy for financial and human resources management, teaching and learning (Papaioannou, 2018). Although the educator can employ different teaching strategies and methods within the classroom, a set curriculum needs to be covered, leading to formal assessment and official accreditation.

The Ministry of Education, Culture, Sport and Youth in Cyprus is the main body of coordination and policymaking in Adult Education and supervises all provisions of formal and non-formal adult learning spaces. The Ministry's Secondary General Education and Secondary Technical and Vocational Education and Training Departments oversee formal adult education settings, including Evening Gymnasiums-Lyceums and Technical Schools, and VET Post-Secondary Institutes. Non-formal education occurs through Adult Learning Centres and the Cyprus Pedagogical Institute. However, there is not a separate department responsible for lifelong learning. Instead, responsibilities are delegated and distributed through relevant departments (Papaioannou, 2018).

Another governmental body involved in AE is the Ministry of Labour, Welfare and Social Insurance, which directs labour and social policy. Within this Ministry, there is a department dedicated to the Social Inclusion of Persons with Disabilities, which has a series of schemes targeted at the continuous education and training of adults with disabilities. The Human Resource Development Authority of Cyprus (HRDA) is also involved as a quasi-governmental body that targets continuous skill development and lifelong learning schemes for employed and unemployed adults, and enterprises (Papaioannou, 2018). According to their responsibilities, these bodies are often cooperating.

Nevertheless, the absence of a comprehensive legal framework directed at lifelong learning and adult education creates many gaps and restricts access to AE (Ioannou & Vrasidas, 2021). Especially for the migrant population, there is no concrete policy or legal framework addressing adult migrants' continuous learning and education, and existing policies refer to the inclusiveness of migrants from a very narrow and superficial standpoint (Gravani et al., 2021). Migrant adult learning is mainly addressed through learning Greek as a second language to ensure a sufficient level of integration. As such, the current AE system does not allow for "multilingual and intercultural pedagogies" (Gravani et al., 2021, p. 37), which results in the exclusion of adult migrants.

Some of the most pertinent issues that need to be addressed are the fragmented coordination between governmental bodies and the lack of educational opportunities offered (Ioannou & Vrasidas, 2021). In addition, the lack of concrete qualitative and quantitative criteria to measure the effectiveness and quality of AE are highly significant (Ioannou & Vrasidas, 2021). This is the rationale behind the Cyprus Lifelong Learning Strategy 2021-2027, which is an ongoing effort to reform the current AE system and create new synergies, coordination and cooperation mechanisms between different stakeholders and address the learning needs of adult learners (Ioannou & Vrasidas, 2021).

Even though this is a step forward, the policy inefficiencies of AE for adults with disabilities and/or a migrant/refugee background have not yet been explicitly addressed in this strategy. Thus, the policy gaps in the AE system of Cyprus have not allowed its improvement to the degree that it can be considered one of the best practices. This also reinforces this project's significant impact and potential on the Cypriot Adult Education system and its attempt to address basic education competencies through the innovative approach of mathematical museum methodologies.

2.2.3. Greece

Greece does not have a long-standing tradition of providing non-formal education for adults. The Greek accession to the European Economic Community (EEC) in 1981 facilitated the development of this form of provision. The ultimate goal was to

improve the competencies and the skills of the workforce beyond the formal stages of education. Until 1993, ESF financing was primarily channelled to the "popular education" network of 300 liberal adult education centres operating throughout the country. Between 1994 and 1999, adult education rigorously applied the European Social Fund (ESF) guidelines. The aim was to ensure public funding for the development of a system of Continuing Vocational Training (CVET). From 2000 onwards, the implementation of new policies and initiatives within a lifelong learning policy framework covers different forms of education and training. The latter enables adults to develop and reorient their education based on varying individual needs. Based on this context, the holistic concept of general adult education was introduced (law 3879/2010, article 2). It includes all organised learning activities addressed to adults that seek to:

- Enrich their knowledge
- Develop abilities and skills
- Grow their personality
- Develop active citizenship

A large number of institutions, fully or partly subsidised by the state, provided general adult education. The Secretariat General for Vocational Education and Training, Life Long Learning and Youth/Ministry of Education and Religious Affairs, reorganised by law 4763/2020, is the mainly responsible thematic Secretariat of the Ministry for Adult Education and Training. There are also a number of bodies and organisations that operate as legal entities of public and/or private law. The Ministry of Education and Religious Affairs superintends them:

- The Youth and Lifelong Learning Foundation (INEDIVIM).
- The National Organisation for the Certification of Qualifications and Vocational Guidance (EOPPEP).
- In parallel, the Ministry of Labour and Social Affairs and other Ministries also provide IVET and CVET.
- Municipalities and private providers provide liberal adult education.
- Public adult education and training is free of charge and accessible to all (EURYDICE, 2022).

The 3369/2005 law initiated the systematisation of lifelong learning in Greece. It defines lifelong education as an activity across people´s lifespan, aiming to acquire and improve general and scientific knowledge, skills and competencies, as well as personal development and employability. One of the main points of the law is the establishment of the National Committee for Lifelong Learning, which aims to ascertain the needs of lifelong education and training, evaluate the overall quality of delivery and co-ordinate the institutions of lifelong learning. In July 2010, the Greek Minister of Education announced the new Bill on the "Development of the Life Long Learning and other clauses". In general, the new bill mainly focuses on revoking a series of previous laws aimed to rationalise the Greek Adult Education and Training System. The National Accreditation Centre for Continuing Vocational Training (EKEPIS) was founded in 1997 and is the national agency responsible for implementing national planning and making actions concrete, together with the Special Departments of the Ministry of Labour and Social Insurance. The EKEPIS policies are implemented via a network of public and private Vocational Training Centres (KEK). EKEPIS is the official institution for the development, implementation and follow-up of the National Certification System of Continuing Vocational Training in Greece. Regional Vocational Training Centers (KEKs) are activated in the field of non-formal training, certified to provide training opportunities for those who are disadvantaged (Adults, 2011).

The General Secretariat for Adult Education (GGLE) and its regional agencies—the Regional Committees for Adult Education (NELE) throughout Greece—are the only government services responsible for projects regarding Adult Education. GGLE plans and develops projects for underprivileged people in order to educate communities that are considered as vulnerable groups (Author, 2022).

2.2.4. Portugal

Portugal has made great strides of improvement in increasing the level of skills and qualifications of its population (OECD, 2020; OECD, 2021). Even though the economic and financial crisis had negatively impacted the country, its educational attainment has managed to increase significantly. The legal provision that refers to adult education is Article 73 of the 1976 Portuguese Constitution, which underlines free access to education for all (EAEA, 2011). Over the past decades, the

overarching focus of Portuguese policymaking has been to increase the qualifications and skills of the adult population (EAEA, 2011; OECD, 2021; Pinto Carvalho da Silva, 2022). This led to the implementation of multiple reforms and initiatives to address these issues.

An earlier example of a highly successful initiative includes the New Opportunities Initiative (Capucha, 2013; as cited in Pinto Carvalho da Silva, 2022) as a national strategy that focused on coordination between education and vocational training and initiated the recognition, validation and certification of competencies (EAEA, 2011). This also resulted in the establishment of the Agencia Nacional para a Qualificacao (National Qualifications Agency) (EAEA, 2011), which certified secondary levels of education and professional competencies (Xufre, 2017). This was later transformed into the National Agency for Qualification and Vocational Education and Training (Agência Nacional para a Qualificação e o Ensino Profissional, ANQEP), which oversaw the system that included all VET qualifications (known as SNQ) (OECD, 2020).

In 2013, the Centres for Qualification and Vocational Education – CQEP were created to restructure and redesign previous initiatives (Xufre, 2017). This demonstrates the Portuguese government's continuous efforts and commitment to raising the skill level of the adult population. From 2016 onwards, the Qualifica Programme was initiated to increase qualification levels and employability, digital and functional literacy, align labour market needs with training and create tailored pathways for adults (Xufre, 2017). Within this framework, the Qualifica Centres created for guidance, referrals and adult education were not easily accessible to certain groups of people, such as the low educated, due to multiple alterations in names and structures (Pinto Carvalho da Silva, 2022). However, the system created under ANQEP and the level of coordination enacted between relevant stakeholders, as portrayed in Figure 3 below, has been considered one of the prime examples of good governance (see OECD, 2020).

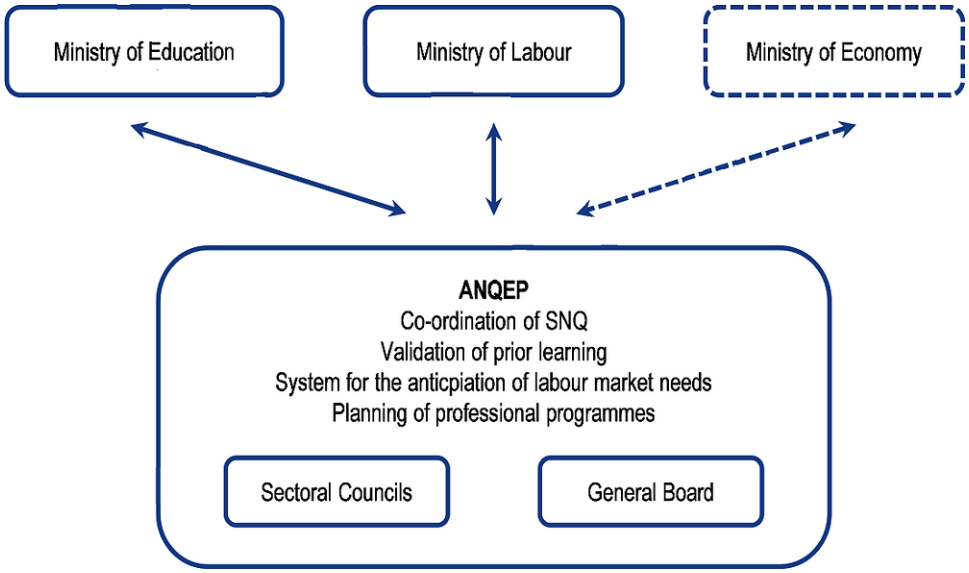

Figure 3. Governance of ANQEP (OECD, 2020, The role of ANQEP in Portugal's education and training system. In Strengthening the Governance of Skills Systems: Lessons from Six OECD Countries)

2.2.5. Spain

The Spanish education system is highly decentralised. The state of Spain is solely responsible for basic legal coverage regarding education, whereas the development and implementation of the basic educational legislation is the responsibility of the Autonomous Communities (LSE & CASE & CSES, 2020). The Organic Law 3/2020 on Education was passed and amended the previous Organic Law 2/2006 (Ministerio de Educación y Formación Profesional - Gobierno de España, n.d.).

One of its key modifications in AE refers to the collaboration between educational administrations and competencies administrations to align educational courses with the labour market needs (Article 67, par. 10). Another important modification that addresses AE is the necessity for lifelong learning programmes to adopt digital tools, personalised learning techniques and inclusive education practices with a particular focus on diversity and organisation to improve teaching quality and school functionality (Article 102). The modifications to the Organic Law 3/2020 on Education aim to address the fragmented cooperation between relevant stakeholders and the lack of training and high turnover of educators to prevent disengagement and lack of quality education. In addition, it should be noted that Spain has made great progress in raising the educational attainment of its population over the last decades (European Commission/EACEA/Eurydice, 2021).

During the COVID-19 pandemic, the government initiative of Aula Mentor promoted online free training courses with more than 100 different courses in order to reach adults in remote areas (Pinto Carvalho da Silva, 2022; Ministerio de Educación y Formación Profesional, n.d.). This initiative involved the coordination between multiple stakeholders, such as other Ministries and the Autonomous Communities (Ministerio de Educación y Formación Profesional, n.d.) and is considered among the best practices in the EU (Pinto Carvalho da Silva, 2022).

Nevertheless, due to the high level of decentralisation and variations found across the country in AE, we will focus on the region of Catalonia based on our partner's location. The Catalonian region includes Barcelona, Girona, Lleida and Tarragona. In the region, adult learning centres (escoles d'adults) offer courses for learning how to read and write, basic training, language, secondary education certification (Graduat en Educació Secundària/GES in Catalan), preparatory exams for university access and other non-formal courses (Generalitat de Catalunya, n.d.).

Data derived from the Statistical Institute of Catalonia (2019) demonstrates the level of educational attainment achieved for 25 to 64 year olds based on gender. As it can be seen, the highest percentage is secured for adults who have completed secondary education (64.9%), followed by tertiary education (41.0%) and primary education or less (8.4%). Some gender disparities are apparent, with women surpassing men in secondary (68%) and tertiary education (44.9%).

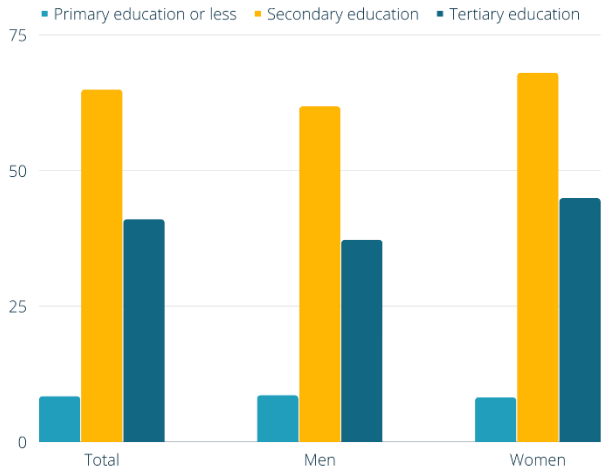

Figure 4. Educational attainment achieved by gender in % (Adapted from the Statistical Institute of Catalonia, 2019)

Even though the percentage of adults with educational qualifications below secondary education can be considered negligible, it is still above the EU-27 average (see Section 2.1.). The new legal adjustments aim to improve existing issues in the AE. Still, the implementation remains up to the Autonomous Communities, and different challenges can be faced at the micro-level with upcoming reforms.

2.3. Qualitative characteristics and behavioural traits of the adult population with low proficiency in basic education competencies from empirical data

Coverage at the policy level varies from country to country and is targeted at different groups of people according to each country's needs and priorities. This creates additional barriers for individuals belonging to specific groups and, in some cases, perpetuates existing social inequalities. As such, the collection of empirical data from Belgium, Cyprus, Greece, Spain and Portugal aims to provide us with a better understanding of different policies' implementation and their impact on adult learning.

Data collection occurred through questionnaires and interviews targeted at lifelong learning educators/trainers, social workers, psychologists and other relevant stakeholders involved in the sector. The questionnaires aimed to provide a general description of AE for educators and adult learners in the selected European countries. On the other hand, interviews allowed us to gain a more in-depth understanding of the complexities and barriers faced by adult learners in AE. We were able to reach a total of 86 participants for the questionnaires and a total of 10 participants for the interviews. We realise that the realities presented in the questionnaires and interviews do not provide a comprehensive picture of Europe. Nevertheless, they still represent a significant sample that allows us to explore the educational, psychological, and social dimensions that hinder adult learners' participation in society and the labour market.

Regarding the questionnaires, 15 responses were set as the minimum goal per country. Some of the questions were optional; thus, some questions were not completed by the participants. For instance, 13 out of the 86 participants choose not to declare their age. Based on 73 responses, the distribution of the participants' age shows higher proportions in the early 20s and 40s and lower proportions in the early

30s and late 50s. The median age of the participants is 44 years old. Our sample is quite spread out and indicates a variety of experiences.

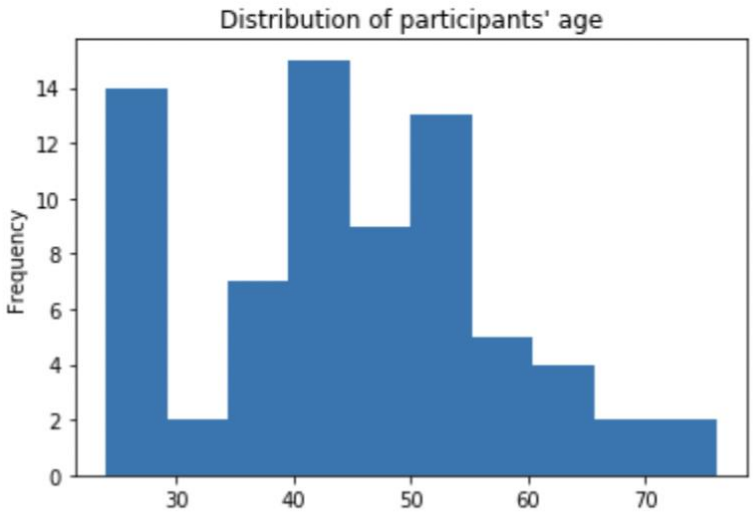

Figure 5. Distribution of participants' age

Most of our participants (67%) work as lifelong learning educators/trainers. Other professions include teachers, higher education teachers, psychologists, and members of professional development programs, among others. Their experience with adults varies from 1-2 years to more than 6 years. The highest proportion of participants, 61.6%, have worked with adults for more than 6 years, followed by 20.9% that only have 1-2 years of experience. The rest are divided between 5-6 years of experience (9.3%) and 3-4 years of experience (7%). A very small percentage of 1.2% does not have direct contact with adults but works in the sector. This indicates that our participants have a pretty significant amount of experience to offer.

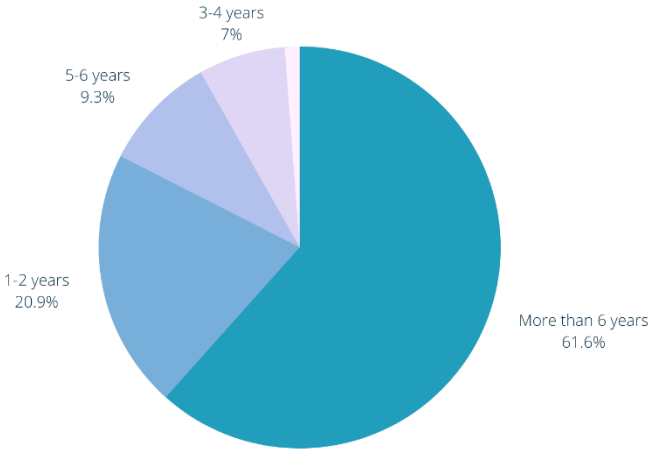

Figure 6. Experience of participants in AE

Regarding educators' professional development and training in AE, 78% responded that their institutions or organisations provide them with training opportunities, whereas 22% responded that they do not receive any training.

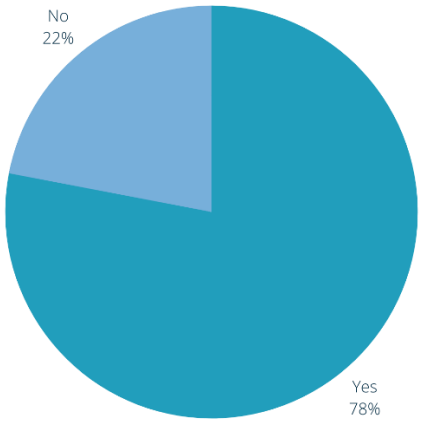

Figure 7. Training provided to educators in AE

Teacher training focuses on new teaching methodologies, including project-based learning, gender perspective and co-education, andragogy, case studies, and specialised training depending on areas of expertise (i.e., technology, literacy, numeracy, etc.). Depending on the country, its priorities and sociocultural approaches to education, there are differences in the educational approaches taken and their focus.

Moreover, 64% of institutions or organisations involved in AE offer accredited certifications to adult learners compared to 36% that do not. Though, a significant percentage of institutions or organisations in AE offer accredited programs. Still, more than 30% do not, which impedes adult participation in the labour market.

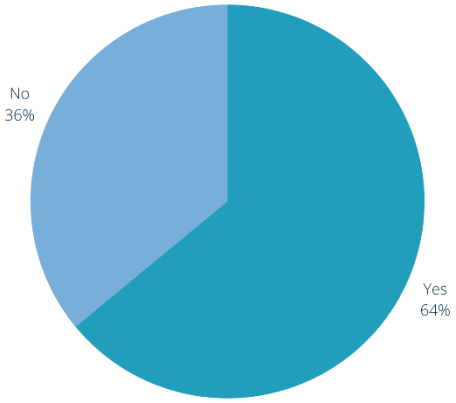

Figure 8. Official accreditation in AE

Similarly, most institutions or organisations (57%) provide official learning materials to adult learners, whereas 41.9% do not, and 1.2% responded that they do not know whether their organisations do.

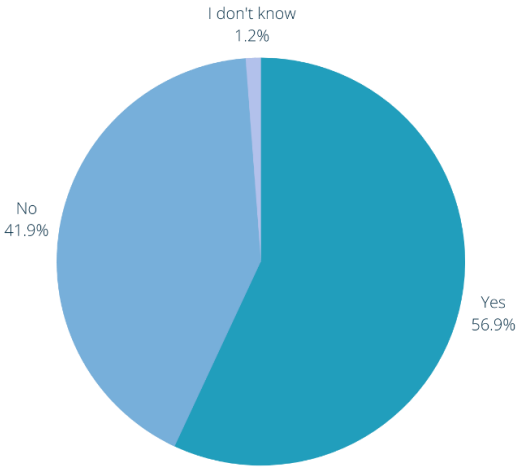

Figure 9. Official learning materials

The duration of classes varies from 1-2 months to more than 8 months. Based on the responses, 36% of classes last more than 8 months, 29.1% last for 6-8 months, 22.1% last for 3-5 months and 12.8% for 1-2 months. There are some differences observed between the participant countries. Most participants in Belgium, Spain and Portugal reported that their classes last more than 8 months. However, in Cyprus, the numbers were equally divided between 1-2 months and more than 8 months, depending on the type of the organisation and training. In Greece, the most common duration was 3-5 months.

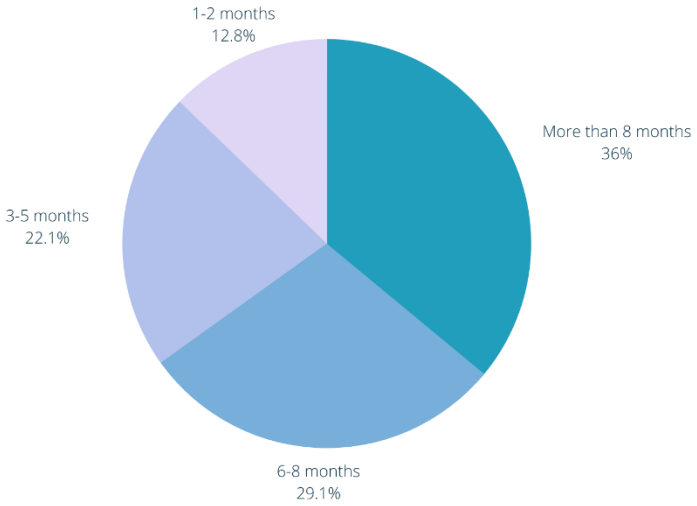

Figure 10. Duration of classes

The composition of the classrooms is mainly based on the competencies or skills of adult learners, according to 40.7% of the responses. Some other responses mentioned that classes are formed based on both competencies/skills and age (10.5%), age (5.8%) and other answers based on different conditions such as motivations, interests, specific exam results and relevant criteria. A proportion of the participants (17.4%) did not know the requirements for classroom formation.

The last questions of the questionnaire were dedicated to adult learners with Specific Learning Disorders (SLDs) and visible disabilities participating in AE. Most participants (40.7%) did not know whether adult learners with SLDs were in their organisations or institutions. Of the remaining participants, 36% reported “Yes,” and 23.3% reported “No”. When asked to specify a percentage of adult learners with SLDs on average, the majority noted that it is usually between 1 to 15%. Other participants indicated a percentage higher than 30%, and some said it varies between groups and geographic locations. However, we presume the percentage of adult learners with SLDs to be much higher due to the difficulty of diagnosing SLDs and the potential lack of relevant training.

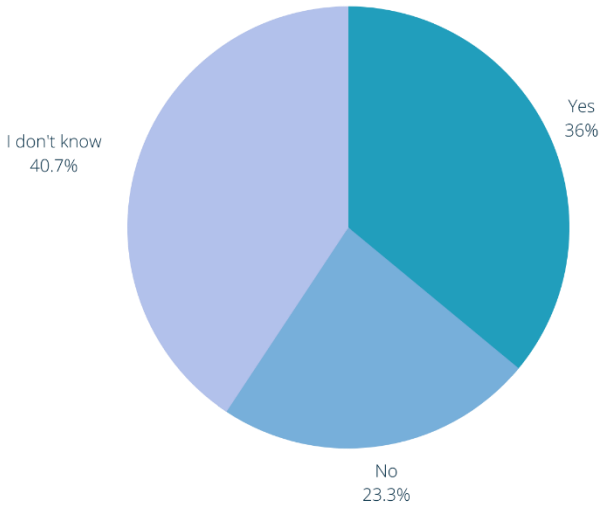

Figure 11. Adult learners with Specific Learning Disorders (SLDs) in AE

Regarding visible disabilities, participants reported that 46.5% did not have any adult learners with visible disabilities in their institutions or organisations compared to 42.3% that did. The remaining 11.3% of participants did not know whether their organisation or institution had adult learners with visible disabilities. When asked to specify an average percentage of adult learners with visible disabilities, the rate

ranged from 5% to 30%. Some participants also noted that it varies according to the class group, and a percentage cannot be specified.

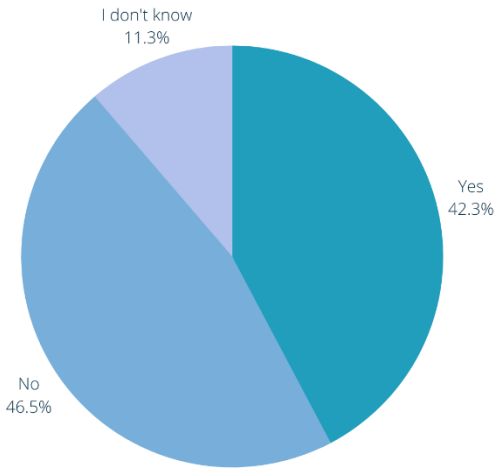

Figure 12. Adult learners with visible disabilities in AE

Even though policy coverage differs in the selected European countries, some common themes are emerging across adult learners' educational, psychological, and social dimensions. The themes identified correspond to the characteristic typology of Cross (1981), which includes:

- Dispositional barriers refer to one's personal beliefs, perceptions and attitudes, such as past negative experiences, self-confidence in learning and their capabilities.
- Situational barriers mainly describe one's personal situations, such as employment status, skills and responsibilities.
- Institutional barriers refer to practices and procedures of adult education.

These themes are not only limited to access and participation in AE but represent recurring issues throughout adult learners' journey and can also result in them quitting educational programmes. As such, clear distinctions between them cannot be made easily due to their interrelated nature in specific contexts and variations presented among partner countries.

2.3.1. Educational dimensions

The issues explored under educational dimensions were problems with access to AE, the most useful and efficient teaching-learning methods, preferred and challenging activities, and topics of interest to adult learners.

According to the vast majority of the participants, restrictions to accessing AE mainly consisted of dispositional and situational barriers. Some dispositional barriers discovered are lack of motivation or interest and negative preconceived ideas. Common situational barriers included overbearing schedules and responsibilities at home and work, financial issues, low educational background or skill levels and access to the internet. Institutional barriers were mainly reported in Belgium and Portugal, where the respondents mentioned administrative barriers, lack of support services to parents, inappropriate educational spaces, content deemed irrelevant or not valuable to adult learners and lack of recognition of prior learning and professional qualifications for migrants. Another relevant dimension is informational barriers, which refers to the lack of valid information or unawareness of learning benefits (Desjardins & Rubenson, 2013). In most partner countries, informational barriers were mentioned in the context of relevant and reliable information related to educational programmes. In contrast, it was more about the lack of awareness of potential learning benefits in Portugal and Spain.

Some suggestions made by the participants to improve access to AE revolved around schedule flexibility, content and activities in other settings that correspond to adult learners' interests, problems and needs. Other suggestions focused on individualised systems and tailored procedures for evaluating prior knowledge and skills in order to remove barriers and create an inclusive environment in adult education or the labour market. One of the interviewees underlined that the development and recognition of adult education in the policy realm should be supported and regulated whilst allowing adult educators and learners autonomy.

Based on discussions around effective teaching and learning methods, inclusive and intergenerational classrooms, adult learners require environments and contents that can accommodate their needs, interests and peculiarities. These perceptions directly relate to the understanding of inclusive education practices as a place of learning that

should accommodate the needs and learning styles of all learners (e.g., European Disability Forum, n.d.; COM, 2020). In multiple instances, the educators stated that cultivating a cooperative, friendly and respectful atmosphere in the classroom positively impacts learning. Some considerations about intergenerational classrooms centred on controlling the dynamics to create a meaningful learning experience for all learners involved. An equally important aspect of creating meaningful experiences for learners is seeking their feedback and actively implementing potential suggestions.

As reported by the participants, adults commonly enjoy engaging in activities focused on active learning methods, where collaboration, problem-solving, critical thinking and discussion are encouraged and applied in educational settings. In this context, the development of critical thinking and problem-solving skills for adult learners is mainly understood from the situations they encounter and the experiences they gain through the course of their lives. This understanding is not a new concept, but it can be confirmed from Paulo Freire's research as early as the 1970s, where he underlined the importance of connecting literacy learning to the learners' everyday practices and situations (Knox et al., 2017). However, educators noted that activities with unclear objectives, requiring autonomy and selection of information, and involving overly complicated texts and exercises are more difficult for adult learners to complete. Some topics said to be attractive to adult learners included health, unemployment, working conditions and other current affairs directly affecting their lives and well-being. Therefore, activities should be clearly defined, use simple language and reflect adult learners' real-life situations and realities to avoid frustration, lack of interest and motivation.

Content, teaching and learning methods should be useful, relevant and meaningful for them to actively participate. This is also highlighted by the widespread use of diverse teaching and learning methods among our participants, where 94.2% reported using diverse learning materials compared to 5.8% that do not. The most-reported materials are audio-visual materials (e.g., videos or podcasts), presentations, textbooks and digital tools. Depending on the nature of the course, educators select appropriate materials such as case studies, manipulative objects, role-playing activities and texts from newspapers, brochures, etc.

2.3.2. Psychological dimensions

In the psychological dimension, we explored the concepts of adult learners' self-esteem and confidence, limiting beliefs about themselves, their capabilities, and their motivations.

In this dimension, the same themes emerge, with dispositional and situational barriers being strongly apparent. However, institutional barriers cannot be excluded from this dimension as they, directly and indirectly, affect dispositional and situational barriers. Generally, adult learners' perceptions, attitudes and experiences determine their overall participation and completion of educational programs.

Based on the data collected, some divergent opinions about adult learners' self-esteem and self-confidence were expressed. Most educators mentioned that learners portray low levels of self-esteem and self-confidence. Their life situations also perpetuate this, such as difficulties faced and how others treat them. When presented with a difficult task, they are initially reluctant to try. This is the case with topics or subjects they have had negative past experiences with. On the other hand, a minority of educators voiced that adult learners are self-confident during the learning process and are not shy to express their opinions. They further explained that this might be attributed to the fact that they have nothing to lose since it does not determine their professional development.

Adult learners' self-esteem was also discussed in the context of their interactions with their educators and peers. The participants mentioned that adult learners could initially be a bit shy and reserved when attempting to interact with educators. Still, once they feel safe, they are more open to discussing, expressing their opinions and asking questions. This initially reluctant stance of adult learners also relates to the importance of cultivating a friendly and relaxed atmosphere and the educator's role as an encourager and supporter of the learners' journey. As mentioned by the educators, casual conversation, jokes, regular breaks, and a friendly atmosphere are crucial elements to ensure an inclusive and motivating learning environment. Interactions with peers are more easily done to an extent, but it also depends on the dynamics and diverse backgrounds of the group. There are instances where some even become friends outside the classroom, whereas others cannot relate to one

another. Educators also pointed out that adult learners' preconceptions or inflexibility can act as obstacles to creating a collaborative environment.

Another important issue is adult learners' motivations behind their participation, which are related to why they might abandon educational programmes. Extrinsic and intrinsic motivations of involvement have diverse effects on each person. Mixed reactions are observed when adult learners are presented with financial or professional incentives to participate in and complete an educational programme. These reactions are primarily based on adult learners' intrinsic motivations and whether a clash occurs between their extrinsic and intrinsic motivations. Thus, pressure facilitated by extrinsic motivations does not always work since it might not align with a person's intrinsic motivations.

This is further demonstrated by the educators' responses about adult learners' loss of motivation and abandonment of educational programmes. The most common reasons behind these are overbearing responsibilities, financial, health and family problems. These reasons are considered situational barriers, but dispositional barriers are also apparent. Educators also mentioned that if participation is not voluntary or adult learners do not see the relevance or meaning of the sessions, they are more likely to lose their motivation and interest. In certain instances, adult learners might abandon their education and return after their issues have been resolved. Nevertheless, this is not always the case since their determination and situational conditions can obstruct their return.

2.3.3. Social dimensions

Under social dimensions, we explored adult learners' perceptions about their role in society, their family and socioeconomic background, and civic participation.

Adult learners' perceptions are often interlinked with their self-esteem and sociocultural standards according to their geographic location. As such, adult learners might feel excluded due to their low self-esteem, limited knowledge of unfamiliar tools or tasks, and belonging to specific communities. According to the educators, adult learners restrict themselves in familiar environments based on their

individually asserted role in society. This can be assumed as a defence mechanism against potential exposure, fear of failure and previous negative experiences.

A considerable number of adult learners have a low educational background and face different realities in their everyday lives. Some educators mentioned that most adult learners have to take care of their families and are mainly concerned about their children's future and learning difficulties. In other cases, they are overly concerned with finding employment or improving their skills and life conditions. As illustrated, 52.3% of the participants stated that less than 50% of adult learners are employed. In contrast, only 38.4% said that more than 50% of adult learners are employed, and 9.3% did not know their employment status. However, there are some stark differences observed between the partner countries. Adult learners with low employment percentages are primarily reported in Belgium (16/16) and Spain (14/20). In contrast, more than 50% of adult learners are employed in Cyprus (10/15), Greece (9/15) and Portugal (9/16[3]). These differences might be observed due to the different characteristics of each country's labour market and the opportunities available.

Regarding civic participation and engagement, educators express diverse opinions from each partner country. In some instances, adult learners are more open to expressing their political and social views and engaging in such discussions in the classroom. In others, they are presented as socially conscious with a more reserved attitude towards social and political issues. It was pointed out that employed adult learners are active participants in society and the labour market to support their families and progress professionally. In a minority of cases, adult learners are also members of unions that deal with working conditions and benefits.

Summary

Based on the empirical data collected, adult learners face dispositional, situational and institutional barriers throughout their journey in AE. Even when adult learners with low proficiency in numeracy and literacy overcome the obstacles mentioned above and participate in AE, those obstacles continue to manifest, and they can also

[3] The sample from Portugal included 20 participants. In this question, we only measured the (16) participants that reported adult learners' employment status with less or more than 50% and excluded "I don't know" responses.

result in them quitting educational programs. Dispositional barriers that involve a person's self-perception, attitudes and behaviours continue to resurface as low self-esteem and self-confidence. As such, a recurring narrative of limiting beliefs emerges with sayings such as "I can't do this", "I am not good at this", or "I won't succeed". Other studies also confirm that dispositional barriers are a significant aspect for poorly educated and low-skilled adults (Desjardins et al., 2006; Rubenson & Desjardins, 2009; Van Nieuwenhove & De Wever, 2022) in combination with sociocultural pressure and standards (Porras-Hernández & Salinas-Amescua, 2012).The insecurity that adult learners face when engaging in AE is a significant struggle within oneself that does not seem to evaporate as quickly and represents an ongoing battle. This is further perpetuated by situational and institutional barriers that limit their capacity to access and commit to educational programmes in the long run (e.g., Cross, 1981; Desjardins et al., 2006).

Chapter 3: European Museums of Non-formal Mathematics

In this chapter, we intend to discuss how the pedagogical and methodological approaches of European Mathematical Museums can guide us in creating content tailored to the needs and characteristics of adult learners in Belgium, Cyprus, Greece, Spain, and Portugal. The first section is dedicated to analysing empirical data from mathematics museums in Europe to discover more about their exhibits and philosophies on mathematics. The second section focuses on the intersection between adults with low proficiency in basic education competencies and museum methodologies to facilitate learning and positive attitude changes.

3.1. Collection of pedagogical and methodological approaches from European Math Museum experts

Museums have always had a central role in societal development as spaces of knowledge acquisition and development. However, their role has shifted from a static experience of well-preserved objects available to mainly highly educated individuals to an active experience open to all (Hooper-Greenhill, 1994). In contemporary times, museum learning is heavily influenced by constructivist approaches, where visitors are encouraged to take an active role and create their own meaning (e.g., De Backer et al., 2015; Bamberger & Tal, 2009). Based on this conceptualisation and understanding of museum learning, more museums adopted a more interactive approach to their exhibits in order to attract visitors.

Mathematics museums are no exception. The conceptualisation of museums dedicated to mathematics began as early as the 2000s, with Mathematikum (Germany) opening in 2002 and Giardino di Archimede (Italy) in 2004. From then onwards, mathematics museums and similar activities have started to multiply across the world. The language of mathematics museums uses the visitor's interactions with specific objects to create a learning space based on hands-on activities that stimulate the brain and engage the learner in mathematical experiments (Beutelspacher,

2018). As such, there is a common understanding between museums dedicated to mathematics of the virtuous cycle of “hands-on, minds-on, hearts-on” (Beutelspacher, 2018).

In this vein, object-based learning or learning through objects is central to the development of mathematics museums. This type of learning is deeply rooted in experiential learning (Kolb, 1984), where learners are self-directed and use their senses to interact with objects (Schultz, 2018). In line with object-based learning, the museographic language template, shown in the figure below, indicates the functions of the object and the phenomenon presented. This entails that the object can represent a phenomenon such as the principles of thermodynamics (metaphorical usage) or demonstrate a phenomenon such as the DNA double helix (literal use). In either case, the concept explored can be manipulated by the visitor to discover diverse mathematical concepts and their effects.

<table>
<tr><td rowspan="13">Basic assets of the museographic language
(Components of tangible reality with an attributed meaning - semiophores)</td><td rowspan="6">OBJECT
(Perceivable element of reality: what exists occupies a space)</td><td colspan="6">COMMUNICATIVE APPLICATION</td></tr>
<tr><td colspan="3">PRESENTING
Character: immediate (no mediated). Literal use</td><td colspan="3">REPRESENTING
Character: mediated. Metaphorical use</td></tr>
<tr><td colspan="3">OBJECT
Real object that represents itself (introduces itself) to communicate a message relating to its essence.
Classifying according to origin:</td><td colspan="3">TEMPLATE
Real object that does not represent itself, but another object or concept.
Classifying according to the purpose of representation:
Classifying according to the purpose of representation:</td></tr>
<tr><td colspan="2">Related to nature</td><td>Related to human activities</td><td colspan="2">Duplicate of an object without trying to replace it</td><td>Model of a concrete concept</td><td>Model of an abstract concept</td></tr>
<tr><td>Inert nature (a geode)</td><td>Living nature (a bone)</td><td>A craft (a jarapa)
Historical (an old coin)
Artistic (a statuette)
Technological (an engine)</td><td>Identic duplicate (The Lady of Elche)</td><td>No identic (giant chloroplast)</td><td>(DNA double helix)</td><td>(Fontaine by M. Duchamp)</td></tr>
<tr><td rowspan="6">PHENOMENON
(Tangible manifestation of reality: what happens lasts some time)</td><td colspan="3">DEMONSTRATION
Real phenomenon that represents itself (introduces itself) to communicate a message relating to its essence.
Classifying according to origin:</td><td colspan="3">ANALOGY
Real phenomenon that does not represent itself, but another object or concept.
Classifying according to the purpose of representation:</td></tr>
<tr><td colspan="2">Related to nature</td><td>Related to human activities</td><td colspan="2">Duplicate of a demonstration without trying to replace it</td><td>Model of a concrete concept</td><td>Model of an abstract concept</td></tr>
<tr><td>With inert nature (a soap bubble)</td><td>With nature alive (an ant carrying a leaf)</td><td>A craft (touching silk)
Historical (ringing an ancient bell)
Artistic (a kaleidoscope)
Technological (the smell of something burning)</td><td>Identic duplicate (The smell of a Viking house)</td><td>No identic (Terrella by K. Birkeland)</td><td>(Principles of thermodynamic)</td><td>(Ferrofluid works by S. Kodama)</td></tr>
</table>

Figure 13. Basic Assets of the Museographic Language (Source: Fernández, G., 2022, El Lenguaje Museográfico)

In order to comprehend this framework, some examples are provided. The exhibit “Tracks of Galileo” is used by adjusting the track and finding the fastest path downwards to the bottom. The concept is implemented with simple instructions, and it

is used to prove that the simplest straight line top to bottom is not the fastest solution. Addressing such misconceptions is crucial. The users can work in groups to move the sections of the track simultaneously, as shown in Figure 14 (MoMath, n.d.).

Figure 14. Users of the Tracks of Galileo working together to adjust the track. (Source: https://momath.org/explore/exhibits/)

Some other examples of exhibits include conic sections and cross-sections of different shapes in MoMath and Mathematikum. At Mathematikum, the conical exhibit is filled with liquid, while at the MoMath, a plane of laser light is used to shine through the shape and demonstrate the section.

Figure 16. Conic Sections Exhibit at MoMath (Source: https://momath.org/explore/exhibits/)

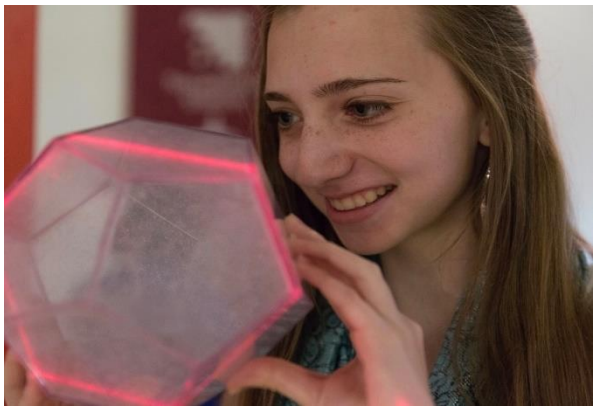

Figure 15. Conic Sections Exhibit at Mathematikum (Source: https://www.mathematikum.de/en/das-mathematikum/exhibits)

The function of mathematics museums is to provide visitors with “fun” experiences by exploring mathematical experiments through hands-on exhibits (Beutelspacher, 2018) as a way to spark curiosity, impart knowledge and a deeper understanding of mathematics. This follows the contextual learning model developed by Falk & Dierking (2000), where learning occurs in socio-cultural, physical and personal contexts. The interrelated nature of these contexts stipulates multisensory activities with opportunities for knowledge and skill development in a stimulating environment that provokes interaction and discussion amongst visitors (Cigrik & Ozkan, 2015; as cited in Nesimyan–Agadi & Ben Zvi Assaraf, 2022). By absorbing the physical and socio-cultural stimuli provided, the visitors can use this experience to transform their personal perspectives, attitudes and future actions (Nesimyan –Agadi & Ben Zvi Assaraf, 2022).

Insights from European Mathematics Museums

The aspects mentioned above contribute to the popularity of mathematics museums that is continuously growing with the global interest and necessity of mathematics as a subject and skill for societal development. Based on our project’s aim to develop the basic education competencies of adult learners, we collected data from European Mathematics Museums experts. The Mathematics Museums that took part in this survey are: Mathematikum (Germany), Fermat Science (France), IMAGINARY (Germany), MMACA (Spain) and the Garden of Archimedes (Italy). Even though the commonalities discussed exist between mathematics museums, their philosophies present distinct differences. These differences are centred on how they view the visitors and their interactions with the exhibits.

All mathematical museums have a goal to prompt the process of discovery of a mathematical concept based on objects and/or software. Four out of the five mathematics museums also included the element of playfulness as one of the main goals of their exhibitions. Therefore, discovery and playfulness/amusement are two prominent characteristics and goals of most mathematical exhibitions.

Nevertheless, discovery and playfulness are used in diverse combinations, which points to five different philosophies:

- Explanatory: The focus is on explaining scientific phenomena through discovery and joyous and playful content.
- Application: The process of discovery through playful content used to show the application of mathematics and its mechanics.
- Individual Mathematical Experience: The focus is on creating an individual mathematical experience through discovery.
- Creation: The process of discovery occurs through the construction and deconstruction of complex mathematical theories by visitors in simulated environments.
- Discussion: Only one museum emphasises collaboration through showing, discovering and engaging in playful mathematical content.

For most mathematical museums, exhibit interaction is primarily perceived as an individual experience rather than a collaborative one.

Topics of Mathematics

There is a vast range of mathematical topics covered in different mathematical museums. Some museums focus on history as a means to transfer mathematical knowledge, while others focus on mathematical research and its applicability. Geometry is one of the most used mathematical concepts found in mathematics museums. This can be due to its relevance in daily life and its potential to be explored through interactive exhibits compared to mathematical concepts like algebra. Still, mathematical concepts are often interconnected and can be found in one another in more subtle ways.

The most successful exhibits

The most successful exhibits in these mathematical museums are those considered popular with visitors. Across the different exhibits, there are some commonalities in what is popular. Popular exhibits are easy to understand, do not require any explanation, and present endless opportunities to be explored from different angles. The selected exhibits contain more complex mathematics at their core, and one of the most exciting aspects is that their mathematical nature might not be apparent to the naked eye. There is also a playful and attractive element to each exhibit.

Combining mathematics with more creative subjects such as music or art also attracts visitors.

The least successful exhibits

On the contrary, the least successful exhibits of the mathematical museums were not perceived as attractive to the visitors and included too complex mathematics. In one case, using words to represent numbers was too challenging for the visitors. Another case prompted visitors to create their own exhibits, which was not as successful due to their lack of willingness. It appears that visitors do not enjoy exhibits that require them to decode or solve a problem at hand or even create something from scratch. In addition, using numbers or complex mathematical equations is not perceived as appealing either. This indicates that if an activity resembles any form of formal assessment such as homework or tests, then the visitor will not engage in it for a long time. In contrast, activities that allow a more freeing and exploratory experience are more appealing and accessible. It can also be assumed that visitors do not like to feel like they are being assessed, especially if they have certain negative preconceptions of mathematics from school.

Process of creating an exhibit

The process of creating an exhibit has different approaches. It mostly follows a cycle of trying, thinking, discussing, and constantly improving an exhibit. Some museums might appoint a specific group of people dedicated to creating the exhibits. In contrast, other museums work with the individuals that are part of their museums to create new exhibits. Whether the approach is more flexible or more structured depends mainly on how each museum functions internally and engages with mathematical concepts to create its exhibits.

Materials used in exhibits

In terms of materials, the most used are wood and plastic. Some museums also use metal and glass/mirrors in combination with software. It should also be noted that mathematics museums attract young children, and one of the prerequisites is that the materials are ergonomic and safe for these ages. The choice of materials is detrimental to the visitors' interactions with the object as the sense of touch is activated and can trigger positive or negative sentiments towards the exhibit. Wood

and plastic are considered more approachable and can be more easily manipulated than metal and glass/mirrors. However, it depends on how metal and glass are combined with other materials. Glass or mirrors usually spark curiosity and allow for other types of manipulation more relevant to observing an item from different angles or understanding symmetry and pertinent other concepts. Thus, materials represent the second interaction of the visitor with the exhibit and its decision to continue its path to mathematical discovery.

Considerations for exhibits targeting adults

Moreover, mathematical museums mentioned some specific considerations of exhibits targeted toward the adult population. These considerations are attractiveness and the use of different colours. One of the mathematical museums noted that the exhibition's theme should be rooted in societal issues. Another museum indicated that adults are attracted to examples based on everyday life. One more consideration when using software is a user-friendly interface and design since adults do not like to feel intimidated or fail. This is also a direct link to the least successful exhibits of mathematical museums. Visitors, especially adults, are not as inclined to try if an exhibit is too intimidating or demanding.

The age groups of visitors differ between mathematical museums depending on each museum's target audience, area of focus, and exhibitions. Some museums have adult visitors over 30 that visit their museums and create exhibits directed at them or other mathematicians and scientists. One of the museums organises activities for adults only, such as evening talks, concerts or museum nights without the presence of children. On the other hand, certain museums do not have adults over 30 who visit their museums without their families and do not create exhibits targeted toward adults. Instead, they focus on creating exhibits for family groups.

Accessibility of exhibits

Regarding the accessibility of the exhibits to people with disabilities, mathematical museums range from 2 to 5 (where 5 is the highest value). An educator's capacity to adapt an exhibition's integration level to specifically adapted modules ranges from 1 to 5. This occurs because some mathematical museums try to design exhibitions that are already accessible to people with disabilities and are considered inclusive.

Educators also adopt the dynamics and contents of the activities to their maximum capacity by assessing the knowledge level and interest of the learners and using appropriate means (i.e., theories, examples, stories, open questions or small discussions) to foster a meaningful learning experience. Three museums also offer the option to arrange the visit modalities with the educators, whereas the rest do not, and it is up to the educator to use the exhibition as they see fit.

3.2. How museum methodologies can facilitate learning and positive attitude change for adults with low proficiency in basic education competencies

The data collected from European Mathematics Museums has provided us with ample information and insights into their pedagogical and methodological approaches. Research into museum learning has underlined the importance of understanding the audience in order to offer meaningful learning experiences to them (Chang, 2006). In line with constructivist approaches to museum learning (e.g., De Backer et al., 2015), the notion of meaningfulness is individually constructed and largely based on individual interests, experiences and expectations (Falk & Storksdieck, 2005). In this manner, we will explore how museum pedagogical and methodological approaches can satisfy the prerequisites of educational, psychological and social dimensions of the adult learning population in selected European countries through the lens of inclusive education.

Characteristics of mathematics museums work in favour of adult learners' preferred learning styles based on the empirical data collected. This is illustrated by the process followed in such spaces, where users engage in problem-solving scenarios through objects within a collaborative setting. The use of manipulative objects offers opportunities for visual and kinaesthetic learners to better understand mathematical concepts and does not always require the use of text. This is especially important for learners who experience difficulties with reading or might not know the language used in this context. Studies have also demonstrated that multi-sensory approaches to learning are vital to understanding mathematical concepts (e.g., Cutri et al., 2022; Manches & O'Malley, 2016) and can be beneficial to persons with visible and

invisible disabilities (e.g., Bouck et al., 2021). Therefore, mathematics museums can be an inclusive space for diverse learning styles.

In this way, users acquire an active role in their learning that is directly related to increased engagement and motivation. Attraction, initial engagement, deep engagement and disengagement are characteristic of the engagement cycle followed in museum settings (O' Brien & Toms, 2008). Engagement in museums stimulates diverse reactions that can be intellectual, physical, social and emotional (Perry, 2012), which are central to learning (Falk & Dierking, 2000; Nesimyan–Agadi & Ben Zvi Assaraf, 2022). Even though research has focused on activating positive emotions in such settings, typically considered negative emotions such as frustration work to engage the user more deeply and meaningfully towards a satisfying result (May et al., 2022). This process of contemplation, framed as a "productive struggle", has demonstrated its powerful nature on visitor engagement and learning when presented with a challenge (May et al., 2022). Completing a challenge can provide a sense of satisfaction, leading to increased motivation and self-confidence.

Another critical characteristic of mathematics exhibits is their potential to be explored from multiple angles to understand a mathematical concept whilst provoking discussion amongst the users. The freedom of exploration allows users to shed the fear or anxiety induced by past negative experiences in mathematics (e.g., Swain et al., 2005) and actively engage in a collaborative setting. During the process of completing a puzzle or challenge, discussion occurs naturally amongst users. Since exhibits are situated within a sociocultural context (Falk & Dierking, 2000), social interaction is expected and encouraged to contribute to deeper learning and understanding (e.g., Civil et al., 2020).

A prominent feature of adult learners is contextualised learning that stems from real-life based on the empirical data collected and relevant literature (see Gal et al., 2020). The inherent nature of "mathematical experiments" (Beutelspacher, 2018) is inspired by real-life problems. Meaningful learning experiences in mathematics are linked to learners' everyday practices as a recurring theme in research (Bernacki & Walkington, 2018; Christie et al., 2016; Modiba, 2011; Reid & Carmichel, 2015; Slavin et al., 2009; as cited in Koskinen & Pitkäniemi, 2022). Through mathematics exhibits, adult learners can realise the usefulness of mathematics. Albeit not all

learners might be intrigued by the same exhibits, they can still engage in the discovery process in a collaborative setting.

Visitors in museums are not necessarily motivated by learning as their ultimate goal, but instead look for ways to experience learning in an enjoyable and satisfying manner for themselves (Bobbe & Fischer, 2022). In this way, intrinsic motivation is detrimental to the level of engagement and motivation shown by the visitor. Mathematical exhibits pose a problem or challenge for adult learners to be able to construct and deconstruct mathematical concepts through dialogue (e.g., Falk & Storksdieck, 2005), which can also be a transformative experience (Packer, 2006) that results in a confidence boost (Pomeroy & Oliver, 2021).

Even though learning is one of the aims of these exhibits, their true purpose lies in awakening users' desire to look beyond their limiting beliefs about themselves and their situations and increase their self-confidence and self-determination. This mindset shift can help adult learners unlock their full potential and enable their participation in society and the labour market in new ways that are not as restrictive as they might believe. Therefore, mathematics exhibits represent an opportunity for learning, engagement and positive changes for adult learners with low proficiency in basic education competencies, summarised in Figure 17 below.

Figure 17. Summary of Section 3.2. How museum methodologies can facilitate learning and positive attitude change for adults with low proficiency in basic education competencies

Chapter 4: The acquisition and development of basic education competencies through museum methodologies in Inclusive Adult Education

In this chapter, we intend to discuss the acquisition and development of basic education competencies through museum methodologies in Inclusive Adult Education. The first section provides a set of requirements for content creation based on empirical data collected on the characteristics and traits of adults with low proficiency in basic education competencies and on the Universal Design for Learning. The second section focuses on translating the pedagogical and methodological approaches of European Math Museum experts into a diverse set of tools that can be utilised to increase literacy, numeracy, and transversal skills through inclusive adult learning.

4.1. Set of requirements for content creation based on characteristics and traits of adults with low proficiency in basic education competencies

Building adult numeracy skills is crucial for citizens' well-being and active social participation (UNESCO, 2020). To do so, it is essential to focus on inclusive learning and content as a starting point, to create resources adapted to adults with low proficiency in numeracy, literacy, and transversal skills. Thus, we need to create inclusive learning materials that are flexible, accessible, and understandable to all learners. Adapting materials can positively impact the learning experiences of all learners, especially learners with Specific Learning Disorders (SLDs) and other forms of disabilities. However, it is essential to bear in mind that not all adaptations will work for every learner.

In the following paragraphs, we will offer general guidelines and a set of requirements for content creation based on the interviews conducted in this project's

scope and on the Universal Design for Learning (UDL). The rationale is to create resources that can also be adapted to learners with Specific Learning Disorders (SLDs) and possibly other forms of disabilities. At the end of this section, infographics that offer practical advice can be found, which summarise the main points of the section and can also serve as a sort of checklist for creating content and activities for adult learners with low proficiency in basic education competencies and learners with SLDs.

What is Universal Design for Learning?

Universal Design for Learning (UDL) is an approach intended to increase meaningful access and reduce barriers to learning for learners with diverse learning needs and those from diverse cultural and socio-economic backgrounds. There are three main principles: Engagement, Representation and Action and Expression (CAST, n.d.). The guidelines were used as an inspiration to create this section, and more information can be found here: https://udlguidelines.cast.org/.

How to adapt the learning environment for adults with low literacy and numeracy skills?

To adapt the activities for adult learners with low proficiency in basic education competencies and learners with SLDs, it is necessary to provide a quiet, uncluttered environment for learning. When designing the activities and the content, try to use a variety of skill sets and tools to stimulate the learning process. The activities should have clear goals, clear guidelines, and, if necessary, a subdivision of tasks in small steps. Based on the collected data, adult learners enjoy shorter activities in different formats with an immediate reward. Moreover, as they may have trouble grasping abstract and theoretical concepts, it is essential to avoid overly complicated texts and exercises containing unnecessary information. Providing too much information can be overwhelming and discouraging for learners. By presenting the most necessary information, the learners will understand the information more easily. Additionally, consistent language, presentation style, and format will help avoid confusion (Pleasant et al., 2016).

The results of the survey and interviews show that the educators use various teaching methods. However, they all have in common the personalisation of the learning experience, adaptive learning and focusing on individualisation rather than on a one-size-fits-all approach. The individualisation of learning supports the creation of an inclusive environment.

Lastly, it is essential to create joyful and playful activities that encourage learners to explore and ensure that activities can have more than one possible solution. According to the data collected from mathematics museums, the most popular content presents endless opportunities and can be explored from different angles.

Use multisensory method

Learners tend to learn through different stimuli. For some learners, this means that they learn better visually, auditorily, or kinaesthetically. In addition, it is often the case that learners will learn the best using a combination of different modalities. Researchers suggest giving learners information in different ways to ensure meeting their learning style and understanding of the task at hand (Pleasant et al., 2016).

One of the main benefits of the multisensory method is that it will be effective for all learners, especially those with SLDs. This means that an activity created using multisensory learning will benefit more learners and be more efficient and flexible in its use (EcomXSEO, 2021). Based on the collected data, using the multisensory method helps adult learners and their learning process. Instead of focusing only on the written content and production tasks, create content that will stimulate different senses: sight, hearing, touch, taste, smell, and balance.

Organise collaborative learning activities

Based on the collected data through interviews and questionnaires, it is beneficial to combine different pedagogical approaches as they lead to positive results. Thus, when creating content and activities for adults with low proficiency in basic education competencies, include individual learning activities but also collaborative ones. An intergenerational space presents opportunities for younger adults to learn from older

adults' experiences and knowledge and vice-versa. As such, collaborative learning holds a vital role in adult education.

Before creating collaborative learning activities, make sure to provide easy-to-understand instructions. Then, when starting the activity, ensure that all learners understand everything before proceeding. In addition, try to organise creative, constructive activities that foster collaboration rather than competition-based activities. Moreover, we recommend that you keep the groups small as it makes it easier to comfortably share insights and experiences without getting lost in the crowd.

How to adapt the written content?

To create inclusive written content, opt for accessible fonts. Sans serif fonts such as Arial, Century Gothic, Verdana and OpenDys are ideal. Line spacing should be 1.5, and the font size should be between 12 and 14 to ensure a more effortless reading flow. If you want to emphasise something in the text, write it in bold and avoid italics or underlining.

If you are printing the materials, think about the thickness of the paper. The text will show on the other side of the paper if it is too thin. On the other hand, the thick paper will help prevent transparency and, consequently, help with concentration. Make sure to print only on one side of the paper to avoid turning pages.

As mentioned earlier, using a multisensory method is important and offers various stimuli. However, the illustrations and images should be used to help understand the task and the activity, not simply for decoration purposes. Lastly, the use of colour codes is recommended, but be consistent with their usage and presentation.

How to create and adapt the tasks?

It is beneficial for adults' learning to create content based on real-life situations and their realities. Thus, it is essential to create tasks and activities that focus on logic and use real-life examples and application of the obtained knowledge, rather than on memorisation and automatisation of tasks and rules. If tasks are situated within

meaningful, realistic contexts, this will also facilitate the transfer of learning (Ginsburg & Gal, 2000).

Additionally, it is essential to consider possible cognitive overload when creating content for adults with low proficiency in numeracy and literacy. Using manipulations and contextualising elements is a great help in engaging learners with difficulties in literacy and numeracy, especially those with SLDs. Though, keep in mind to avoid complex manipulations. Each learner may have a different pace of learning and solving the tasks. Therefore, it is important to ensure enough time for completing the tasks and activities.

Moreover, make sure to use an interdisciplinary approach when creating tasks and activities. For example, combining mathematics and numeracy learning with more creative subjects, such as art or music, could be beneficial.

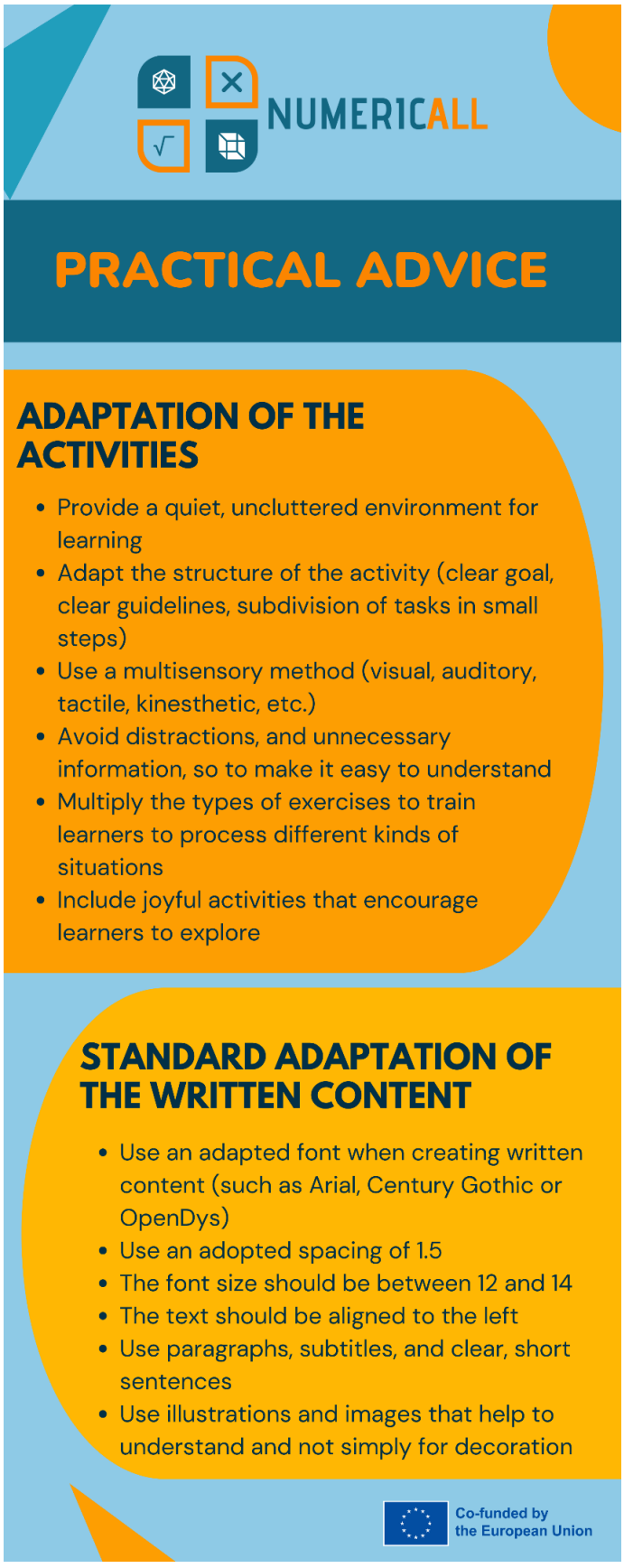

Figure 18. Summary of key points of Section 4.1. Set of requirements for content creation based on characteristics and traits of adults with low proficiency in basic education competencies (Part 1)

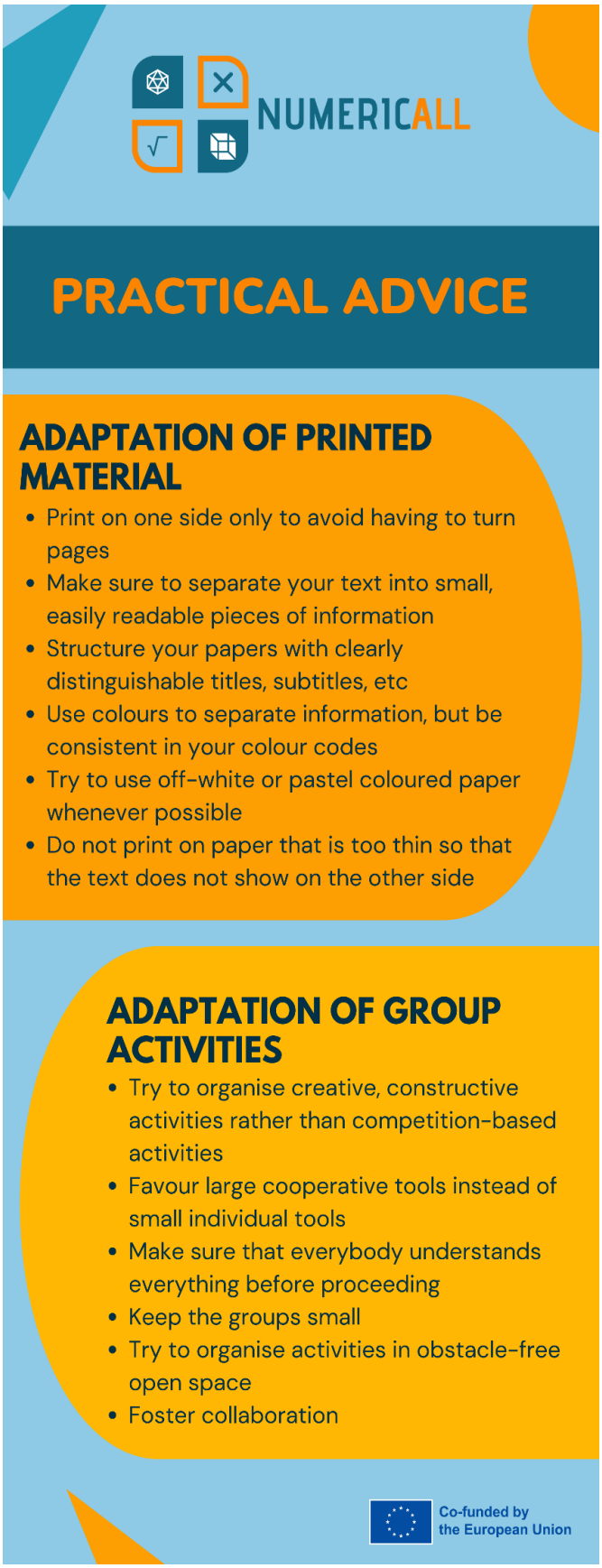

Figure 19. Summary of key points of Section 4.1. Set of requirements for content creation based on characteristics and traits of adults with low proficiency in basic education competencies (Part 2)

Figure 20.Summary of key points of Section 4.1. Set of requirements for content creation based on characteristics and traits of adults with low proficiency in basic education competencies (Part 3)

4.2. A diverse set of new tools to increase basic education competencies of adult learners

Focusing our intervention on the math education of adults with low proficiency in basic education competencies, it is only natural that we stay away from orthodox school strategies and methods. We must not try to emulate ordinary schooling but find our own way. At first, this could appear as a major limitation to our efforts, but when we analyse the purpose and practices of the mainstream context, we reach the conclusion that we face a grand opportunity. We are free to identify the most relevant aspects of mathematics and promote them by means of our choosing and creation.

The real-life uses of mathematics are extremely important, and we must empower our learners with the right tools. We must keep in mind that mathematics plays many roles in human life, and the importance of the powerful connection between the individual, society, and the real world cannot be overstressed. But we must also be aware that the physical and social contexts vary in space and time, which implies that some tools are not able to travel and adapt. Fortunately, mathematics has many levels, some of them deep enough to support the interfaces between individuals and their physical and social environments. It is our goal to aim at those profound stories of mathematics and let the adult learners enjoy their appropriation.

School mathematics deals with the mathematics of the real world in the sense that it tries to prepare the students for the adult, autonomous life out there. Our goals, as we are concerned with adults, cannot be the same. We do not worry about following any syllabus about which students will be assessed. We are free to aim at what is the noblest part of mathematical education. We want our learners to mathematise their experiences, to build personal, gratifying tools to mediate the experience of social life.

The concept of ethnomathematics, introduced by Ubiratan D'Ambrósio (1999), is based on a triple way (etho-mathema-tics) of construction of "techniques", based on "mathema", built by a group ("ethno"). D'Ambrosio and others explain how a culturally identifiable group (villagers, professionals, etc.) may collectively create a response to common environmental problems by thinking mathematically and building appropriate interfaces with their physical and social contexts. From this point of view,

it becomes clear that mathematics, the unique mother of all sciences, the universe abstract cathedral, shows different faces to different agents. Of course, the Pythagorean Theorem is valid all over, but that is hardly the point. The main issue here is that what is relevant in mathematics is culturally dependent, not universal. Many Western scientists and mathematicians, judging from the universal quality of mathematical truth, jump to the conclusion that mathematics must look the same everywhere. They are wrong. Mathematics is universal, of course, but it is also much more than what the Western tradition sees.

In our project, we deal with adult learners, who bring with them varied personal characteristics relevant to the learning processes. We have a similar situation to ethnomathematics. We must look for the right face of mathematics and nurture it. At first sight, it could look like we must approach our scientific topics more superficially, to ease up the path of the learners. Wrong again. We may, and should, go deeper. Because we respect our public, but also because we are free from the usual scholastic constraints. We may emphasise ludic, non-formal approaches to knowledge acquisition which we rarely witness in the traditional classroom. These include, but are not limited to, relevant cultural and historical connections.

Besides, we may also aim at the core of the mathematical thinking processes – the intellectual pleasure that mathematical practice brings. As an illustration, consider basic arithmetic. We may, of course, promote the memorisation of mathematical facts, which are the building blocks for the appropriation of the standard multiplication algorithm. That's what we see in many a school. However, this cannot be our approach for several reasons. Among these are the fact that these methods are designed for young learners and that this approach is often unattractive. Instead, the adult learner may gain familiarity with an abacus – the Chinese abacus, say – together with Napier's bones (see Figure 15 as an example) and other calculation devices from different historical contexts. A little practice with pen and paper ways of calculating from the ancient Egyptians is also enriching. We do not need any pre-established chronological order for the material introduced; the learners make their way while travelling their own path.

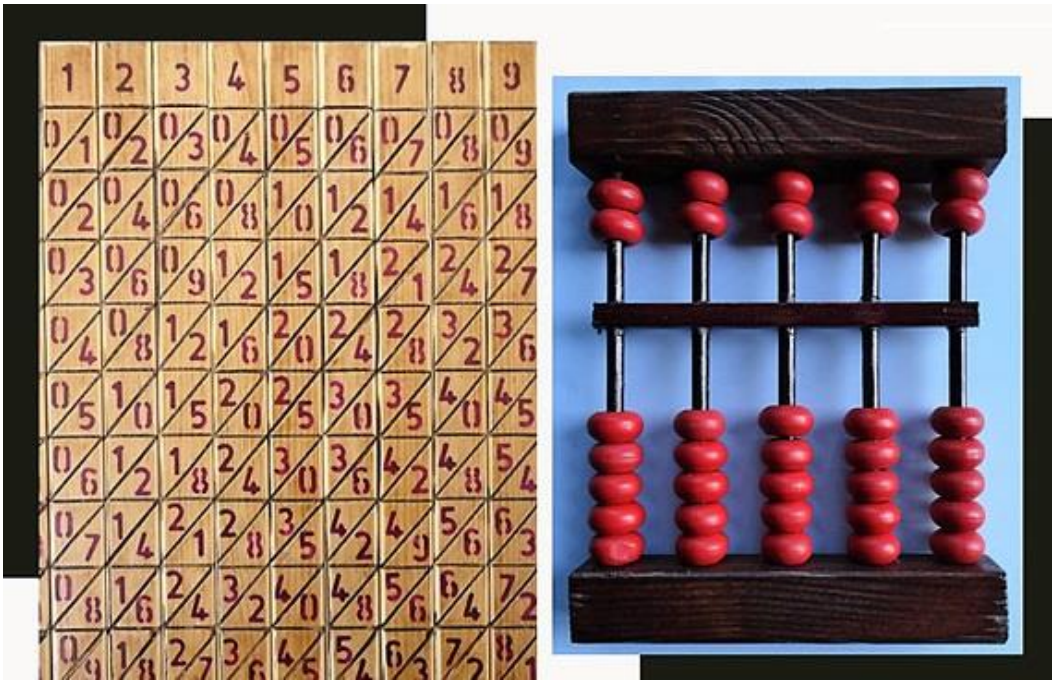

Figure 21. Napier Bones (left), Abacus (right) from Association Ludus Collaboration with the Portuguese National Museum of Natural History and Science having maths afternoons for Adults

With this background in mind, we even suggest that the learners practice mathematical activities with no clear, practical aim. The most profound characteristic of mathematics is its abstract character. The applications, from which sprout the so-needed everyday tools, tend to hide this face of the science. Also, the deeper we go, the easier it is for a competence to transfer to other realms.

In adult education, we have the golden opportunity to promote abstract thinking without a clear goal in mind. Accordingly, we suggest the use of abstract board games and mathematical puzzles. These are not difficult to find in the literature and online. Here we propose a small sample: Amazons, Hex, Slimetrail, Go, Checkers, Product, Chess, Breakthrough, Connect-4.

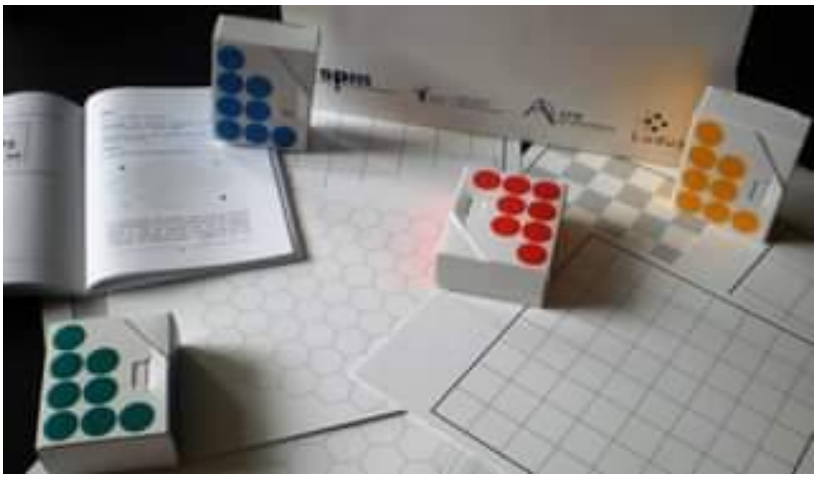

Figure 22. Mathematical Games Kit developed by Associação Ludus together to teach abstract games

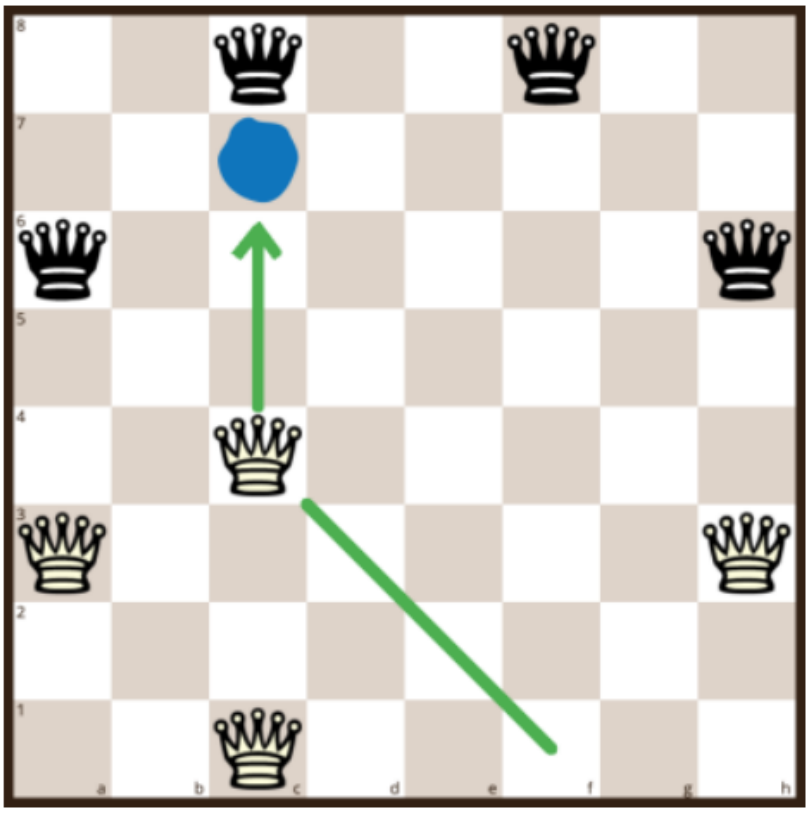

Figure 23. Amazons Game from 8x8 Erasmus+ Handbook, 4 Queens play for area, first they move then they shoot an arrow blocking a square

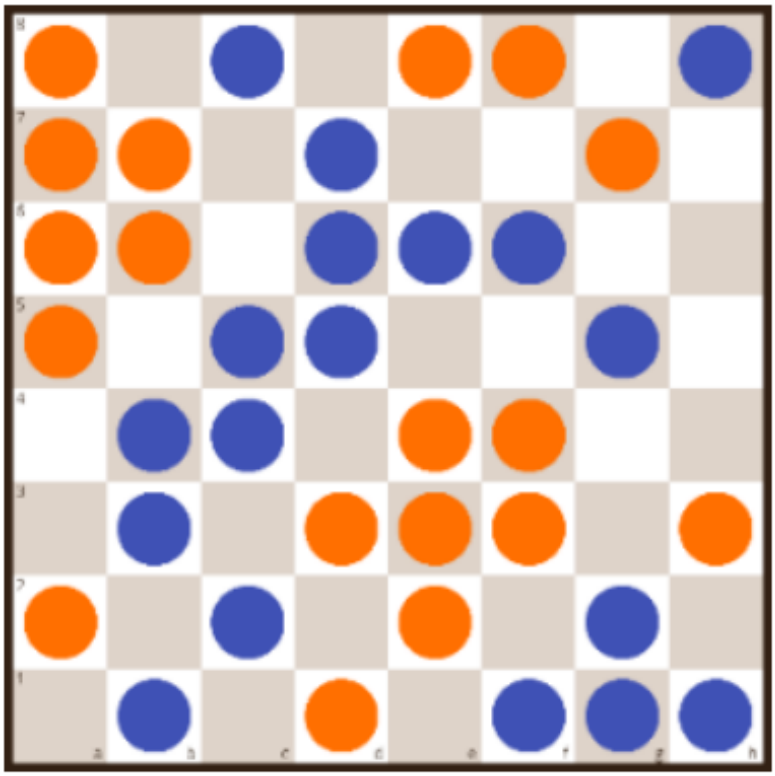

Figure 24. Cats & Dogs exercise from 8x8 Erasmus+ Handbook, Cats (blue) to move and win - no two opposing colours can be played next to each other

There is strong evidence that the practice of mathematical board games and the activity of mathematical problem solving induce similar internal thought processes. For example, it was shown in 2016 that students who were taught to solve chess problems through heuristics later outperformed the control group who had not (Trinchero & Sala, 2016). Moreover, the students taught chess training by professional chess instructors had a more considerable gain of 60% between their pre-instruction and post-instruction maths test scores. This is compared to the 15% gains the two groups of students had, where they were either taught chess training by school teachers or traditionally.

These effects are not limited to students in secondary education. Even during advanced age, adults in adult day care centres have shown improvement in cognitive functions after engaging in board game activities. The effect was tested using structured questionnaires, and results were, again, compared to those of adults who carried on with their routine activities. Indeed, the 2019 paper detailing the results encourages the incorporation of board games into social work care (Ching-Teng, 2019).

Therefore, the museum methodologies we propose to use as adult education tools can be based on such games, but not only. An approach of exhibiting the history of mathematics would not engage the adult audience actively. Instead, the audience must become participants and users. Therefore, we must, with our varied and rich approach, induce in our adult learners the pleasure of thinking, characterised by rigour and creativity. This is the essence of mathematics. From this enjoyment, the adult learners, with our help or by themselves, will construct their mathematical interface with the world. A lifetime process.

Chapter 5: The materialisation of museum methodologies through Numeric[All]'s Project approach

The fifth and final chapter of this Methodological Guide explains how the Numeric[All] project uses museum methodologies for inclusive adult learning. The first section discusses the intersection between museum methodologies and best practices in relation to inclusive adult learning to promote a positive attitude change. The second section briefly describes the following project results to demonstrate their potential and innovative element to adult learning.

5.1. A holistic approach to inclusive adult learning and enrichment of successful EU practices based on non-formal math museums

Experiential learning is related to the process of learning from experience; normally a direct or primary experience that either occurs in the normal course of one's life or is sponsored by an institution as part of a training or teaching program (Elwick, 2013). Learning does not occur in isolation to one's environment, instead, it is considered a social process. This is fundamental to the understanding of both experiential and transformative learning. The process of learning and meaning-making from experiences requires critical reflection and analysis from the individual to become knowledge and lead to new actions (EUROACE, 2017).

In this aspect, the combination of experiential and transformative learning directly relates to inclusive education practices. Access to lifelong learning, especially to transformative education, indicates the chance to participate fully in society. Equal participation in society in the frame of lifelong learning is an opportunity for each person to achieve personal growth and development. Yet, equal participation in education implies desegregation into society, especially regarding individuals with migrant and refugee backgrounds, SLDs and other disabilities. Therefore, implementing an inclusive way of teaching, especially regarding lifelong learning, can

encourage the further consolidation of social cohesion within society (Lifelong Learning Platform, n.d.).

Nevertheless, inclusive education is a contested term interpreted differently according to the time, place and setting used (Byrne, 2022). As explained by Schreiber-Barsch (2017), there is an urgent need to consider different aspects of educational settings like physical infrastructure and teaching and learning approaches from the perspective of dis/ability. Every individual has their own needs, but not all needs can be anticipated in one setting by educators; however, the most crucial aspect is for everyone involved to be adaptable and determined to continuously attempt inclusive practices (Schreiber-Barsch, 2017). It is, thus, important to raise awareness of these issues at all levels of education and across formal, non-formal or informal contexts. As Tisdell (1995) highlighted, the term "inclusivity" directs attention to diversity, which depends on the setting, the participants involved and their individual characteristics in the general society. Therefore, it becomes increasingly important to be mindful of the intersections that occur between society and individuals in educational settings.

Experiential and transformative learning have numerous advantages for those who participate in them. It helps learners better understand the subject at hand through action, increases their appreciation of its applicability, and works towards shifting their perspective. Experiential learning has an added value in the world of mathematics since it has become an effective method for helping learners of different ages overcome their anxiety about understanding mathematical problems. In the same way, experiential mathematics is related to hands-on experience, an activity that can be integrated into the curriculum of educational institutions, inside or outside the classroom (Konversai, 2018). As such, mathematics can be represented in different ways, from symbols to physical and manipulative objects (Goldin, 2020) that make them attractive to learners with diverse needs (e.g., Bouck et al., 2021; Civil et al., 2020; Faragher et al., 2016).

Similarly, the study of Faragher et al. (2016) draws our attention to inclusive practices of learning mathematics. They advocate that the different approaches used to make the subject easier to understand for certain groups of learners do not need to result in segregation since they can benefit all learners. The issue of

inclusiveness in mathematics also concerns the ability to participate. The strategies to achieve an inclusive classroom need to include learners' voices in mathematics education to enable their participation or take diversity as a point of departure in teaching mathematics to embrace inclusive practices (Roos, 2019). This understanding presents similarities to ethnomathematics (Ubiratan D'Ambrósio, 1999) and the contextual learning model (Falk & Dierking, 2000) used in museums since learning is largely dependent on where, when, how, and with who it occurs.

More specifically, the successful implementation of any programme in adult education requires a positive learning environment (Chakanika et al., 2019). On that account, the role of the educator is pivotal and cannot be discounted. Educators need to gain a deeper understanding of their learners' needs and particularities to support meaningful learning experiences for them (see Chakanika et al., 2019). Within this project's scope, we discovered through empirical data collection that mathematics museums could create a stimulating environment for adult learners by accommodating diverse learning styles and fostering motivation and encouragement through challenges. These challenges are designed to have real-life applications and allow for exploration and discussion amongst users. The pedagogical and methodological approaches used in mathematics museums allow greater flexibility for both learners and educators to instil knowledge and meaningful learning experiences.

In the European Union, the recommendation of the 2012 Council supported the official recognition and legitimisation of non-formal and informal learning by 2018 in all member states (Cedefop, 2015). According to the findings of the European Guidelines for validating non-formal and informal learning (Cedefop, 2009; Cedefop, 2015), these arrangements can enable people to boost the level of the visibility and value of their knowledge, skills and qualifications acquired outside of the formal education and training environment: at work, at home or in voluntary activities. The edition mentioned above of the European Council's recommendation is the outcome of a two-year process involving a wide range of stakeholders in validation at European, national and/or sectoral levels (Grainger, 2016). Since then, many initiatives have been launched within Europe to establish an inclusive learning environment for each learner. Formal and informal learning methods are considered

to be accessible to each learner and tailored to their needs, motivations, and competencies. European Mathematics Museums are a prime example of these initiatives. The use of mathematics in a museum setting opens a new world of possibilities for adult educators to use and adult learners to explore to enhance numeracy, literacy, and transversal skills.

5.2. Next steps of the Numeric[All] Project

The empirical data collected from both relevant stakeholders in AE and European Mathematics Museum experts has allowed us to gain a deeper understanding of the psyche of adult learners' preferred learning styles and modes. Our content creation criteria focused on specific considerations to the learning environment, using multisensory methods and collaborative learning activities, as well as adapting the written content. Thus, one of our priorities that we aim to carry out throughout the completion of this project is creating inclusive content that can be accommodating to all adult learners.

As such, our second project result, the Gamified Mobile Museum of illiterate adults, is based on these principles that will be realised through 16 tailor-made hands-on exhibits for illiterate adults to develop and reinforce their basic numeracy, literacy, and transversal skills. Bearing features rooted in non-formal mathematical tools and gamified processes, the interactive exhibits will be conceived and designed in the form of blueprints under PR2. Concrete descriptions, guidelines and instructions will accompany them on how to be used pedagogically for the target groups. The guidelines will thoroughly analyse learning objectives, gained skills and competencies, pedagogical rationale, and applied (hands-on) methodology for potential usage. All blueprints along with the guidelines will be uploaded on the Numeric[All] platform in English and partner languages, whilst they will be treated as Open Educational Resource (OER). Particular emphasis will be given to creating material appropriate for adults with SLDs and other forms of disabilities, both in terms of design and materialisation.

Following PR2, the third project result is the STEM module on 3D Modelling along with a DIY creation kit. This project result encompasses a 20-hour STEM module with a comprehensive introduction to "3D modelling". It aspires to endow lifelong

learning organisations and other relevant institutions with the appropriate knowledge on how to employ computer-aided design software to ideate, design, and print out three-dimensional exhibits. These exhibits will be identical to those conceived, delineated and illustrated in the previous result (PR2) to satisfy the learning needs of adult learners with low proficiency in basic education competencies. The module will be accompanied by the Non-Formal Laboratory Manual, which will outline the target groups, learning objectives, required equipment and necessary software and relevant information on usage, preparation, methods and procedures.

We will also design a DIY creation kit with design maps, detailed instructions, indicated materials and appropriate measurements for all 16 interactive exhibits of the gamified mobile museum. This will consult users on designing, physically building and assembling interactive 3D constructions by embedding relevant photos, pictures, comments, ideas and ready-made tutorials. It will also explain the independent assembly of the hands-on exhibits by indicating all preparatory steps the facilitator should follow to assemble/disassemble and store the 3D objects along with the required timeframes. All information will be provided in all partner languages and remain free and available for anyone aspiring to reproduce and build the exhibits.

The final project result is the Numeric[All] E-Book will be aimed at guaranteeing an integrated, validated and pedagogically sound learning experience concentrating entirely on the quality needs and broader peculiarities of our target group. In this light, we will be able to ensure that knowledge acquisition and peer-interaction opportunities provided through hands-on exhibits produced under PR2 and PR3 will be fully exploited by target organisations. Accordingly, the Numeric[All] E-Book will elaborate on 16 tailor-made worksheets, lesson plans, and videos demonstrating the materialisation process of lesson plans. Each worksheet corresponds to one exhibit of the gamified mobile museum, to be used by lifelong learning trainers during the non-formal style laboratories through which adult learners will experience the 3D constructions of PR2. The pedagogical process is rooted in guiding adults with low proficiency in basic education competencies to formulate their hypotheses in written form, urging them to develop and strengthen essential numeracy skills to effectively manage everyday tasks of everyday life. In parallel, allowing learners to fully comprehend the essence of the experience offered by the gamified museum. The

worksheets will encompass various mathematical concepts related to everyday practices.

The lesson plans will guide the lifelong learning trainer on how to use the interactions of the gamified mobile museum in a broader educational context by providing concrete solutions. These solutions derive from solid pedagogical processes on how to deal with participants' diversity, learning weaknesses and learning disorders, behavioural tendencies and habits, lack of autonomy, learning phobias, fear of change and low self-esteem. Concurrently, particular emphasis will be given to helping vulnerable adults to form teams and interact with each other under collaborative contexts whilst being able to follow the reasoning formulated by others. The lesson plans will also embed suggestions for interactive non-formal workshops that satisfy all the learning needs and pre-set objectives. Recordings will be provided to demonstrate the materialisation process of lesson plans based on the participants' experiences of the interactive 3D exhibits. All videos will be subtitled and uploaded on the project platform and other relevant sites.

Pilot tests will be conducted in every project result to ensure that the produced content and materials correspond to adult learners' needs, interests, and peculiarities and can be successfully implemented in educational settings by lifelong learning educators and trainers. Thus, the viability and sustainability of our project results are our top priorities and concerns throughout our journey to completing the Numeric[All] project. We aspire to combat the issue of adult illiteracy through the innovative methodology of non-formal mathematics museum. We also intend to help adults with low proficiency in basic education gain the necessary skills and competencies to be active participants in society and the labour market.

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