THE ROLE OF HISTORY OF MATHEMATICS IN FORMING AN IMAGE OF MATHEMATICS AMONG STUDENTS AND GENERAL PUBLIC

Discussion panel held during ESU-9, Salerno

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ABSTRACT

The panel which this contribution summarises, discussed the role of the history of mathematics in education focusing on the image of mathematics and mathematicians that students in education and more generally some societies, have. We looked at several such societies: those we come from, and those from our respective historical societies of interest, and compared some notes and made some conclusions.

1 Preamble and Contributors

The organisers of the ESU asked the authors of this report to form a panel for the ESU9 dedicated to the images of mathematics and mathematicians in education, and their historical and contemporary portrayal. We interpreted this question in similar ways but different to the point that each one of us teaches different groups of students and is interested in different historical societies. We also all come from different European cultures, but also bring interests in other cultures, most notably cultures from the ancient Indian subcontinent.

We therefore begin this report by listing our plans and contributions during the discussion, and further the details of conversations that emerged followed with some major questions posed, and finally make a conclusion about the role history of mathematics can play in forming images of mathematics and mathematicians in education in general.

1.1 Jean-Michel Delire

Jean-Michel is a mathematician and a philologist, specialized (PhD in 2002) in Sanskrit mathematics. Delire is still doing research in India, especially about Jai Singh II's (1689-1743) achievements in astronomy and mathematics. After teaching mathematics in secondary schools, Delire is, since 2007, training students-future maths teachers in geometry and history of mathematics. While trying to improve their general knowledge of the historical contexts in which mathematics were produced, Delire's aim is help such students to prepare lessons that will lead their pupils to a better understanding of mathematics.

Delire's credo is that history of mathematics gives both mathematics and mathematics education a more human attire, so that pupils who declare themselves to have skills and interests more in the "literary" than "scientific" disciplines could also begin to like and have a greater interest in mathematics. For that purpose, Delire's method is to take advantage of ancient texts and instruments, in order to immerse pupils in the context and background of the problems they consider mathematically.

In so doing, Delire's hope is that pupils will imagine the situation of the ancient researcher, project themselves into his problem, and give more sense to the mathematical problem than by making the use of the usual (and more abstract) method of learning mathematics. The pupils will so understand that mathematics are not a punishment imagined by a cruel god to torment them, but have been built, little by little, by women and men like themselves.

1.2 Helena Durnová

Helena Durnová teaches mathematics and history of mathematics at Masaryk University in Brno, Czechia. She has written on history of computing in Czechoslovakia in the 1950s and 1960s, including early programming practices there. She is interested in the intimate connections at the intersection of computing, mathematics, and language, and she seeks to incorporate these in her teachings of both mathematics and history of mathematics.

In Czechoslovakia, mathematics as a school subject only appeared in the 1950s. Before that time, textbooks and classes were devoted to arithmetic's (including algebra) and geometry. In 1950, a new journal was founded, named *Matematika a fysika ve škole* (*Mathematics and physics at school*). Probably due to the involvement of top mathematicians (including the topologist Eduard Čech, who was involved in the design of the new curriculum as well as the

textbooks of the period), mathematics education in Czechoslovakia in the early post-war years comprised of lots of purely mathematical topics; especially geometry was represented more than before.

By 1969, a new trend in mathematics teaching arrived also to Czechoslovakia. Since then, children were exposed to traces of mathematics as a science, not just to arithmetics, algebra, and geometry, applied to real-world problems. With the increased level of sophistication involved, it became necessary to justify the topics historically (cf. Znám et al., 1986) and later also from the socio-cultural point of view (Kuřina, 2012,).

History of mathematics, especially as practised by mathematicians, played an instrumental role in positioning mathematics as a universal science through pointing out mathematics (calculations and geometry) in Ancient Egypt and Babylonia. Many of those now counted among mathematicians may have described themselves as philosophers, from Pythagoras to Leibniz and beyond. In the late 19th century, mathematics was seen as the example of correct reasoning, and thus as an example to be followed. This view has penetrated also into the way mathematics education is still thought about: mathematics is primarily a subject that teaches logical reasoning. Pointing to its beauty, on the other hand, is thought of as a good way to make mathematics more attractive for pupils and students who are not mathematically gifted. History of mathematics serves as provider of such connections.

1.3 Snezana Lawrence

Snezana is Senior Lecturer at the Department of Mathematics and Engineering Design, Middlesex University, London. She is a mathematical historian and is interested in the creativity, identity, and engagement in the learning of mathematics.

Snezana has been, for the past two decades, involved in various national initiatives in the UK, and international programmes and institutions (mostly via the HPM) to promote the use of the history of mathematics in mathematics education. She is now the Chair of the History and Pedagogy of Mathematics Study Group for 2020-2024. In the UK, Snezana has been an active member of The Institute of Mathematics and Its Applications and she is their Diversity Champion. She is also the Associate Editor of the BJHM (British Journal for the History of Mathematics). In all these roles, engagement with mathematics is an incredibly important aspect of the interaction with the educational as

well as wider public. The images of mathematics and mathematicians are therefore at the centre of Snezana's work most recently, and the critical reflection on the role such images of mathematics play in society in general have been a major driver for her publishing output.

It is this focus that also drove her to write the book *A New Year's Present from a Mathematician* (Lawrence, 2019), which is more broadly dedicated to two questions: «What is it that mathematicians do?» and «Who gets to be called a 'mathematician' and why?». These questions, in turn, arise from her work with mathematics teachers, and more recently mathematics undergraduate students.

Preconceptions about mathematics and mathematicians can of course be positive, negative, and anything in between. Their influence on students' perceptions of mathematics are an important motivating force in their learning processes. These influences can directly be linked to the engagement strategies that involve developing students' critical analysis of mathematical techniques, contexts, and tools at the disposal of historical mathematicians so that students become more able to identify what they have at their own disposal, as well as what it is that is of interest, and therefore most appropriate to their own quest of finding mathematical 'truths'.

Contributions from panellists

In this section we note our own reflections on how mathematics can help students form a positive and productive image of both mathematics and mathematicians. The reflections are given as they were presented and are therefore reported in the 'first person' manner.

1.4 Jean-Michel Delire

Mathematics is generally considered as a very abstract subject that only supermen and super-women can understand, people who has something in the brain called 'bosse des maths' in French. Of course, this conception is related to the ancient and erroneous theory (developped by G. Lavater, *L'art de connaître les hommes par la physionomie*, Paris, 1775) that the head of a human being is covered by humps that could reveal his/her defects and qualities. This theory has been abandoned today, but the conception remains that if you are attracted by mathematics, you must be bizarre somehow.

Another very popular – and erroneous – conception is that you are either a 'scientific' or a 'literary' person (see C. P. Snow, *The Two Cultures*, 1963, Cambridge University Press - French translation *Les deux cultures*, Paris 1968). Many journalists in Belgium, for instance, declare themselves as 'literary' and, sometimes, admit that they never understood anything in mathematics. But, as good 'literary' as they could be, they still don't see the difference between a number and a digit. When they have to quote a numerical information, they always say 'le chiffre (of the unemployment, of the Covid epidemy, etc.) est 15%', by instance. This is probably due to their difficulty with abstraction, for a digit is a concrete sign, while a number cannot be shown.

In any case, these examples show that mathematics are misunderstood, and that the journalists – and not only them – give a very bad image of our discipline. Some weeks ago, on a Belgian program RTBF1, one of them who had to talk about mathematics began his presentation by apologizing for addressing this subject.

The teachers themselves have their responsibility in this bad image. I have been teaching mathematics and I am still teaching history of mathematics to future teachers and I try to guide them so that they could tell their pupils when, why and how a certain mathematical problem occurred. But, very often, they choose the 'easy way' of teaching the rules, the steps their pupils should follow to solve a certain type of problems. And, of course, when the problem appears in another guise, the pupils are no more able to find their steps, for they don't understand the reason of these steps.

In many of the cases exposed so far, history of mathematics could be of some help: the 'literary' could find something else than terse and abstract rules when discovering the context and even the mathematical texts themselves; the future teacher could understand some of the pupils' difficulties when he/she is placed before a text for the reading of which he doesn't know the rules yet – not even a text in an ancient language (Latin or Greek for example), but a text written three or four centuries ago, by instance.

Of course, I could go on and enumerate all the qualities history of mathematics has – we are all convinced that it is a very useful approach which complement our understanding of mathematics, a complement that for many of us has taken the main place in our research. I developed some of these qualities in the introduction of a bulky book I wrote some years ago. It is a mathematical book with a lot of history (J. M. Delire, *Mathématiques multiculturelles I* –

Arithmétique, Algèbre, Géométrie élémentaire, volume 3 de la Collection *Sciences, Arts et Cultures*, Les Editions HE2B, Bruxelles, 2018, 431 p.).

The real problem is not the usefulness of history of mathematics, but its implementation in the cursus of our students. History of mathematics is still not compulsory – for future maths teachers – in too many European countries. I will begin by exposing the situation in my own country, Belgium. As far as I know, it is not compulsory for future maths teachers to take a history of maths course during their studies, at least in the French speaking Belgian universities. In the Hautes Ecoles where maths teachers for the lower secondary school (Collèges in France) are educated, the situation depends of the school. By instance, I succeeded, several years ago, to create a little course (24 h/year) of history of maths at the Haute Ecole de Bruxelles. I could even double the number of hours for this course last year, but I really don't know if this good situation would last after my retirement. It is very often like that: by instance, the history of maths course given by Jean Doyen at the University of Brussels is in latency since his retirement seven years ago…
The situation of the history of maths courses is too often dependent on one person, who devoted him/herself to the subject but has rarely a successor.

I can also say a word about some other countries, with information from contacts I have there; these reflections follow below.

Germany. Prof. Krömer and Klaus Volkert at Wuppertal University: the students-future maths teachers at the University follow a 6 hours/45 min (3h Vorlesung – 3h Seminar = oral presentation by students) in M1 or M2. And Prof. Krömer considers it as «probably the heaviest package in a German university (…) it depends certainly heavily on the competences and interest of the persons in post». He esteems that there are 30 to 40 researchers-teachers in the history of maths in Germany and Wuppertal has the greatest team: 6 persons, of which 2 are retired + doctorants and postdocs. In Siegen, he says, there is a history of maths course (4 hours) for the future primary school teachers, but the future Lycée teachers have rather course on the philosophy of maths. The education program of the Nordrhein-Westfalen Bundesland mentioned only once history of mathematics «Schülerinnen und Schüler erfahren, dass Mathematik eine historisch gewachsene Kulturleistung darstellt.» i.e. pupils experienced that mathematics has a historically grown cultural achievement; Prof. Krömer adds that every Bundesland has its own program.

France. It is comparable in a way, since the history of maths/science courses and research are mostly the prerogative of philosophy Faculties. But the INSPE, which prepare the future maths teachers, have their own courses on history of maths, depending again on personal interest (because the teachers are generally recruited on mathematics only oriented list = 25, but there is a certain liberty to create courses – generally 15 hours). The IREM are also to be taken into consideration as organisms of education through research, but they are open only to already diplomed students. They do a tremendous work and I must say that it is through their publications that I personally learned a lot after my first steps in Aarhus (Denmark) with K. Andersen and K. P. Moesgaard.

Netherlands. I have recently been informed that it is compulsory there for a future maths teacher to take a course on history of maths… Which is a good thing, comparable with the situation in Denmark.

Denmark. As far as I know (from my personal experience there 30 years ago), it is also compulsory, at least at the University of Aarhus. But, there again, there was a particular person, a historian of astronomy and mathematics, Olaf Pedersen, who heavily influenced the evolution, back in the sixties.

I would like now to listen to the reactions of the auditors about the situation in their countries, but I would also like afterwards to ask the question of what we could do, as a European organized body, in order to reinforce the teaching and use of the history of maths in our universities, Hautes Ecoles, INSPE (France), etc.

1.5 Helena Durnová

Should we teach history to mathematicians and mathematics teachers? If the answer is yes, what history should we teach and why do we teach it? Before unfolding the plethora of considerations, I would like to express my thankfulness to all my colleagues and also students with whom I have discussed the topic over the years.

Historians often organise their findings chronologically, so let me start with my own 1990s experience of being taught history of mathematics systematically for the first time. Then, each future upper-secondary school mathematics teachers had to go through a two-semester course in history of mathematics. It was presented to be a novel activity, starting around 1980 upon the initiative of the mathematician and didactician of mathematics Jaroslav

Šedivý (1934-1988). The people (usually mathematicians) interested in history of mathematics gathered at summer schools since 1980. The summer schools were called World-view Education in Mathematics, which the participants remembered as a clever cover name for history of mathematics, a field allegedly not supported by the ruling party of the 1980s. The participants of the 1980s summer schools thus understood history of mathematics as a dissident field which could only enter mathematics teachers' education under a cover-up title, namely world view problems of mathematics. Thus, history of mathematics, the story has it, could only enter the programme for upper-secondary school mathematics teachers through a back door.

There are a few question marks connected with this, which I will try to sketch below.

The first puzzling question is, how is it possible that history of mathematics and history of science would not be promoted by a regime that was based on science and the scientific world view? Would it not be only natural for a society based on the scientific worldview to promote history of science as well as history of mathematics?

Another puzzling question concerns the resources already available two decades before 1980. In 1963, *A Concise History of Mathematics* by Dirk Jan Struik was translated into Czech by Jaroslav Folta (1933-2011) and Luboš Nový (1929-2017), who were both originally trained as mathematicians and mathematics teachers. Those two also co-operated on the comprehensive volume published in 1961, *Dějiny exaktních věd v českých zemích do konce 19. století* (*History of the Exact Sciences in the Czech Lands until the end of the 19th century*) and on the overview published in 1979, *Dějiny exaktních věd v datech* (*History of the Exact Sciences to Date*). In other words, contrary to what the participants of the World-View Problems in Mathematics summer schools believed, history of mathematics was cultivated in Czechoslovakia between 1948 and 1989.

Yet another puzzling question might be why history of mathematics was (and is) taught to the future teachers, but not to the future mathematicians, but that is a quite different story.

As for the topics discussed in history of mathematics lectures, they often depend on the lecturer. Some prefer ancient mathematics, while others are fond of discussing late nineteenth and early twentieth century mathematics. In Czech history of mathematics and physics, there are several canonical figures,

some of whom are internationally renowned, while others are also mentioned because of their contact with Czechia. They include René Descartes for his introduction of Cartesian coordinate system, but also for his alleged participation in the Battle of White Mountain (1620), a key event in Czech history; Johannes Kepler, who spent some time in Prague; Bernard Bolzano as a precursor of set theory and a native of Prague, who belongs to Czech history of mathematics, even though he wrote in German; and Albert Einstein, whose three-semester stay in Prague has been repeatedly described. Rather recently, Kurt Gödel, who was born in Brno, is also remembered, although he studied in Vienna and worked mainly in Princeton. Faculty of Informatics of Masaryk University in Brno chose his face to be on the medal worn at festive occasions by the dean of the faculty.

In general, these topics reveal the purpose of teaching history of mathematics to future teachers, which is creating a shared body of knowledge about history of mathematics among mathematics teachers. In creating it through the courses, it becomes apparent that such a shared body of knowledge is necessarily selective and often culturally biased (for better or worse).

Let us now take it for granted that all future mathematics teachers should know something about history of mathematics, as they themselves will be the point of contact in this matter for the pupils and students. They approach the topic differently, ranging from classroom decoration to using historical problems in their teaching. Different history of mathematics courses may look very different, depending on the personality of the teacher. While some teachers emphasize the dates and names, others emphasize the mathematical content. Also, different teachers may wish to emphasize different periods and different geographical regions. In what follows, I would like to present the vision I follow in the course I have been teaching, with the hope that it will stimulate some discussion.

For my students in the secondary mathematics teacher training programme at the Faculty of Education of Masaryk University, the one-semester compulsory course in history of mathematics (worth 5 ECTS) is often their first conscious contact with the field. In the one-hour lecture, they receive an overview of history of mathematics, whereas in the seminar, we read extracts of almost original texts, i.e. texts in translations closely following the original. These include Simon Stevin's *De Thiende*, Christianus of Prachatitz's, *Algorismus Prosaycus*, and Jacob Bernoulli's *Ars Conjectandi*. The aim of the course is

rather to make students more open-minded than to teach them how to do history of mathematics themselves.

Mathematics teacher-training students will soon become mathematics teachers, and as such, they will also serve as a point of first contact in history of mathematics for their pupils and their parents. They will become a part of one of the three substantial groups of audience of historians of mathematics namely: mathematicians, mathematics teachers, and the general public. The interest of the last section of audience in history of mathematics lies, in particular, in biographies of mathematicians, but they also show interest in the mathematics hidden behind computers and artificial intelligence.

Let me take future history teachers as another example of the general public: not having had much mathematics education, the mathematical content presented to them has to be either elementary, or greatly simplified. As anyone who has ever tried to explain Gödel's results to the layman will probably agree, such a simplification is not at all a trivial task. However, let me use this example to elaborate on a different point, namely that of popularisation mathematics and especially history of mathematics. The books are in the shops and in the libraries, so rather than avoid them and claim they contain mistakes, I have found it more useful to make future teachers aware of their existence and encourage them to use these books with their students, as they have a value in speaking to young people and children in their language. At the same time, popularizations of history of mathematics can be used as material for emphasising what a good history of mathematics should look like. Historians should namely give us a chance to travel into the past with them, let us see with their interpretation how differently mathematicians thought in the past from the way we think now. Equipped with this, students may find it easier to phrase their own questions about history of mathematics and try and answer them. My role as a teacher therein is warning them that for particular topic, they may not be able to find the sources to finish their essay within the semester and redirecting them to a different topic. In marking their essays, the clarity of their expression has an indispensable value.

Having said all this, let me finish with a provocative question: How does knowing about Pythagoras help pupils master Pythagoras' theorem?

1.6 Snezana Lawrence

I found the most intriguing aspects of mathematics always to be those related to the reality and context of mathematicians who invented or discovered some new mathematics, and the reasons they were impelled to do so. For me, this is the most interesting part of mathematics, and I think we should do much more about talking with students about how new mathematics gets created or discovered, and then communicated, and how it sometimes travels huge geographical and temporal distances to connect people from very different backgrounds.

In the book about which I wanted to talk today (Lawrence, 2019), I chose to try to answer two questions:

- What is it that mathematicians actually do?
- Who gets to be called a mathematician and why?

I tried to answer these questions by adopting a structure based on a calendar, that is familiar to many amateur historians of mathematics, or rather many of the people who engage in popular history of mathematics on social media, like those on twitter for example (or following my twitter handles @snezanalawrence and @mathshistory). So, my book answers the above two mentioned questions through a series of stories from ancient to modern mathematics, but not in a chronological order. It rather uses calendar months to anchor stories about famous mathematicians and their contributions to mathematics in a particular fashion. I've presented therefore twelve stories – I tried to report on mathematical inventions as if I was an observer of a scene from another time and place. I imagined opening this metaphorical door and looking at the mathematicians or their inventions or discoveries, and reporting on what I saw just as a journalist would report from a field.

It is possibly not obvious to mathematics educationalists, or rather to us in the HPM network, that lots of mathematicians, in particular the mathematicians in industry and government, obviously like mathematics, but do not have enough of the material to talk about its importance to others without going into the detail of their, often highly technical or skilled work. So, this book was dedicated to this audience also. I came across this large group of mathematicians whilst engaged on the various committees and being the Diversity Champion of the Institute of Mathematics and Its Applications (UK). So partially, this book was dedicated to this group of people too, other than general public interested in history of mathematics. Most of all, it aimed to enchant and engage a reader who knows a little bit of mathematics, and also

wishes to learn more about how various developments happened in the history of our discipline.

There is, in fact, no prior knowledge needed to read this book. I wanted to write as if writing for a wide-raging audience, with concepts explained in an easy-to-read-and-digest way without trivialising their nature. The book is Euro-centric but another method I used in writing was to describe the whole journey through time as also a journey through a geographical area. I hope that I would, in time, write another book of another area – Middle East is something I have started to look in the recent years.

Discussion

After our presentations, we had a discussion which we summarise here from the notes taken by Delire.

A question from an Italian delegate came about the expansion of history of science after WWII. The delegate asked why no similar expansion of courses in the history of mathematics occurred in universities of Europe. Snezana answered that there are not many modules in UK (England, Scotland, Northern Ireland, and Wales) – some years ago, the British Society of Mathematics undertook a survey and found that across the whole of the country, and in around 130 universities in total, had only less than twenty such modules/courses in the history of mathematics. We discussed how students would choose history of mathematics if there is an offer. But a problem of having such a small number of courses, and hence positions in the history of mathematics, there is not enough qualified people to be employed as purely historians of mathematics, which is something we should work on as a community.

Another question was posed about the history and philosophy of mathematics and their joint role in education. Snezana argued here that there is a useful international group on philosophy of math practice called Association for the Philosophy of Mathematical Practice (Association, 2022) which has much to offer in terms of considering precisely such questions and with whom we should perhaps have more contact. Helena proposed that the teachers, in their professional practice, also constantly develop their priorities and purposes, and that this is not something that remains the same all the time for each individual teacher. For example, when teaching, maths teachers will constantly re-examine their priorities and think about what is most important for them: to help develop their pupils‘ minds, select what is important or not in mathe-

matical thinking, look at ancient texts (this too comes with different aims, depending on the historical period). Jean-Michele added his comments here about Indian mathematics culture and the fact that Indian mathematics didn't develop in the same way as Greek (ancient) mathematics did, and was not of the same hypothetico-deductive systém. This contrast between two ancient systems of mathematics could bring interesting questions if presented in the classroom. He further added that our own, contemporary philosophical thinking, is also always evolving and, thus is also our way of teaching.

A question then arose about the social images of mathematics, by instance through films (which show mathematics is made by some extraordinary genius) and what we thought about that. We answered that we all thought it is necessary to present maths as a collective construction, and offered an example of Perelman's conjecture solved by several mathematicians. Snezana further added a comment about a fantastic resource for the classroom on this particular aspect of popular images of mathematics in the movies, made by a Harvard academic, *Mathematics in Movies* (Knill, 2022), which has numerous clips from many films from the last two-three decades in which mathematicians are portrayed in different ways. This resource she often uses in teaching mathematics as it can offer good starting points for conversations in a classroom. Helena alluded to theatre plays about Gödel, for example one by William Hugel, and a more recent one by Marcus du Sautuy, *I is a strange loop*.

A fourth question was about the fact that secondary maths teachers and their pupils, even when interested in the history of mathematics, don't know about libraries, but use Wikipedia instead. Snezana's answer was about the methodology and nature of a course in the history of mathematics. Such course/module has to cover both history *and* mathematics. These two subjects sometimes can confuse students, so they need some training also in the way they conduct historical research, if they are in fact doing a mathematics degree (or post-graduate course in mathematics primarily rather than social sciences). Helena added that there are a lot of discussions among French colleagues about historical teaching and sources. In terms of mathematics and philosophy or mathematics and history courses, as in Hungary and Czechia, pluridisciplinarity is appreciated, she believes.

Conclusions

In some of the other discussions and questions we came to the conclusion that we should, perhaps, as a community develop a greater and more accessible platform to enable teachers from around the world to access resources and communicate with each other online. Although our network is large, there are many more people who may want to be able to access resources in the history of mathematics and use them in their every-day work in the classroom.

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