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UDC 510.21(091)::616.98(410.111)
DOI 10.46793/Uzdanica19.S.017L
Analytical research paper
Received: September 25, 2022
Accepted: December 2, 2022

# REVISING THE ROLE OF THE HISTORY OF MATHEMATICS IN POST-PANDEMIC WORLD

*Abstract*: In this short philosophical and discursive paper, the main objective is to reassess a new emergent role of the history of mathematics in order to bring about greater diversity and engagement in the mathematical sciences. The discussion is based around the project undertaken at a North London university and their partner pre-university college, which piloted the larger national project in the UK in the local context. The success of the project, it is further suggested, would greatly benefit from a framework in which the history of mathematics as a humanistic discipline is closely related to viewing mathematics as a virtuous practice. We also include a short summary about the lives and careers of two Serbian mathematicians, Judita Cofman, and Milica Ilić-Dajović, to showcase how learning about the ways in which marginalisation takes place can help students position themselves and contextualise their priorities as they enter the professional mathematics landscape.

*Keywords*: Levelling up, humanistic mathematics, decolonising mathematics, mathematizing, virtuous practice.

## INTRODUCTION

This article relates to the lessons learned post-pandemic in Britain, and more precisely London. We believe that some of its findings can be applied to any setting, including that of the Balkans and Serbia in particular. In this article we will first

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describe the widening participation project which had very few connections to the history of mathematics. However, the assumptions before the start of the project and the analysis following the conclusion of the project led to the re-examination of the role that the history of mathematics can have in mathematics education and in similar projects in the future (Levelling Up Scheme 2020; Lawrence et al. 2022). This re-examination is directly related to the roles of narratives in mathematics education as we will show.

## THE PANDEMIC AND CALLS FOR GREATER DIVERSITY IN EDUCATION

We start our story with how the pandemic made some inequalities in the UK educational system more visible than they had been previously. The lockdowns in UK were of varying durations, but each meant that the majority of the UK's children were not able to attend school in person and hence suffered interruptions in their education (Institute for Government 2021).

By UK law, all children under the age of 18 are required to attend school full-time (or a training or apprenticeship programme) and during the pandemic lockdowns, this had to be organised mainly online. To attend online schooling, children had to have access to computers and the internet. The number of children who could not access online schooling was never fully investigated, but the government established a 'Get help with technology' scheme which allowed such children to get a computer from the government. The children who were eligible to get a computer had to either not have a digital device in their household, have only one such device for the whole household, or have no broadband (access to the internet) at home (Education Statistics Government 2022).

A series of other events also took place during this unhappy period that greatly influenced the sense of inequality of outcomes for different sections of communities. For example, the protests that followed the death of George Floyd in May 2020 reignited attention to the disparity in outcomes between different races and were further articulated in the protests of the Black Lives Matter movement in both the UK and US. The abduction and murder of a young woman on a peaceful street in London by a serving police officer showed the vulnerability of women during the pandemic when the streets were emptied. Both of those events initiated a period of unrest in the UK, particularly concentrated in London (Parliament 2021).

In terms of less turbulent expressions of dissatisfaction, some new phrases were born during the first and most severe pandemic lockdowns in the middle of 2020. These phrases sometimes related to the new virtual world we found ourselves working in and some were to do more with the greater awareness of systemic racism or inequalities in our social institutions (Herrera 2020). The articulation of these phrases showed the significantly growing awareness of the inequality in both

the UK and US. This was further followed by an awareness of how the prevalent narratives of the history of mathematics and sciences seem to favour one particular subset of the population: middle aged, middle class, well-to-do, white men. Following this pandemic-induced awakening towards the inequalities seen in everyday life and in historical narratives, some urgent calls were put out to organise conferences and begin the reassessment of history, bring decolonisation to STEM (Science, Technology, Engineering, and Mathematics), and initiate projects to create new resources. All of this was envisaged to give greater support to disadvantaged groups in education and showcase examples and methods of bringing greater diversity to mathematical sciences (Barrow-Green, Stenhouse 2020).

The project that first mentioned *levelling up* was also conjured in the north of the country, financed by a single donor (Levelling up Scheme 2020). It is worth noting that this particular phrase – *levelling up* – was then also used by the UK government beginning in July 2021 (Government 2021) to describe a programme that unveiled additional funding for the disadvantaged communities to 'level up' to those that are not.

## THE WIDENING PARTICIPATION PROJECT AND ITS FINDINGS

In view of these events and reports, the founding of the Levelling up Scheme was envisaged as a starting point to inspire A-level students of "under-represented backgrounds in Maths, Physics, and Chemistry" (Levelling up Scheme 2020) to undertake study of these disciplines at the *leading* universities in UK. There are various measures of university ranking, but the one to which this project referred was *The Times' Good University Guide*. According to this guide, the top leading five universities are interchangeably the University of Cambridge, University of Oxford, University of St. Andrews, Imperial College London, and Durham University (the last two swap places sometimes). Their intake shows consistently less than 70% of students to be those who come from state-funded education (HESA 2021). In contrast, students who study at Middlesex University come from predominantly disadvantaged backgrounds; in 2019–2020 we ranked 7$^{th}$ across the Higher Education sector in this respect, and in 2020–2021, we were the 1$^{st}$ (top) in the league of universities in number of students coming from disadvantaged backgrounds studying at a higher education level.

The programme gained recognition from major professional associations in the UK and in Mathematics both from the London Mathematical Society and the Institute of Mathematics and its Applications. The national level project provided funding to these professional bodies to coordinate local engagement, and the universities that took part provided funding for the projects involving their own students and the targeted group of A-level students.

In our university setting, we had a small team who decided to conduct a trial of the project (Lawrence et al. 2022). We do not count as a leading university according to *The Times Good University Guide* but were happy to pilot the project as envisaged by the national team in order to support students with preparation for entering the other universities.

Whilst we conducted the project, we partially used the framework of evaluation of the national project. The national project had overwhelmingly positive reviews, and our pilot similarly showed positive results. However, the question as to whether the targeted group of A-level students had progressed on to undergraduate study in mathematics (or planned to do so) at one of the *leading* universities did not meet our expected outcomes. Whilst the students acquired greater skill in mathematics and therefore increased their ability to gain top grades and pass entrance examination to the targeted group of leading universities, they did not express great interest in this particular aim of the project.

Both the national project and our own project team expected this to be desirable for students. And, despite our project running on a much smaller scale, we discussed this with students and found that the primary impact on A-level students was the increased confidence and improved results they achieved after they had been tutored by our undergraduate mathematics student-teachers. Conversely, the A-level students did not consider support to get to a 'leading' university as one of their priorities.

We found instead that the participants considered various universities for their undergraduate study (not only ours) and that their consideration was not based on the *Good University Guide* annually published by *The Times*. Instead, students looked for (in order of preference) the universities that

a) offered degrees that they would like to study,
b) those that they would be able to get an early employment through (possibly work-based further studies), and
c) those that were easiest for them to access geographically.

Furthermore, we found that our undergraduate students, the student-teachers in the project, and the A-level students from the local college had not lacked confidence in terms of applying to study mathematics, *nor* were they ambiguous as to whether they should study mathematics, in fact they were quite certain of that. They did, however, not find confidence originally (in the project) with which to discuss and work on mathematics together, nor did they find it easy to talk about mathematics with others.

With these findings we began reconsidering two supporting mechanisms trialled before in mathematics education, beginning to form a proposal for another project yet to be undertaken. These supporting mechanisms were the development

of narration in the learning of mathematics and the use of the history of mathematics in promoting positive outcomes for students (Lawrence 2008; Lawrence 2016).

## THE NARRATIVES IN MATHEMATICS EDUCATION AND THE HISTORY OF MATHEMATICS

The narratives in mathematics education can roughly be divided into those that look at mathematics from the outside and those that deal with mathematics from the viewpoint of a learner. The first type of narration describes mathematics, looks at it as a discipline, and studies the mathematicians as persons within their own contexts. It tends towards an external dialogue within a group or between two or more groups. The latter type, concerning the internal dialogue of a learner, deals with how one develops an internal voice to do mathematics, to reflect on mathematics, to describe to oneself how one copes with doing mathematics, and so on.

These two types of narratives are not completely distinct, and the dialogues with oneself tend to blend towards the narratives of others over time, as one gains confidence to voice them loudly. So, whilst saying that we can divide narratives into two groups, we also mean two groups and everything in between (Lawrence 2016).

I want to add further layers to the understanding of that budding 'internal' dialogue that eventually becomes a confident external dialogue and encourages the positioning of a growing mathematician towards the discipline. This growing confidence and acceptance of mathematics as something that is part of oneself can be seen as a virtuous practice (Aberdein, Rittberg, Tanswell 2021).

This term itself now needs further explanation. In developing one's confidence to deal with mathematics, a learner tests themselves continuously in skill and perceived aptitude (e.g., 'Am I really understanding this?'), but also in seeing themselves further developing into a yet unknown future person who will live life in a certain way. That way is inevitably virtuous in some manner. Very few people can imagine one starting on a mathematical journey thinking they will become hopeless and will never make a penny out of their profession (there is a whole story in here about romanticising unsuccessful artists and possible parallels with unworldly mathematicians, but we will leave that for another paper).

For this process of growing as a person, Fried (2018) offers a humanistic perspective and ascribes an additional role to the history of mathematics. This role is not only that the history of mathematics can contribute to the learner becoming good or even excellent in mathematics, but becoming a fuller person:

> "[…] the history of mathematics, if it is taken seriously, can become a mode of thinking about mathematics and one's own humanness. What I mean by the latter is that by studying the history of mathematics rather than simply using it as a tool – and that means attempting to understand it as a historian does – one becomes aware of how mathematics is something human being do that therefore informs our human

> identity. In this way, the history of mathematics in mathematics education has the potential to make us fuller human beings […]" (Fried 2018: 85)

But how does one connect the internal narrative that allows for some connection between the success of becoming good at mathematics, with, at the same time, a process of becoming a 'fuller human being'? Of all the techniques of studying narratives in mathematics education, the most useful in this respect is to consider 'mathematizing' as a virtuous practice (Kant, Sarikaya 2020).

In this framework, the practice of *mathematizing* is one that is originally put forward by Freudenthal's Realistic Mathematics Education (RME) (Freudenthal 1968) and can be updated to mean making sense of our context and reality through mathematics. As it has been shown earlier (Lawrence 2016: 147), it is a method in the sense of both transcending and re-enacting what one sees others do in order for one to find one's own voice and construct one's own stories about mathematics and their ability in the discipline. Within that method, it is important to *not* use the stories from history that repeat and reinforce the established general narrative of history in which the figures that seemed to be marginal were in fact, marginalised. We will explore two of such figures shortly.

Of course, to make progress with defining how to look at both mathematics as a virtuous practice and the method of developing one's own voice through the history of mathematics, we need to define what mathematizing means. In Freudenthal's model the constant *mathematizing itself* is a virtuous practice. Mathematizing involves all the things that one does to model contexts and problems in mathematical terms, and it can be compared to acts and states such as art appreciation or art production within one's context, in this case applying mathematical tools to appreciating and doing mathematics. Doing various mathematical things including describing, proving, applying, making abstract conclusions, and using mathematical symbols to understand something within a mathematical context, is what Freudenthal calls *mathematizing*:

> "In its first principles mathematics means mathematizing reality, and for most of its users this is the final aspect of mathematics, too. For a few ones this activity extends to mathematizing mathematics itself. The result can be a paper, a treatise, a textbook. A systematic textbook is a thing of beauty, a joy for its author, who knows the secret of its architecture and who has the right to be proud of it. […] What humans have to learn is not mathematics as a closed system, but rather as an activity, the process of mathematizing reality and if possible even that of mathematizing mathematics" (Freudenthal 1968: 7).

Freudental originally, and more recently Kant and Sarikaya, show (Freudental 1991: 10; Kant, Sarikaya 2020: 3410) that the main components of mathematizing are axiomatizing, formalizing, and schematizing.

Building a schema, modelling of a schema, creating schemes to fit complicated data, or eventually representing reality in some mathematical way is closely related to what Lawrence has called the historical landscape of mathematics (Law-

rence 2019). This is not an ideal landscape, nor is it a neat or perfect one. Often it is perilous, desert-like, muddy, and untidy, but every so often a vista may show itself to a mathematical student, when the beauty of the mathematical landscape glows in its full glory (Lawrence 2019). Making the learning of mathematics a habitable landscape is akin to making a map in multi-dimensional personal space as one learns things from mathematics and from history of mathematics. It involves learning how to build networks of knowledge and understanding and how to leave some posts with little embarrassing flags to point to where further details should at some point be added to aid understanding.

Through formalizing, focusing on form, using appropriate symbols and formal expression to describe a scheme or an object, whether real or ideal, becomes possible. A young or recent mathematician can start using the tools and methods at their disposal to try to mathematize whatever obstacle they are trying to overcome. As history teaches us, this is possible with a great variety of tools and hence some mathematicians can potentially be viewed (with the hindsight of history) as pragmatists, mystics, sceptics, radicals, or ascetics (Brunson 2020; Lawrence 2019).

Axiomatizing through identifying rules by which we ascribe meaning to compose mappings of various kinds, whilst satisfying the well-known postulates is probably the most delicate of all aspects of becoming mathematician through *mathematizing*. In this particularly intricate and prone-to-mistake process, one needs a friendly guide. Who can offer such an example? The history of mathematics has long been used in this particular way, and the mathematicians of history are thus invoked to offer reassurance to the contemporary students (Lawrence 2008).

Now that we have mapped mathematizing (in Freudenthal's sense) onto the history of mathematics – in Jankvist's (2009) sense of using history as a tool in mathematics education – we can look for examples of how to build a method for de-marginalising groups of mathematicians and making their presence greater in the Mathematical landscape of the future. What possibly can we gain from that? Perhaps the exemplification of principles on which marginalisation takes place and the creation of new tools for young mathematicians to avoid themselves being put in that position.

## THE TWO WOMEN FROM SERBIAN HISTORY OF MATHEMATICS

I will give two examples of women who contributed greatly to both Serbian and English (and more widely European) mathematics and mathematics education in the past century.

The first is the mathematician Judita Cofman (1936–2001). Cofman was born in Vršac (in Vojvodina, the northern autonomous province of Serbia), was of Jewish-Hungarian ancestry, and came from a wealthy family who owned one of

the largest breweries in the province. Cofman's father was educated in Germany, and she spoke at least three languages from an early age: Serbian, Hungarian, and German. At the end of World War II, the family's wealth was nationalised, and Cofman enrolled to study mathematics at the Faculty of Philosophy at the University of Belgrade, which then had an outpost in Novi Sad in 1954. At the completion of her studies, Cofman became a teacher in Zrenjanin, a town almost exactly halfway between Vršac and Novi Sad, where she stayed for two years. In 1960, the University of Novi Sad became a university in its own right, and Cofman went back to study for her PhD and to become an assistant to the first female professor of mathematics at the university, Mileva Prvanović (1929–2016). When she completed her PhD, Cofman did postdoctoral research as a Humboldt Fellow at Goethe University in Frankfurt am Main, where she stayed from 1964 to 1965. She then moved to work as a lecturer at Imperial College London from 1965 to 1970 and then University of Perugia, Italy in 1970. In 1971, she gained a position at the University of Tübingen in Germany, then moved to the University of Mainz in 1976. But in 1978, Cofman moved back to London and gained employment as a teacher at Putney High School, a private school for girls (Durnova, Lawrence, Beckers 2022; Lawrence 2022).

Cofman was invited to this prestigious private school by the British mathematician Margaret Hyman, neé Crann (1923–1994), who was at the time the Head of Mathematics at the school. Margaret was a well-known mathematics educator and was President of the Mathematical Association of UK from 1974 to 1975. With her husband Walter Hyman (1926–2020), a professor of mathematics from Imperial College (where Cofman worked a decade earlier), Margaret founded the British Olympiad as part of the International Mathematical Olympiad. Another co-founder was their friend and a teacher at Eton College, Norman Routledge (1928–2013). While in England, Cofman published textbooks dedicated to problem solving based on the work she did with talented young mathematicians in mathematics summer camps. She helped organise and run these camps whilst teaching in England. Routledge was later named the most influential teacher of Tim Gowers (1963–) and Stephen Wolfram (1959–), a Fields medallist and professor at the University of Cambridge (Wolfram 2019).

Cofman was also the PhD supervisor of professor Albrecht Beutelspacher (1950–), via whom she left a considerable legacy in mathematics education in Germany (Mathematikum 2022). She did this through her work at the Johannes Gutenberg University Mainz, where Beutelspacher later produced 47 further descendants. In fact, her influence has recently been recognized in Germany through a conference in the winter of 2021 at the Johannes Gutenberg University Mainz that was held in her honour for her contribution to mathematics education in the country.

Judita Cofman is one of those marginalised mathematicians and mathematics educators who did not see in her lifetime the acknowledgement of merit that were due to her (Lawrence 2022; Nikolić 2014).

A second example is the mathematician and mathematics educator Milica Ilić-Dajović. She was born in Paris, where many of the Serbs sought refuge from the advancing Central Powers (Austro-Hungarians, Germans and Bulgarian forces) during WWI. From childhood, Ilić-Dajović spoke French and Serbian and eventually became fluent in German and Russian (Mićić 2019). Ilić completed her mathematics degree at the University of Belgrade where she met her husband Vojin Dajović. From the mid 1950s, Milica became interested in the competitions of secondary school pupils and organised the first such competition for the country in 1958, a year before the first IMO. She then piloted the first similar competition for primary school children (primary school in Yugoslavia covered ages 7–14) in 1965. Milica was the leading educator of her time in the country. She also initiated the formation of the journal *Nastava matematike* (*The Teaching of Mathematics* 1992–2022).

In 1963 to 1964, her husband Vojin had a ten-month stipend to spend at the Mechanical faculty of the Moscow University Lomonosov. Upon his return, Milica translated two textbooks on mathematical problem solving published by the Moscow Mathematical Olympiad team. She edited these texts, one with preparatory questions and one from the Moscow Olympiad in 1966, and wrote introductions to both. Milica became the country representative for the IMOs in the early years after Yugoslavia joined and was the president of the international committee for the IMOs held in Yugoslavia (IX in 1967 and XIX in 1977). She became, with Vojin, the force behind the founding of the Mathematical Gymnasium (or Mathematical Grammar School as it is sometimes called) in Belgrade. Currently, however, her contribution is sometimes interpreted as second to that of her husband. Ilić-Dajović doesn't seem to be a marginal person at all, but rather one that has been at the centre of mathematics education in her time and context; nevertheless, the historical narrative has positioned her in a supportive, marginal role.

What can we learn from her example and that of Cofman's?

## CONCLUSION

The somewhat surprising feedback from the pilot project we undertook in the past academic year has been the fact that students didn't share our, or more precisely, the project's assumption that they would aim for one of the *top* universities in the UK. Instead, they prioritised courses and universities that they considered to be best suited to them. A second surprise was the students' openness about how low their confidence to talk about mathematics had been during the project, despite having dedicated themselves to study mathematics and become mathematicians.

By examining these somewhat contradicting aspects of the project in its context (the post-pandemic world), it became clear that some of the negative aspects of the post-pandemic world also matured into positive and real changes within the

younger generations about to enter mathematical landscapes. This change we can describe is in expectation rather than in situation. This expectation is related to the choices they make based on their value-systems and priorities. At the same time, these young people are open about talking about problems with taking ownership of *their* choices. They also seem to need some further support to become more able to articulate their position within the mathematical landscape and envision landscapes they want to further develop themselves.

The stories of those such as Cofman or Ilić-Dajović, who were in some way central to their mathematical landscapes and yet became almost invisible within the historical accounts dealing with their time, can perhaps help. Such stories can unearth the mechanisms by which marginalisation happens both within a lifetime (like with Cofman) or afterwards (like with Ilić-Dajović). The central part of their stories are still their mathematics and their professional lives, but it may help to dissect how their contributions were not respected equally as others' based on their gender and social positions. This can be reflected upon with this new post-pandemic world-view to offer some new tools for those who undertake mathematics as a new calling.

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## РЕВИДИРАЊЕ УЛОГЕ ИСТОРИЈЕ МАТЕМАТИКЕ У ПОСТПАНДЕМИЈСКОМ СВЕТУ

*Апстракт*: Циљ овог теоријског и прегледног рада јесте преиспитивање нове улоге историје математике у циљу постизања веће различитости и посвећености у области математике. Анализа се заснива на пројекту који је спроведен на Универзитету у Северном Лондону и партнерском колецу, а који је покренуо један већи национални пројекат у Великој Британији у локалном контексту. За успех пројекта од велике користи би било да се историја математике као хуманистичке дисциплине уско повеже са виђењем математике као добре праксе. У раду је такође дат кратак приказ живота и каријера две српске математичарке, Јудите Кофман и Милице Илић-Дајовић, са циљем да се студенти упознају са видовима маргинализације како би научили да се изборе за своје место и да поставе себи приоритете у тренутку када почињу професионалну каријеру у области математике.

*Кључне речи*: равноправност, хуманистичка математика, промена улоге математике, математизирање, добра пракса.