Mathematics Education for Adults: Can It Reduce Inequality in Society?

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Abstract Adult education in mathematics is considered from a number of perspectives. It is a key element in the general concept of lifelong learning. Lifelong learning is essential in a rapidly changing economic and technological world. For example, quickly changing production conditions in companies lead to quickly changing demands on skills possessed by company employees. Skills that are taught in schools and institutions of vocational education also need to be adapted to fulfil the requirements of a changing job environment. Lifelong learning is a process that corrects omissions in basic education. In this sense, lifelong learning is viewed as an opportunity to reduce societal inequalities. However, not only is economic life changing, but conditions within society are changing, too. In this essay it will be argued that lifelong learning is undoubtedly a prerequisite for making democratic participation possible for all members of a society. All adult learners have a learning history that is intimately connected with their experience of learning at school. The school experience has a great influence on learning as adults, particularly if the adult is forced to, acquire new skills because of unemployment. In this chapter we begin with a discussion of the general conditions of lifelong learning. We continue with an account of the role played by mathematics in societies. We then conclude with problems faced by adult learners of mathematics.

1 Introduction

While social inequality—differences in living conditions, income, job opportunities or opportunities to participate in social and political life—is a problem in all societies, the way it is manifested depends on each particular society's characteristics. This paper focuses on inequality in highly industrialised societies. Clearly, social status can impact an individual's education. For this reason, Article 26 of the "Universal Declaration of Human Rights" asserts the "right to education for everyone." However, in industrialised countries, even if every child is able to go to school, the educational system alone is unable to eliminate social inequality. In particular, chil-

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H. Forgasz, F. Rivera (eds.), *Towards Equity in Mathematics Education*, Advances in Mathematics Education,
DOI 10.1007/978-3-642-27702-3_25,

dren of parents with a low level of education, as well as children of immigrants, are likely to leave the school system with a low education level. This restricts their chances of getting a job, increases the probability of unemployment, and ultimately limits their opportunity to participate in cultural and social life. In other words, highly industrialised countries, too, have a need to reduce inequality within society. The aim of this chapter is to investigate whether adult education—particularly adult education in mathematics—can help reduce education-related aspects of inequality in the sense of inequality caused by an insufficient level of education.

Adult education is a key element in the general concept of lifelong learning (Aspin et al. 2001; FitzSimons et al. 2003). Lifelong learning is essential in a rapidly changing economic and technological world. For example, quickly changing production conditions in companies lead to quickly changing demands on skills possessed by company employees. Skills that are taught in schools and institutions of vocational education need to be adapted to fulfil the requirements of a changing job environment. Lifelong learning can also be considered a process that corrects omissions in basic education. In this sense, lifelong learning can be viewed as an opportunity to reduce societal inequalities. However, not only is economic life changing, but conditions within society are changing, too. In this chapter it will be argued that lifelong learning is a prerequisite for making more equitable participation in society possible for all members of a society.

All adult learners have learning histories that are intimately connected with their experiences of learning at school. The school experience has a great influence on learning among adults, particularly if they are forced to acquire new skills because of unemployment. In this chapter we begin with a discussion of the general conditions of lifelong learning. We then continue with an account of the role played by mathematics in society. We conclude with problems faced by adult learners of mathematics.

2 Lifelong Learning: A Consequence of Technological Development and Globalisation?

Clearly everybody continues to learn over his or her entire lifespan; nobody finishes learning when he or she has completed his or her formal school education. However, the term "lifelong learning" is usually not used only in the simple sense of "everyday learning" or so-called "situated learning in vocations." In many discourses, lifelong learning also means a specific form of organised learning during adulthood.

For a long time, only philosophers and pedagogues discussed lifelong learning (Aspin et al. 2001). In the final decades of the 20th century, however, lifelong learning became a key concept in proposed solutions to social and economic problems in highly industrialised countries. International bodies such as the United Nations Educational, Scientific, and Cultural Organization, the Organization for Economic Cooperation and Development, and bodies within the European Union (EU) declared that education has to be a lifelong undertaking (Aspin et al. 2001; FitzSimons et al. 2003). It meant that education could no longer be considered as a process that ends at the beginning of adulthood, and adults could no longer be considered experts in their jobs based only on the competencies acquired in their youth. To understand this development we must understand the nature of recent societal change and its driving force. Highly industrialised countries are characterised by the use of technologies because technology determines the structure of their societies (Hülsmann 1985). While Hülsmann emphasises the significance of the natural sciences in the development of technologies, it is important to note that other sciences, particularly the social sciences and economics, play a role in the technological formation of our society (Schlöglmann 1992). Thus scientific research leads to technological development, which in turn leads to a change in the competencies required to fulfil the demands of the technological change.

Lifelong learning was the societal solution to conditions arising from rapid economic and technological change. It has a number of functions, as follows:

> [We] suggest that lifelong learning policies currently introduced across the globe could be classified into four categories: (1) a compensatory education model, which aims at compensating for inequality in access to initial school education, and improving basic literacy and vocational skills; (2) a continuing vocational training model, which aims at coping with changes occurring in the workplace and solving problems arising from unemployment; (3) a social innovation model, or civil society model, which aims at overcoming social estrangement and promoting socio-economic transition and democratisation; (4) a leisure orientated model, which aims at enriching the leisure time of individuals and personal fulfilment." (Aspin et al. 2001, p. XXII)

The concepts embodied in the four categories address lifelong learning and its role within a society in a very general way. Within specific nations and societies, the four categories are realised in a variety of ways. It should also be kept in mind that even in highly industrialised countries, the context of lifelong learning can be very heterogeneous. Although in industrialised countries, too, a need exists that will eliminate inequalities in education and improve basic literacy and vocational skills. Hence, distinctions nevertheless ought to be made, for instance, between people who have passed through the education system with a low level of achievement and people who have migrated to these highly industrialised nations from countries with a weak education system. Moreover, in economically advanced countries, more people want a higher level of education.

When authorities speak of lifelong learning, they usually have in mind the continuing vocational training model (Aspin et al. 2001, p. XX). From the point of view that lifelong learning is a means of coping with the consequences of technological development and globalisation—bearing in mind that governments and supranational bodies often resort to rhetorical set phrases when referring to lifelong learning (FitzSimons et al. 2003)—we must extend the concept of lifelong learning to encompass the needs of people in a democratic society. The concept of lifelong learning ought to be seen as a social innovation model or civil society model that stresses structural and political aims. This concept is often called "critical citizenship" (Evans and Thornstad 1994, p. 65).

While the third category introduced by Aspin et al. (2001) in the quotation above emphasises people as social beings (the social innovation model), the fourth category (the leisure model) emphasises people's individuality. In order to account for all of these aspects of lifelong learning, Aspin and Chapman (2001) suggest three necessary purposes of lifelong learning, as follows: economic progress and development; personal development and fulfilment; and social inclusiveness and democratic understanding and activity (Aspin and Chapman 2001, p. 29). Aspin and Chapman further express an important point. Lifelong learning is often seen only as institutional organised learning, but this view obscures the fact that life and work are always combined with learning. Learning in context, "situated learning" and workplace learning are not usually the focal point when one speaks of lifelong learning. Therefore, in light of the importance of lifelong learning to a well-functioning democracy, democratic societies ought to broaden the scope of institutional learning and thereby create more opportunities for adults to pursue further education.

3 Mathematics and Society: Some Remarks

In the preceding section, we discussed general aspects of the concept of lifelong learning. If we are to focus on a special subject like mathematics, we must consider its status within an industrial society, within the technology used in this society, and within the society's economic and social life. Understanding the influence of mathematics in these three areas is essential in understanding how adult education in mathematics can help reduce inequality in society.

To understand the various functions of mathematics in society, we begin with a few historical remarks. The historical development of mathematics in Western culture is sketched below since the nature of this development sheds light on the role of mathematics in industrialised societies (Schlöglmann 2002). Incidentally, while we speak here of Western societies, it should nonetheless be borne in mind that developments in mathematics existed in other cultures and these developments followed the demands in those cultures (Bishop 1991).

3.1 The Development of Mathematics as a Tool for Economic Growth—The Relationship to Culture

The development of mathematics is always concomitant with the development of a society and activities within it. Bishop (1991) describes six key universal activities (counting, measuring, locating, designing, playing and explaining) as driving forces in the development of mathematics. The importance of these activities in the life and culture of a society leads to the observed strong relationship between mathematics and culture.

> I have presented the case that six key 'universal' activities are the foundations for the development of mathematics in culture. I have also demonstrated that it is the case that all cultures have necessarily developed their own symbolic technology in response to the 'demands' of the environment as experienced through these activities. As a result, however, of certain within-cultural developments, and also of different cultures interacting and conflicting, so a particular and traceable line of development has emerged. (Bishop 1991, p. 59)

The following remarks sketch some important steps in the development of mathematics as well as the demands and activities that are at the root of this development. The first signs of numerical concepts can be found in the early Stone Age, and for thousands of years the signs remained rudimentary (Struik 1967). The development of mathematics took a leap forward following the emergence of settlements in Mesopotamia at about 10,000 BC. Agriculture demanded planning and documentation and trade between villages contributed to this demand. Small artefacts made of clay, so-called "tokens," were used to count and document goods. The system of tokens evolved into a hierarchical system with various subsystems according to local commercial demands. Arithmetic appeared in a primitive form (Schmandt-Besserat 1977).

The next leap occurred after the formation of cities. These bigger societal units created a demand for new and better organisational methods. Division of labour and the demand for a growing economy required new planning methods as well as the standardisation of quantitative measurements for the different kinds of goods. The first systems of writing and numerical symbols emerged in Mesopotamia and Egypt. It is important to note that a single unique number system did not exist at that time. According to the system of tokens, there were different systems with different bases for different objects (people, animals, grain, areas, time and calendar, milk products etc.). We can deduce that neither an abstract conception of numbers existed nor a well developed arithmetic. Arithmetical operations were strongly related to operating with clay tokens (Nissen et al. 1991). The development of a unique number system and arithmetic was the result of a longer process. At the end of this process, mathematics was a tool used in many professions for documentation, planning, measuring, ordering, organisation of trade, astronomical and calendar calculations. As it has comprised an essential component of these important activities, mathematics has always been a part of culture.

Many important developments in mathematics occurred in ancient Greece. While mathematics was developed as a tool for solving practical problems in the Orient, it was the Pythagoreans—the first group of mathematicians—who first used mathematics as a means to understand the laws of the world (Bishop 1991; Van der Waerden 1979). In their philosophy, the laws of the world were written in mathematical language. Just as musical harmony was based on proportions of numbers, the harmony of the universe for them was based on mathematics. To the Pythagoreans, studying mathematics was a way of discovering the eternal laws of the universe. Therefore, mathematical objects like numbers and geometrical figures became objects of interest. The aim of mathematical development amongst them was not to solve practical problems but to discover mathematical laws. New and systematic ways of defining mathematical objects and of justifying were necessary. Real-world applicability was not the main justification for the correctness of a mathematical algorithm, but only proofs that followed the laws of logic were acceptable. Furthermore, only human reason was able to discover eternal truth. Mathematics was a means for applying reason. The result of this new philosophy was a close relationship between mathematics, logic, and truth. Mathematical thinking and rational thinking were closely related (Pichot 1995).

A most important impact of the work of the Pythagoreans in the further development of mathematics was the separation of mathematical terms from their real representations (Van der Waerden 1979). This separation alone led to the development of mathematics as a means for rational thinking and a general means of communication. As a basis for rationality, mathematics became a part of the culture of societies that have rationality as their societal foundation.

3.2 What Kind of Society Needs Mathematics as a Tool?

Demands created by the changing forms of society required new means for documentation, planning, trade and so on. The solution in all cases was the development of some kind of mathematical objects such as a system of tokens or much later, systems of written signs for numbers.

Is mathematics a necessary tool in a special kind of society? To discuss this question, we make use of a concept introduced by the philosopher Heintel (1992), that societies can be classified according to the kinds of communication that occur within them. Small groups can be organised by direct communication. All information is transmitted from person to person. No other mediation channels are necessary. Learning processes are also organised directly. In larger societies, such direct communication between all members of the community is impossible. The society changes from a society organised by direct communication to one organised by indirect communication. Such an organisational form demands common standards, values, and so on. Societies therefore need a more sophisticated language because the standards and values must be formulated in new, more abstract concepts. In larger societies, labour processes are mostly specialised and often organised in a hierarchical way. Specialisation and division of labour demand more planning and more documentation to organise labour in a rational way. To fulfil these demands, a need exists for a means of communicating advice, regulations, as well as various skills in a more abstract way. Written documents are able to reach more people.

In short, mathematics is a tool that fulfils the demands of societies organised by indirect communication. Mathematical terms allow documentation through mathematical procedures, and reliable calculations in the context of labour and trade processes become possible. All processes in such societies evolve from the particular to the general. Mathematics, too, has developed like this. It first appeared in forms whose terms and procedures depended strongly on context, and evolved into a general tool for many problems.

3.3 Mathematics and Democracy

The roots of modern democracy lie in the ideas of the Enlightenment. Rationality is fundamentally important for the structure of society. Mathematics is an important background for rationality. Bishop (1991) argues that

> rationalism is at the heart of Mathematics. If one had to choose a single value which has guaranteed the power and authority of Mathematics (and the ideal of Mathematicians) it is rationalism. (Bishop 1991, p. 62)

Democratic societies are, as we have seen, usually organised by indirect communication. Therefore, democratic societies have a need for, on the one hand, values and principles, and on the other hand, procedures that implement some of the values and principles that facilitate democratic practice by communicating the principles in an unequivocal and reliable way, and "rationalism, logic and reason have a very well elaborated vocabulary" (Bishop 1991, p. 62). For example, consider the democratic election procedure. Ideally, the election procedure has to implement the principle of same value per vote. This basic principle is often combined with other principles, such as the principle that the result of the election should lead to a stable majority in parliament. Taking into account particular historical features of a society, the democratic system has many instantiations—many different election procedures are possible. But every procedure is formulated as a mathematical algorithm.

In recent political discussions in the EU and elsewhere, a new interpretation of equality has been introduced, according to which equality should not only be a principle that is valid at the individual level, but that it should also be valid for social groups. This means that within a democracy, each social group should be represented as an important subsystem of society with its own appropriate societal share. This principle, too, is based on mathematics, in particular, on statistical arguments. Statistical methods are important for analysing societies (Evans and Rappaport 1998; Frankenstein 1990).

In discussing the relationship of mathematics to democracy, the status of mathematical models that underlie various aspects of democracy ought to be mentioned at least briefly. These models are based on norms, and norms are the consequence of a social process. Norm-based models, which are used in many applications (such as business), are not justifiable by mathematics. Mathematics is only used to guarantee a reliable implementation of a norm; but mathematics is not able to guarantee the correctness of the norm. A norm is a consequence of a social process.

3.4 Mathematics and New Technologies: New Functions of the Tool "Mathematics"

In the preceding sections, it was argued that societal demands led to the development of mathematical methods and procedures. Mathematics affected the structure and condition of society. Trade and administration, in particular, with the extensive use of money, stimulated the search for better methods, and mathematics was applied extensively in these areas. Later, mathematical methods were used in astronomical calculations and more and more professions began to use mathematics. The new status of mathematics in Antiquity led to a relationship between mathematics and rationality and to research in "pure" mathematics as well. In particular, the separation of mathematics and its applications opened the way to the development of mathematics as a "general tool" that could be used in sciences and numerous other fields. The use of mathematics in more and more areas of social, economic and professional life increased. In many cases, mathematics became integrated into a field to such an extent that it became a standard fixture in the background while losing its visibility in the foreground. Great changes have occurred in recent years. With the dawn of new technologies, mathematics began to play a new role within the society. We begin to describe this new role with a quotation from a report from the US National Research Council on the resource Mathematics: "When we entered the era of high technology, we entered the era of mathematical technology" (David 1984, p. 435). This can be interpreted to mean:

- Mathematics is the basis of all new technologies since algorithms are the basis of software and materialised mathematical logic is the basis of computer hardware (microprocessors).
- Mathematical theories and models are becoming increasingly important as the basis of a variety of forward-looking alternatives and in simulating planning in economic and technical fields, for example, in control, automation and construction, or in political and social life.
- Mathematics has long been established as the scientific core of the natural sciences and, to an increasing extent, also of social science (Maaß and Schlöglmann 1988).

An important necessity of technology is that it should facilitate the distinction between the development of knowledge and the application of knowledge—between the "why" and the "how." The user of knowledge needs an understanding not only of how to apply the knowledge, but also of what the knowledge really is in the first place. We all use computer programs, but we do not know what goes on behind the scenes in the computer box. Mathematical black boxes have a long tradition (Maaß and Schlöglmann 1988), however, with the rapid ascent of the computer, their use has increased very strong. The increased use of mathematical black boxes has contributed to the "disappearance of mathematics". Further, these black boxes determine our work processes, economic, and social life. It is an open question what a user of a black box should know about the implemented program.

3.5 Why Are Mathematical Methods so Credible?

The status of mathematics in our society is rather paradoxical. On the one hand, many people see mathematics as abstract, remote from the life, and incomprehensible. On the other hand, the same people have full confidence in mathematical methods—they pay invoices, accept calculation of election results, and accept the use of complex mathematics in technology and the economy. Fischer (1999) notes how "mathematics is the materialisation of the abstract" (p. 89).

Mathematics puts abstract thought into concrete form. Mathematical objects are seen as abstract, but in their concrete form, consisting of numerical symbols, formulas, graphs, they make manipulations and presentations possible. For example, we use graphs to present complex, abstract relationships in a concrete way. This specific characteristic of mathematics—the construction of abstract concepts on the basis of concrete representations—could be the reason why many people have confidence in results obtained through mathematical methods.

3.6 Should Everybody Learn Mathematics?

The foregoing discussion regarding the various functions of mathematics within our society provides a strong argument for mathematics to be a part of all school curricula and also of many courses in adult education. We raise the following two main points: that mathematics is a tool; and that mathematics is an integral part of culture.

1. Mathematics in our society is a tool used to organise our everyday lives. Mathematics is also used as a tool in many occupations. The use of mathematical black boxes in the form of computer programs gives them a new quality and a new challenge for didactics.
2. Mathematics is a part of our culture. Democratic principles such as equality, righteousness and so on need an operational concretisation. On the one hand, democracy demands a means for communicating and discussing principles in a rational way. Mathematics, with its close relationship to rationality, is our concept that will enable us to do this. On the other hand, democracy demands operational procedures for its concrete implementation. Mathematics is again the tool that facilitates this.

The concept of the "responsible citizen" as a citizen who is able to participate in societal processes in a rational way is a part of numerous educational philosophies.

4 Adult Education in Mathematics

The field "adults and mathematics" is characterised by great heterogeneity, particularly in the course system (FitzSimons et al. 1996). To gain a better insight into the situation it is useful to reduce the heterogeneity and complexity by categorising the various concepts into appropriate classes. The guiding goal in the categorisation process is to reproduce the important subject areas that constitute the field. One class is "mathematics as a system," in which the ideas of mathematics are represented as a science. Another is vocational practice, together with the use of mathematics in everyday life situations. The third and newest class concerns new technologies. Mathematics is a key science for computer hardware and software. Software programmes in particular contain mathematical structures behind the scenes, which has led to an immense change in the use of mathematics in many vocational situations.

The focus of educational *intention* ought to be a structuring (i.e. organisational) element. This is because nowadays the educational goal can be any of the following: mathematics; *content* that is not in itself mathematics yet uses mathematics to formulate results (mathematics used as a language); and the use of software that is based on mathematics. Numeracy courses are ubiquitously organised according to a mathematical systematic, and the goal of the students taking them is to learn mathematics (e.g. courses for adults that supplement high school examinations). Some numeracy courses are organised according to mathematical content (e.g. percentage calculation) and their aim is to calculate credits. Today many computer programmes exist that contain mathematical algorithms but the goal of a course that utilises the programme is to teach the student to use the programme—not to teach mathematics. For many occupations, mathematics is an important tool and therefore mathematics is the (often hidden) content of many vocational courses.

Two different conceptions of course organisation are used when dealing with the problem of mathematics learning. In the first conception, the required mathematics is separated from the vocational field and taught as a separate course (for instance, mathematics for building construction) and the application of mathematics to the field takes place at a later stage. In the second conception, the mathematics is not separated and the required mathematical algorithms are taught as part of the vocational content. Here the mathematical algorithms are often very specific and only usable in isolated situations. Many computer programmes used in production processes, for instance, contain mathematical algorithms, but the user is only trained to handle one specific programme and is often unaware that mathematical algorithms in the background control the process. In training courses nowadays one may find learning software for practising mathematical operations and algorithms. This type of software belongs to the category “training programmes” and its goal is to provide mathematical practice. Other software used in adult education courses is classified according to vocational criteria (for instance, bookkeeping) but nonetheless require mathematics for their operation. Finally, some courses aim to teach proficiency in the use of specialised software (for instance, Excel), and these, too, require mathematical concepts (variables and so on) for their use.

5 Vocational Mathematics Versus School Mathematics: Some Remarks

The aforementioned cases demonstrate the complex situation of adult education in mathematics. The aim of education is, on the one hand, to learn mathematics, and on the other hand, to acquire occupational and professional skills in which mathematics is part of the context. The relationship between school or academic mathematics and vocational mathematics has long been discussed (Benn 1997). In the following paragraphs, I discuss the problem from the point of view of lifelong learning.

Generally, two different forms of learning organisation can be distinguished, that is, learning in practice and learning at school. Learning in practice was studied by Lave (1988). In collaboration with Wenger, Lave developed the concept of “situated learning” (Lave and Wenger 1991). The basic idea is that a learner can participate in the working process with the guidance of an experienced person. This participation is possible on the basis of a contract that legitimises the learner for “peripheral participation" in the working process. It is important to analyse the structure of knowledge that is required in such a learning process. An experienced person's vocational knowledge is often a repertoire of actions that can be seen as a unit and which belongs to a specific task. Many of these actions are used in some form of routine. Such "action units" contain a plan to organise the courses of action, the use of different tools, the need for collaboration and so on. The organising elements are vocational conditions and the specific context. If mathematics is part of such an action unit then it is integrated into actions that comprise the action unit—and that means mathematics is part of an action course; and the mathematical tools used in these actions are part of the vocational process. During the learning process the learner does not acquire a system composed of disjoint parts that must be combined to form a whole. Instead, a unit is acquired that is to be used in a specialised situation. The mathematics is often not visible to the learner because it is part of an action system that is realised through the use of specific tools. This action and tool relationship leads to optimal integration into the vocational situation and prevents transfer to other situations (Evans 1999). For our problem we have to bear in mind that vocational mathematics is context-related; requires specific tools to fulfil the necessary actions; and is often hidden within the context and actions. "Mathematical terms" derive their meaning from their position within the vocational process and not from their position within a mathematical subject systematic.

School mathematics is based on the criteria of mathematics and uses a content-related systematic (arithmetic, algebra, geometry, analysis, probability). For our problem it is important that the historical development of mathematics led to a theory system whose terms are described according to their properties, which in many cases have no corresponding reference objects in reality (Dörfler 2002). Operations on such mathematical objects are based on their properties and are rule-guided. The status of mathematical objects within some context is controlled only by their properties. This possibility to use mathematical objects and operate with them inside the mathematical structure has certain consequences:

- Mathematics is a "general language" that is applicable in numerous different contexts. The correspondence between context and mathematics is a problem of the structure of some context.
- A mathematical formulation of a contextual problem is context free. The mathematical terms and signs acquire a contextual meaning only by interpretation within a context.
- Operating with mathematical objects entails operating within the mathematics and not within the context.

Let us summarise these brief reflections. If mathematics is seen as a "general tool," which means that the same mathematical method can be used for many problems in very different contexts, then the method needs only to fulfil the same structural properties in each case. On the other hand, mathematical methods cannot be part of a vocational action unit. The use of mathematics requires reflection on the structure of a problem. Such reflection is not a part of situated learning processes. Situated learning deals with a problem "as it is" and not with reflecting on the situation to discern its structure.

The concept of lifelong learning emerges naturally in a society where qualification requirements are rapidly changing. The skills that are acquired in situated learning processes are optimally adapted to a specific vocational situation and are therefore very useful in this specific situation. But they are also very strongly connected with this specific context, and a transformation to another context is often very difficult or impossible. Therefore lifelong learning requires both general skills that are transferable and specialised skills for specific vocational requirements.

6 Some Results from an Empirical Study of Adult Education in Austria

In the first section, we argued on theoretical grounds that lifelong learning in general, and lifelong mathematics learning in particular, is important for the functioning of highly industrialised societies. However, it is the "reality" of lifelong learning that is important for research and practice. Hence, between 1993 and 1997, Jungwirth, Maasz, and Schlöglmann explored the state of mathematics education within the adult education system in Austria (Jungwirth et al. 1995, Schlöglmann 2006). Adult education in Austria is characterised by a diversity of agencies offering a variety of programs in community services or vocational education. These agencies include the following: state-run institutions of adult education; trade unions or the federation of industry; industrial enterprises; and the education departments of public or private sector enterprises.

This diversity is also reflected in the numerous courses and offers of study programs, in mathematics as in other subjects. In the above empirical study, we distinguished the courses according to whether mathematics teaching explicitly took place or whether mathematical concepts and methods were used in an implicit way (for instance, in courses in CAD, Excel, or other computer software). Furthermore, courses were distinguished according to the level of mathematics (basic, upper secondary, or university) as well as whether they were part of general education or vocational education. To explore the state of adult education in mathematics we selected 419 participants (80.5% men and 19.5% women) from 19 courses in seven institutions within the Austrian adult education system. In all the courses, mathematics was either explicitly or implicitly included and the courses ranged from basic (10.3% of the participants) to upper secondary level (36.3%) and vocational education (53.4%). The extensive questionnaire elicited each participant's personal data, including sex, age, vocation and education. It also contained the following questions: the course of study; the institution and the participants' attitude toward mathematics and school; their use of computers and mathematics at work; their motivation for participation; their appraisal of the value of further education; the goals and priorities of the course they were studying; their learning problems; and suggestions for improvements in mathematics education. In the second part of the questionnaire, we asked for their individual beliefs and attitudes toward mathematics. Besides the questionnaire for participants, we also asked the teachers of the courses to answer a questionnaire with partly analogous questions. This quantitative part of the study was complemented by interviews with participants and teachers. Even though the data were collected between 1993 and 1997, they are still relevant today because the situation in adult education in Austria has not changed.

In this chapter we only refer to a small portion of the results of the study, namely, those that pertain to their motivation for participating in an adult education course and the individual attitudes toward mathematics and mathematics learning. To investigate these motives, we used a 5-point Likert scale (completely agree, partially agree, undecided, partially reject, reject). The main motives for participation in adult education were: "joy of learning new subjects" (86.8% completely agree or partially agree); "improvement of personal education" (86.3%); "acquisition of latest professional knowledge" (79.8%); "increased vocational demands" (73.3%); "financial gain" (72.4%); "security in economically unstable times" (69.9%); and "higher position in the company" (64.2%). To get a better insight into the structure of participant motives, principal component analysis was used to extract the factors of motivation. The results showed four significant factors at work in motivating the participants to take part in adult education courses. The first factor was "professional and economic advancement" and includes preparation for a better position as well as protection of the position already attained. The second factor was "personal motives" such as the desire for more knowledge as part of the individual's general thirst for knowledge. The third factor was "general professional performance orientation", which means that the participants considered their job to be significant to a greater degree than usual. The fourth factor was a "change in job" with change being either an aspiration or a forced move.

In order to obtain a better understanding of the participants' motives, it was fruitful to consider their opinion of the value of higher education. As a word of explanation about this issue, we should say that the concept of "Bildung" has a long history in the German educational tradition. "Bildung" means more than "education" in a narrow sense. An individual that is "gebildet" not only has knowledge and the ability to acquire new knowledge, but he or she is also able on the basis of this knowledge to develop their inner abilities to the full extent (Klafki 1975). The significance of higher education (höhere Bildung) in German tradition can give a better insight into the participants' motives.

Principal component analysis was also used to extract the independent factors. The results suggested a model with three factors: the value of higher education lies in (1) its effect on vocational advancement, financial security, and personal prestige; (2) its potential for personal development; and (3) its contribution to a better understanding of society. We can see that these factors—explaining the value attached to higher education by the participants—are similar to the factors of the participants' personal motives.

Regarding the mathematics content in the courses, we have found that in many cases, the adult participants did not have any choice in studying the mathematics component. For instance, if a participant desired to acquire a certificate for completing a lower secondary or an upper secondary school, he or she had to study mathematics. Therefore, in order to understand the learning conditions experienced by adults in their further studies in mathematics, it was of interest to know their attitudes toward mathematics education at school. A heterogeneous picture emerges, as follows:

- Interested in mathematics in school (57.7% yes, 37.7% no).
- Had ability in mathematics in school (50.2% yes, 42.5% no).
- Good rapport with mathematics teachers at school (60.3% yes, 30.3% no).

The correlation between interest and claimed ability is high ($R = 0.63$). Those who were interested in mathematics had no problems with mathematics (75%) and had good rapport with teachers (72.9%).

Regarding the adult education system in Austria, two groups of adult learners with very different motives and personal situations could be discerned. Members of the larger group chose to participate in adult education. They viewed learning as an opportunity to increase their chances in the labour market, to raise their prestige, and so on. They were highly motivated to learn. They usually had a positive recollection of their school experiences. Members of the other group, in contrast, had been compelled to participate in adult education (in many cases they had lost their job or had to change their job on health grounds). The existence of this group did not emerge from the data of the questionnaires (we had not asked the right questions to identify this group) but from the interviews with the participants as well as the teachers. From the interviews, we received hints to the problems that the adult learners faced. The number of persons for whom these conditions were relevant depended strongly on the state of the labour market. However, the existence of this group is not specifically an Austrian problem (see, for e.g., Wedege and Evans (2006) that considered the problem of adult learners who had a resistance to learning in childhood schooling).

Mathematics learning is not just a cognitive process since it is also influenced by affective conditions (Evans 2000). From narratives given by adult learners, in particular, we know that many adults had negative experiences with mathematics learning in school (Ingleton and O'Regan 2002; Stroop 1998). Hence, in the next section below, we consider influences on the emotional states of members of the second group above.

7 "Must Learn Mathematics:" Some Remarks on the Emotional Constitution of a Group of Adult Learners

Consider individuals who have just lost their job possibly through an accident that incapacitated them or because of company restructuring. They are now forced into further education in order to prepare for a new job. Learning for a new job is not their decision; it is forced on them by circumstances. To understand the circumstances of such a person, we use the concept of "situated learning" (Lave and Wenger 1991). This concept is applicable to many participants in the Austrian adult education because most participants, after their compulsory schooling, are educated in companies as apprentices. They acquire their qualification by working in companies. Therefore, in most cases, they were members of a “community of practice” (Lave and Wenger 1991) in their previous workplaces. In order to be accepted into such a community, a newcomer or apprentice must go through a long process of practice within a framework of legitimate peripheral participation (Lave and Wenger 1991, p. 53). The goal of all learning processes amounts to becoming an experienced member of the community. Such a position requires numerous skills, experience of responsibility for various tasks, knowing codes within the community, and so on. The result is a place within the community. A person is part of the community and the routine of a company (Schlöglmann 2003). All of these together bestow a sense of prestige and identity (Lave and Wenger 1991, p. 122).

In recent years it has been commonplace for experienced staff to be replaced by inexperienced newcomers. For a significant number of these “old-timers” this has led to a loss of self-confidence (Wenger 1998, p. 148). Furthermore, many of these people have had bad recollections of their time at school. Their narratives give us an insight into these recollections (Ingleton and O’Regan 2002; Stroop 1998) and can give us also hints to their implications for mathematics learning. Taken together, loss of prestige and identity, marginalisation of experience, low self-confidence, and low confidence in one’s ability to learn mathematics as a consequence of the school learning experience can lead to emotional barriers during new mathematics learning processes.

8 Is Mathematics Learning Possible for Adults?

Possible reasons for adult students who are not studying by choice have been discussed in the previous section. Successful learning often requires motivation of learners by teachers, particularly learners who must learn mathematics. Teachers in adult further education report anxiety and learning blockages in mathematics learning processes (Lindenskov 1996; Wedege 1998). To understand learning better, we use a model introduced by Hannula (1998) with a continuously changing “landscape of mind”. The process of change is stimulated by information arriving from the senses, as well as by mechanisms and structures within the brain. One central principle is the distinction between dynamic and static systems of representation. Dynamic representation includes all systems that are activated at a given moment. Static representation encompasses all the information stored in the memory systems. The structure of each static representation—cognitive and affective schemata—is crucial for all processes. The schemata representing the static representations are changeable via learning processes. In all situations of interest to us, many brain systems are activated; in particular, so is a certain system that generates so-called “background emotions” (Damasio 1999). Background emotions influence cognitive processes in a positive or negative way.

Teachers in adult education classes can help adult students manage their learning situation. In the previous section, we have discussed reasons for negative background emotions. The adult student has lost the position as an experienced professional and this position is likely to have been a crucial part of their identity. Now, like children, they have to learn new things. In many courses, adult participants have had no formal education since their school years. They often feel unable to learn because their learning processes have occurred over a long time, whereas they recognise that mathematics learning requires intense processes of abstraction and generalisation. A frequent consequence of this is an adult student's fear that his or her memory is unable to hold all the abstract concepts required. Formal learning often brings back memories of mathematics learning in school and it is generally accepted that for many adults these memories are bad. So speak Wedege and Evans (2006) from a resistance to learn:

> In adult education, resistance to learning is a well known phenomenon. There is an apparent contradiction between many adults' problematical relationships with mathematics in formal settings and their noteworthy "mathematics-containing" competences in everyday life. However, there is very little research done on the subject, and resistance is often explained purely as a lack of motivation and the symptom described as non-learning. In order to investigate adults' resistance to learning, we must take into account the set of conflicts between the needs and constraints in adults' lives. In this paper people's resistance is seen as interrelated with their motivation and their competence and thus as containing the potential to be a crucial factor in all types of learning. (Wedege and Evans 2006, p. 28)

It is important to impart on adult students the importance of their knowledge in situated learning processes. They also need to feel that they have valuable knowledge at their disposal, and using situated knowledge for mathematics learning processes is possible (Schliemann 1999). But it is important for teachers to help open the eyes of adult learners to the mathematics that is contained in the situated knowledge. Processes of abstraction and generalisation must be done very carefully viz a viz their situated knowledge. Creating a successful learning process ought to include steps to help students better manage their fear and to change their emotional background. However, it is important that students actually understand mathematics by doing real mathematics and not learning a diluted form of mathematics via what is called "replacement strategies" (Schlöglmann 1999). Mathematics teaching in adult education is a very demanding task that requires handling the emotional difficulties of the students and developing mathematical concepts with care.

9 Can Mathematics Education for Adults Reduce Inequality in a Society?

Inequality within a society is, first and foremost, a societal problem with many aspects. Solving social problems require a coordinated strategy involving several activities; silver bullets do not exist. Mathematics education for adults can at most comprise one measure in a coordinated strategy and can only have an effect on inequities that are consequences of the education system, like low education or insufficient qualifications for a new job. As discussed in a previous section, four models of lifelong learning strategies can be discerned, as follows: a compensatory education model; a continuing vocational training model; a social innovation or civil society model; and a leisure-oriented model. Mathematics is woven into, and competencies are necessary in, everyday economic, vocational and social life in our society.

It is important to reduce inequality arising from inadequate formal schooling. This concerns both weak learners who emerge from the local school system and immigrants with a low education level. The number of jobs for persons with a low education level is diminishing. Therefore, improving basic literacy can open the way to a higher qualification and to a better job. Given the importance of mathematics in the modern workforce, this compensatory education needs to succeed in improving basic mathematical literacy. Underskilled adults can then acquire at least some vocational skills necessary for a new and better job even when the learning phase is emotionally difficult, a phenomenon that is felt by some unemployed adults. In this sense, compensating the weakness in basic mathematics literacy opens the way to continuing vocational training. It also helps the learner handle changes that are occurring in the new workplace with the concomitant demands for new qualifications.

Also significant is the reality that mathematics lies at the heart of new technologies and strongly influences the use of these technologies. Being able to deal with computer software is a necessary prerequisite in many professions. Hence, mathematics education can improve computer literacy even if this is not its direct aim.

Mathematics education for adults helps develop and improve skills for further professional and economic advancement or at least provide the qualifications necessary to meet the new demands in a job and can therefore have an effect on personal financial security and prestige. In this sense, mathematics education for adults can help develop the skills necessary for living well. Importantly, mathematics education for adults can also offer the potential for personal development and can contribute to a better understanding of society. Particularly in democratic societies, responsible citizens such as those who participate in political life need mathematics.

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