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History of mathematics and current developments in education

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With the introduction of so-called educational standards, the German government has mandated by law that German schools, universities and teacher training colleges use the language of competences as a universal language to describe, plan, test and develop teaching and learning processes. This shift to output orientation resulted in a break with the formerly internationally recognized educational tradition of the Enlightenment. In order to understand and highlight the magnitude of this, we look at different historical perspectives regarding these reforms.

Keywords: Democracy, history of mathematics, educational reforms.

Introduction

The present paper responds to a desire that several of our colleagues had expressed at the International Conference on the History of Mathematics Education (ICHME) in Utrecht in the Netherlands in 2017: To place current developments in German mathematics education in a historical context. The reasons for this request were that these colleagues realised similar developments sometimes, possibly with a time shift, in other European countries, such as output and competence orientation, the introduction of educational standards, central tests and global assessments, or the economization, centralization and digitalization of the education system. The study of the history of mathematics and mathematics education seems to support a critical view of these developments. It was pleasant to find congeniality. However, it immediately rose questions which of these issues constitute a common concern. What precisely is going on with these developments? Another aspect of this debate inspired by our lively discussions was whether and how the study of history can support the teaching of critical judgement and the safeguarding of democracy and human values in pedagogy.

In the meantime, some new perspectives such as a better understanding of the origins of competence orientation in psychology (cf. Ryan & Deci, 2000 or Gelhard, 2011) emerged from the study of the developments in mathematics education at the end of the last millennium, and from the authors' attempts to incorporate them into seminars on mathematics education. The reforms and changes we are going to discuss are, however, not specific to mathematics education. Therefore, this discourse should be relevant to the history of education, pedagogy, sociology and psychology.

However, the changes in German education policy at the beginning of our millennium were accompanied by a shift in the subjects and theoretical foundations of educational sciences towards applied psychology, empirical research and the notions of evidence and measurability. The latter had an impact on school development and beliefs and convictions about the superior importance of factors that contribute to good teaching and "effective" learning. Still, if there were to be a lecture about the history of current reforms in education, it would probably be attended by only a few people. Most students put educational sciences on a par with a general methodology (cf. Jahnke,

2008), and therefore, above all, want to receive the latest and empirically proven approaches in these subjects in order to be able to adapt themselves to the requirements of their future working situation. Here the economization of the university system and the new role of students as customers and future employees plays its part.

Why should the *history of mathematics education* be taught to future teachers and in which form can it be incorporated in mathematics education?

Learning from history does not automatically mean that history prevents us from repeating mistakes. Politicians are not supposed to be historians: Historical situations never completely recur, and therefore the future cannot be predicted from even the most profound knowledge of the past. However, on a small scale with limited demands, it is quite possible to learn from history (Geiss, 2019). The recognition of constellations and gradient patterns occurring over time plays an essential role in this. Even though it is not possible to transfer causal connections, the study of structural components, which recur and make up these constellations and patterns, can certainly contribute to sharpening political judgement. However, the tightrope between showing such patterns and indoctrination through the political or even ideologically influenced production of time references is extremely narrow (Bergmann, 2002).

Because of this, and the highly political significance of the reforms, we are going to work backwards: We start with a description of the current situation and ask the students to find differences with the practices, school subjects and events of the past, which look at first sight very similar or carry similar names to those of today. Thus, the formation of analogies does not arise through our study of historical sources, but is rather questioned by these sources.

In the implementation of educational policy requirements, teachers in Germany have a great deal of freedom in the design and application of these requirements through the legally guaranteed freedom of methods (Gasser, 1982). Dealing with the history of mathematical teaching can help to appreciate existing structures, to include experiences from the history in change processes and to relativize so-called “new approaches”.

Through taking a historical perspective on the development of mathematics education and related educational policy, our goal is to support our students’ need to question the reasonableness and necessity of political reforms and to shape them as responsible future teachers.

Some features of educational reforms

The study of the history of educational reforms and their theoretical foundations is particularly relevant today. German students have experienced several reforms during their school time. The theoretical foundation of these reforms has not yet taken place. Keywords for these reforms are *output* and *competence orientation*, the introduction of educational standards and central tests, the abolition of the orientation classes and pre-school education, the reduction of upper secondary classes by one year, the digitalization of learning environments, the restructuring of secondary schools, and the overall present *inclusion*¹.

¹ Political activities of the Government to implement the *UN Convention on the Rights of Persons with Disabilities*.

In particular, these political reforms have been pushed through with tremendous pace. Therefore, it is certainly worthwhile to engage in reforms, which had been prepared and installed during half a century; e.g. the *Meraner Reform* was discussed widely and implemented in small steps (Schubring, 2007). However, the current reforms have a different character. The abolition of the *orientation level*² and pre-school education, the reduction of upper secondary classes by one year, the restructuring of secondary schools, the shift from special schools for specific disabilities to integrated/ inclusive forms of schooling, the shift from the three-tier school system towards a comprehensive school: All these can be seen as structural reforms of the school *system*. Looking back at the history of German schools, it strikes us that every of the former changes in the education system was related to just one type of school and perhaps their related types, and was prepared for and carried out over a period of 200 years. The current reforms, however, took place almost simultaneously in a period of just 20 years and involved all school forms at once.

It is worth studying the history of different school types and of preschool education separately and to investigate their links to teacher training and assessment development for teachers and students (Leschinsky & Roeder, 1983). There is a large body of literature now starting from original sources like school archives, commission reports and resolutions, as well as secondary literature, which studies these reforms from the point of view of institutional history (Müller et al., 1987). Of course, the study of these sources relates institutional aspects to the biography of its main actors and of the study of political and economic contexts. It is noteworthy that it is often difficult to find historical sources with plans, programs and resolutions, but if one does find them, one knows the names of the main institutional actors. This is not the case with the present documentation of reforms. Here, the authors hide behind huge organizations and their programs. It is hard to find out who is responsible.

Another approach when looking at the history of reforms is to see the teaching community as a *community of practice*. When doing so, the importance of associations, societies, clubs, unions etc. should also be taken into account. One can also study reforms as the history of concepts, ideas and value systems as they develop in communities.

In order to describe the current changes in mathematics education as a change of value systems from input³ to output orientation in terms of economization with a measurable and an only functional notion of education, we here give a short historical overview of where the notion of *competences* comes from.

What is the dispute about competence orientation all about?

The concept of *education systems*, which is based entirely on economic aspects, has a long tradition in the OECD. The conference documents and the results of the discussion at the “OECD

² Grade 5 and 6 of secondary school were supposed to be an orientation period in order to decide about the type of school.

³ Input orientation is often misleadingly referred to as the lack of qualification goals and results as well as interpreted evaluations see (Ladenthin, 2011, p.1).

Conference in Washington”, which was also decisive for the entire public discussion of educational and educational issues, showed unequivocally in 1961 the limited economic and technical view of human development and progress:

“It goes without saying that the educational system must be an aggregate of the economy, it is just as necessary to prepare people for the economy as real assets and machines. The educational system is now equal to highways, steel works and chemical fertilizers’. Thus the claim can be made ‘without blushing and with good economic conscience that the accumulation of intellectual capital is comparable to the accumulation of real capital – and in the long range may outmatch it.’” (Graupe & Krautz, 2014, p. 3)

Earlier, Graupe and Krautz explicated:

“The same conference volume states that, with regard to developing countries, it would be ‘nothing short of cutting a million people loose from a way of life that has constituted their living environment for hundreds or thousands of years. Everything achieved by these countries’ schools and education until now has served social and religious aims which have primarily allowed for resignation and spiritual comfort; things that completely go against any economic sense of progress. Changing these century-old approaches may perhaps be the most difficult yet also most important task for education to accomplish in developing countries.’” (loc. cit., p. 2)

Here, human development is reduced to economic growth and technical progress. Socio-historical, cultural and educational aspects are not only ignored, but also presented as disturbing and negative. In essence, the views expressed by the OECD have not fundamentally changed since then, but the causes of the need for unifying reforms are now general concerns, such as the growing globalization of the economy and the new requirements of a technological society.

50 years on, the OECD has in its own words, “become central, providing indicators of educational performance that not only evaluate but also help shape public policy.” (Gurría, 2011, p.318). The introduction of competence orientation is not a particularly German phenomenon. However, it seems that in Germany it leads to more radical changes in the educational system than elsewhere. The pretext for a radical change in education policy was the “moderate performance” of German students in the PISA test 2003, which was not in line with social expectations. In the media and by politicians it is referred to as the “PISA shock”.

Although the OECD had already tested in mathematics decades before, and the TIMS study had already taken place (since 1995), the second PISA test in 2003 was suddenly taken as “the truth” by German politicians and media about the German educational system and as an indicator of what students “really” know. The political goal became to improve the result of tests such as PISA or the TIMS study. Competence orientation promises, among other things, to be able to do this and turn education into a manageable system:

“Educational standards with their reference to student competences are explicitly formulated in a way that allows them to be checked with the help of corresponding questions or tests. This measurability characterizes them nationally and internationally, and with all due modesty, it is this characteristic that makes it possible to determine at certain points in time whether and to

what extent students are adequately prepared for life or whether there is a need for optimization.”
[Blum et al. 2006, p. 9, translation by the authors]

As a measure against the PISA shock, in 2004 the German Conference of Ministers of Education adopted the so-called “educational standards” (*Bildungsstandards*) and reorganized the curricula on the basis of competence orientation.

However, is ‘competences’ really just a new word for something akin to learning goals? Has that not always been around? And, who can object to schools and universities at least formulating the goal of ensuring that graduates are fully competent when leaving? Would anyone not want them to apply this knowledge meaningfully and use it to solve “inner-mathematical problems” as well as real-world ones? Do the practitioners and theoreticians of mathematical doctrine focus on an enemy who is not actually a threat? Is it not good that requirements are standardized so that they can be taught systematically? This critical discourse may appear to large parts of a general mathematical audience as splitting hairs. The introduction of competence orientation as a universal and legally prescribed paradigm for the description and design of learning processes, however, has a very specific impact on the mathematical culture in teaching and research. The definition, which is based on the German competency orientation, goes back to Weinert:

Competences in this context are the cognitive abilities and skills available to or learnable by individuals in order to solve specific problems and the associated motivational, volitional and social readiness and ability to successfully and responsibly use the solutions in variable situations. (Weinert, 2002, pp. 27-28, translation by the authors)

The introduction to this definition in the above-cited text is rarely added:

In this context, the OECD has repeatedly suggested that the ambiguous concept of performance should generally be replaced with the concept of competence.

It is vital for mathematics teachers in schools and universities to understand these developments more thoroughly and to engage in a humanities discourse with pragmatic consequences that cannot be fundamentally clarified by empiricism and that only partially takes place within the mathematical culture. In competence orientation, we are dealing with a fundamental change in our understanding of learning. Is it about learning to understand something, or is it about convincing others on the basis of measurable output that I have understood something?

The conceptual system of competence orientation derives from applied psychology (Gelhard, 2011). For a long time it was used for the selection and adaptation of workers who were meant to meet specially defined psychological requirements in the workplace, such as patience, accuracy, speed, etc. Although competence orientation with regard to teaching was promoted on the initiative of the OECD (cf. Weinert, 2002, p. 27) and by pedagogical psychologists and educationalists working predominantly on a quantitative empirical basis, there is still no unequivocal empirical evidence to date that suggests that the competence orientation currently implemented by the state has a positive effect on the knowledge and skills of high school graduates or new students.

As of now the concept of competence, the credo of the testing industry, based on a definition by Franz Weinert, has become the central concept of the transformation of our entire education system.

It has evolved from a psychological selection tool into the guiding principle for quality control of industrial production of human capital, as the OECD has promoted for decades. After all - and this cannot be emphasized enough - competences are a psychological instrument. Modeling, collaborating, arguing and even moral competences (Weinert 2002, p. 28) etc. are elevated to context-free problem-solving activities. As they do not have to do justice to any context, they become observable and measurable psychological categories.

Are there developments in the past akin to competence orientation and educational standards?

If we look at competence orientation as a promise of salvation, as a concept of being able to acquire skills applicable to any subject without learning to be an expert in that subject, then we cannot find similar developments during the last 200 years: Skills and knowledge are traditionally closely related to content, either from the perspective of vocational training or from the perspective of humanistic education.

The existence of very general concepts guiding educational reforms leads us to the reform of school geometry, driven by the slogans such as “Neue Geometrie” (new geometry) or “Los von Euklid” (away from Euclid), both in the 19th century. We may also think of the Meraner Reform and its motto of “Erziehung des funktionalen Denkens” (Education of functional thinking) or the “Neue Mathematik” (New Maths movement) (Schubring, 2014, pp. 241-257). In all these cases, the principles for the reforms were inspired by developments in mathematics such as projective and other non-euclidian geometries, descriptive and analytic geometry in the 19th century and functional analysis, algebra, logic and set theory, and probability theory at the turn of the last century.

If we think about the pretext of the reform the so-called “PISA shock”, it sounds quite similar to the “Sputnik shock” on the eve of the New Maths reforms. The Sputnik shock however, was part of world affairs whereas PISA was enacted especially to get an influence on national educational systems.

We traced the development of the notion of competences back to its original use as a psychological selection tool and its modern use to limit the notion of “Bildung” to practical usefulness and functionality. The discourses about role, extent and place of applications and modeling in today's mathematical education have also a history and can be retraced to discussions during the twenties, fifties and eighties. The current so-called modeling problems in A level tests became part of German school mathematics in the context of the PISA shock and its subsequent reforms to improve the poor performance of students in the field of modeling competences.

As we can see, there are various ways to explore the history of mathematics education: On the one hand, we went back to the roots of current educational reforms; on the other, we looked for similar patterns in the past.

Conclusion

We did not answer the question of how to continue the discourse, which started at ICHME, but it inspired us to look for ways to include the history of mathematics education in teacher education. The current gradual shift in the fundamental principles of the German education system make reflecting on these foundations even more important.

Notably the *von Humboldt Bildungsideal* is built on two notions: the *autonomous individual* and the *cosmopolitan or Universalist (Weltbürger)* – that is, a universally interested person who cares about the important questions of humankind. The university should be – both for students and professors – a place for autonomous individuals to become such a *Weltbürger*. Student teachers, who are about to become responsible experts for *Bildung* at school, not only need to come in contact with these ideas, but should also be given opportunities to work on their own *Bildung* and personal development.

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