Studies on Mathematics Education and Society

BREAKING IMAGES

ICONOCLASTIC ANALYSES OF MATHEMATICS AND ITS EDUCATION

EDITED BY BRIAN GREER, DAVID KOLLOSCHE, AND OLE SKOVSMOSE

https://www.openbookpublishers.com

All external links were active at the time of publication unless otherwise stated and have been archived via the Internet Archive Wayback Machine at https://archive.org/web

Any digital material and resources associated with this volume will be available at https://doi.org/10.11647/OBP.0407#resources

Volume 2 | Studies on Mathematics Education and Society Book Series
ISSN Print: 2755-2616
ISSN Digital: 2755-2624

ISBN Paperback: 978-1-80511-321-8
ISBN Hardback: 978-1-80511-322-5
ISBN Digital (PDF): 978-1-80511-323-2
ISBN Digital eBook (EPUB): 978-1-80511-324-9
ISBN HTML: 978-1-80511-325-6

DOI: 10.11647/OBP.0407

Cover image: *Fall* by Tara Shabnavard
Cover design: Jeevanjot Kaur Nagpal

Published with the support of the Open Access Publishing Fund of the University of Klagenfurt.

15. Networks, controversies, and the political in mathematics education research

Lisa Björklund Boistrup and Paola Valero

The stories about what constitutes the field of mathematics education research are threaded in a network of institutions, people, and materialities that both produce and sustain them. In such distributed network, controversies concerning these stories are constantly negotiated. Drawing on Latourian concepts and analytical strategies, such stories, network and controversies are explored in an attempt of understanding the political in mathematics education as a 'matter of concern'. An analysis is deployed of the contemporary controversy on the justification for school mathematics in the school curriculum as it is played out in research that engages with the Organisation for Economic Co-operation and Development (OECD)'s Program for International Student Assessment (PISA) as an event shaping the political reasoning about mathematics education. Using the format of a play, the results show the positions entangled in the controversy surrounding mathematics education in current societies. Casting light to these controversies helps trace the multiple entanglements between mathematics education and the cultural politics and economy of our times.

Stories in/on mathematics education

What to say about mathematics education as a domain of scientific research depends on the perspective from which one decides to look at the field. Already in 1998, Jeremy Kilpatrick and Anna Sierpinska

 https://doi.org/10.11647/OBP.0407.15

(1998) published an ICMI-Study[1] volume on mathematics education as a research domain wherein a number of recognised researchers at that time reflected on the core of the research field. Since then, a number of overview publications in handbooks and in special collections in books and journals have produced new insights and discussions about the advances and limitations of the field of research (e.g., Inglis & Foster, 2018; Niss, 2019). In these meta-reflections, that show the field's reflexivity regarding its practices and results, one can find stories about its history, origins, development, and evolution, as well as its hopes and aspirations for its future. To call these accounts 'stories' does not imply any kind of diminishing of their veracity, accuracy, or foundation. It only signals that there may not be an absolute and objective description of mathematics education research and its results, but that there will always exist localised attempts by storytellers to articulate an account of the people, materialities, and practices that, in specific time-space configurations, are considered key elements in shaping mathematics education as a field of investigation. That stories are diverse and are told from different vantage points does not, however, mean that those stories do not have a resonance. Indeed, they do, as they become part of what the many people involved in the activities of the field come to express when referring to mathematics education research.

Traces of those stories are to be found in the very same way that the people involved think and talk about the field: a relatively new area of research with a place in universities, of interdisciplinary nature but identified as a social science, where mathematics in a broad sense plays a role. It is a field of academic inquiry in search of an identity, with local and regional roots, but also highly international, with the overall aim of understanding teaching and learning practices and contributing to their improvement. It is necessary as a foundation and support for bettering teacher education and actual teaching and learning in schools. It contributes to achieving higher results in large-scale measurements, a part of the national strategies to increase interest in the Science, Technology, Engineering, and Mathematics (STEM) fields and promoting and sustaining individual progress, social development, national economic competitiveness, and so on. Out of all these traces,

1 International Commission on Mathematical Instruction (ICMI).

and plagued by a mathematical desire to find order or at least a secure point to hold onto, one could succumb to the temptation of producing a definition that most people – if not all – could endorse:

> Mathematics education is [...] concerned with the technologies of learning and teaching in institutionalized pedagogic settings. It [also] includes researching mathematics education in sites beyond the classroom (e.g., local communities and families, workplaces, policy making, the media, textbook production) and research activities that describe and theorize these practices, including research that is directed towards studying the social, economic and political conditions and consequences of those practices. (Jablonka et al., 2013, p. 43)

This definition, broader than the one proposed by Kilpatrick and Sierpinska in 1998, features a widely encompassing variety of elements, resembling the sense of a network of practices of mathematics education (Valero, 2010). From another perspective, inspired by the Anthropological Theory of Didactics (e.g., Artigue & Winsløw, 2010), there are the multiple, embedded levels of praxeologies that organise mathematics education practices and also its study. Yet other resonant accounts of the field are to be found in the onto-semiotic approach to the didactics of mathematics (e.g., Godino et al., 2019) or the socioepistemology of mathematics teaching and learning practices (e.g., Cantoral, 2020), to mention a few. All these accounts are frequently seen as theoretical frameworks that articulate notions about what constitutes mathematics education, identifying the people, processes, materialities, and institutions involved in its making. These stories about mathematics education and, concomitantly, mathematics education research unfold particular sensibilities towards the focus of attention. They inevitably foreground some elements and shade others. What is common to all these accounts, however, is that each one of them actualises ways of conceiving of the elements that constitute mathematics education; and through such actualisation, the stories, in fact, actively shape what counts – and what does not count – in research. In other words, these stories do something; they have agency; they effect power.

When we come to the discussion of how to determine what counts – or not – and what is possible to think and do in mathematics education, we usher in the political question of how the stories of mathematics education research constantly contest one another and how they perform the very same objects and relationships that they intend to portray. Thus, what is said in a field of study about itself is subject to discussion. It is a controversial issue, more than a matter of fact. It is indeed here that thinking about mathematics education research with Bruno Latour (e.g., 1999, 2005, 2018) may help map new territories. In particular, this approach may help us when considering the power effects of the accounts. What could be possible? What may become new potential imaginations for mathematics education research?

In this chapter we embrace some notions and analytical strategies in the work of Latour to think about the stories of mathematics education as a field of research. While his insights on the functioning of the natural sciences as a terrain of practice have informed studies on science and technology in society and, to some extent, have also illuminated directions in science education (e.g., Elam et al., 2019; Kwak & Park, 2021), the use of Latourian ideas in mathematics education has been limited (De Freitas, 2016; Valero, 2019). As Latour's recent work on the intermeshing of the multiple crises facing humanity poses unavoidable questions about the political orientation of the world (Latour, 2018), we find that troubling the political stories of mathematics education as a field, bringing it in conversation with Latourian concepts and analytical strategies, is a fruitful and compelling step to take.

The chapter starts with an account of some of Latour's ideas – such as actor-network theory, controversies and globalisation in a time of climate change – that we adopt when discussing mathematics education research. Then we concretise these ideas as analytical moves to explore a central controversy in mathematics education nowadays, namely the justification for school mathematics in the school curriculum. With an interest in mathematics education research around the globe, we made the decision to pay specific attention to a global phenomenon, which has had significant influence on mathematics education, namely the Organisation for Economic Co-operation and Development (OECD) Program for International Student Assessment (PISA) (Jablonka, 2016). Assessment in various forms clearly shapes what mathematics and mathematics education may be about (Boistrup, 2017) and in these international comparisons the political aspects of assessment also on a societal level are highlighted. Working with Latourian tools, we performed a limited empirical investigation of how mathematics education research texts from 2004 to 2020 establish relationships to PISA and which controversies are noticeable in the research. We conclude with some remarks about how Latourian tools offer us a different set of concepts and strategies to understand mathematics education research as an actant in sustaining particular possibilities and stories about practices in the field.

A new political look at mathematics education research

How many hours, if one were able to count them one by one or do a rough estimation, do the children of the world sit in a mathematics lesson? (Far too many?) And of that enormous number of hours, in how many did children follow, listen, and actually grasp a mathematical idea? (Far too few?) If far too much time is being spent with little result, such time for children and all those involved could be seen as a poor investment… any savvy capitalist mind would say. Wouldn't it be more productive or generate a better outcome to do something else instead? Doing exercise to improve health, mastering a practice, or serving the community could give a more profitable return. And still, all around the globe there seems to be a sustained political clamour to increase the allocated hours of mathematics in compulsory school curricula. The expected effects have the attention of a wide range of people, all hoping wishfully to score the jackpot of a mathematically talented child.

Few school subjects cause as much of a stir as mathematics, and few have so many contradictions. It suffices to look at local newspapers around the world every time there are new mathematics test results (e.g., Barwell & Abtahi, 2019; Lange, 2019). The question that emerges is: What sustains the ways of doing that generate this situation? 'The social' would be one answer. If we follow Latour's provocative challenge (Latour, 2005) to the social sciences, the use of the adjective 'social' to refer to the fuzzy 'something among people that makes things happen' is inaccurate, even not productive. Instead of assuming the existence of the 'social', he proposes to identify and trace the relationships that take place when things happen, and understand how those relations among people, artefacts, and other types of materialities, institutions, etc. are instances of performance and enactment and, at the same time, the moments that, repeated over time, sustain how we collectively do things and think about them. Furthermore, such relationships are not simple one-to-one exchanges or points of contact, but rather extended, changeable networks with more or less strong connections among a wide range of actants (Latour, 2005). 'Actants' is also a term that signals the attempt to not only focus on human actors, but also on the wide diversity of things that can mobilise agency. Networks are unstable, fragile arrays that depend on the multiple materialities that allow connections to become established within a fully local universality (Latour, 2011). And rather than an existing entity, the network can better

> designate a mode of inquiry that learns to list, at the occasion of a trial, the unexpected beings necessary for any entity to exist. A network, in this second meaning of the word, is more like what you record through a Geiger counter that clicks every time a new element, invisible before, has been made visible to the inquirer. (Latour, 2011, p. 799)

In other words, networks make visible the arrays in which things – human and non-human – emerge as significant and powerful. In this sense, Latour means that notions that were coined centuries ago to designate some kind of 'phantom' forces that steer or regulate people – such as 'nature, society, or power, notions that before were able to expand mysteriously everywhere at no cost' (Latour, 2011, p. 802) – can finally be pinned down to the localised configuration of relationships that constitute collective existence in all its manifestations.

With these ideas in mind, we can now refine our question into more specific inquiries. What relationships among actants (human and non-human) sustain the ways of doing in mathematics education, with its successes and failures? In particular, what relationships sustain the heightened focus on school mathematics, and the desire to politically steer it towards an expected benefit of individuals, communities, and nations? To explore the questions above, an empirical investigation that follows the actants and their relationships would be appropriate. There could also be many points of entry into the exploration. Latour (2005) suggests that the identification of a dispute, a controversy on what seems to be central for the whole arrangement of practice, can be a productive point of departure.

Controversies constitute important jolts from which the functioning and doing of science can be entered (Latour, 2005). While some views of scientific knowledge and practices would emphasise the production of facts and truth as the main result of the scientific endeavour, a relational form of inquiry makes it possible to reveal that results stand, not just because of their intrinsic veracity, but rather because there is a network of people, institutions, and materialities that sustain their production and their legitimacy as reliable discoveries or significant factual revelations. This, in no way, means that the results of science are simply 'social constructions' or fabrications of discourse without a real material existence. On the contrary, the point is rather that the formulation of scientific statements is the instantiation of different concrete scientific work, doings and crossings of the elements, human and non-human, that produce them. Their being is not in the fact, but in the network of relationships that supports the fact. Such production is full of discussions, ranging from the methods and artifacts used in the investigation to the support for findings and their dissemination in society. Suffice to say that the discussions that scale to serious controversies have to do with the fact that scientific results do not just stay as debates among academics – in scientific journals or conferences – but are part of larger connections that mobilise resources, influence, and even the belief in their rightness and adequacy. As knowledge and scientific practices are entangled in the broad network of actions and decisions in society in issues that are at stake for different actants, science is no longer a matter of finding true facts. As Latour argues, the doing of science and its result has become a matter of concern. And, as such, science – of any type – is not an external observer, nor a privileged vantage point to tell the world – but one of the many forces is in the midst of politics and of the effecting of power.

The controversies of science come close to all people, even in instances that do not seem so evidently clear. Scientific controversies of different types are at the core of democracy in times where governing is deeply enmeshed with, and steered through, expert knowledge. This is the characteristic that Michel Foucault had already pointed to concerning the entanglement of knowledge and power in modernity (Foucault & Faubion, 2000). Recent times have made this clear: Is it safe and preferable to be vaccinated for the COVID-19 virus? Which of the vaccinations is best and for whom? These have been quite large controversies of global reach during a massive scientific mobilisation following the outburst of a pandemic in the years 2020–2021.

Still, other minor controversies could be: Which type of assessment of students' mathematical learning is more desirable? Which one is fairer, or which can be more inclusive? This controversy has been discussed in terms of the configuration of an assessment dispositif, encompassing multiple associated discourses and practices (e.g., Boistrup, 2017). Apparently, some controversies are more 'important' than others, some more 'scientific' than others. However, in different times and scales and for different people, these issues come closer and can have different effects. In the terrain of mathematics education, controversies that have to do with knowledge and science constantly emerge and are negotiated. This is why one can consider the network of mathematics education as a field of cultural politics (Diaz, 2017; Valero, 2018) where constant issues of concern are under dispute to be defined. One of these issues is why school mathematics is important to keep as a central subject in the school curriculum – despite its many sustained failures. The controversy on the justifications for school mathematics does not only occupy researchers in mathematics education (e.g., Niss, 1996), but also concerns politicians, economists, educators, local authorities, and of course the very many children who enjoy/suffer it and ask: Why do we have to learn mathematics?

This controversy is pivotal for mathematics education research and the many stories about its purpose, objects, and methods discussed at the beginning of this chapter. The controversy lies at the heart of how the reasons for school mathematics are articulated – implicitly or explicitly – through the relationships among the multiple actants involved in directing mathematics education. With that also come the types of knowledge and research that are deemed valuable and useful to operate in the network. Different stories about mathematics education as a field of research link in particular ways to the clamour for more mathematically competent populations to secure a large enough workforce qualified in STEM. For example, a recurring assumption in the field is that the mathematical knowledge learned in the classroom can easily be transferred to other fields, such as technology and even everyday use. This assumption has theoretically and empirically been contested, addressing how transfer is a simplistic idea connected to particular views of knowledge and learning (e.g., Lave, 1988; Lobato, 2006). What takes place is rather the transformation (recontextualisation or transposition) of mathematics into other fields for it to be relevant, for instance into vocational contexts (FitzSimons & Boistrup, 2017) or, even in university, interdisciplinary contexts (Valero & Ravn, 2017). The point is that mathematics, when entering other fields and connecting to other knowledge-tools and practices, does not remain 'the same' as before, but is actively re-assembled with elements and overarching ideas of the new context (Boistrup & Hällback, 2022).

The narrative of the power of mathematics residing in its transferability – and direct usability – to almost all fields of knowledge, in turn, has been supported by an array of actants such as governments and changes in educational policy and school curricula. Also, by professional associations and economic interest groups demanding the production of a qualified workforce, and by international organisations, such as the United Nations Educational, Scientific, and Cultural Organization (UNESCO) and the OECD, providing quite concrete tools for action to make STEM education a clear element of modernisation (e.g., Zheng, 2019). In particular, the earlier Organisation for European Co-operation (OEEC), which in 1961 turned into the OECD, as part of the support of education for technological development and building of human capital (Rizvi & Lingard, 2009), has systematically sponsored both national school reforms in mathematics and the establishment of collaborative sites of meeting between practitioners in schools and people who started studying and developing mathematical pedagogy and curricula at teacher education or universities. The role of OECD in the boosting of mathematics education has been discussed in the case of various European countries (e.g., De Bock & Vanpaemel, 2019; Gispert, 2014).

The clearest example of this support was the realisation of the Royaumont Seminar in 1959 (OEEC, 1961), which is recognised as an important event, a point of controversy regarding the purpose of mathematics and mathematics education in the context of educational modernisation for economic reconstruction. Research on the history of mathematics education, particularly at the time of the New Math movement (Prytz, 2020) has documented and studied its impact in mathematics education. Historians of education have also contextualised the event as a point in the creation of the scientific modernisation of education, central to the medicalisation of educational research (e.g., Tröhler, 2015). While for mathematics education researchers the Royaumont Seminar initiated a controversy on the ideal views of mathematics that should inform a New Math curriculum, for a historian of education this is an important point of configuration of a 'technocratic culture characterized by confidence in experts rather than in practicing professionals' (Tröhler, 2014, p. 749). The network of connections around what should count for (mathematics) education allowed a 'particular organistic understanding of the social reality [to be] taken for granted and research [to be] conducted under the mostly undiscussed premises of this particular understanding' (p. 749). Within this configuration, mathematical competence has come to be perceived as a key factor in individual and national development (e.g., Tsamadias, 2013). Mathematics education is an area of the curriculum that can be used to monitor and govern differences among people and populations. Research in mathematics education is expected to produce the expert knowledge to improve schooling and to support the growing desire to make populations mathematically literate and competent, a central asset in the production of human capital (Valero, 2017).

At this point, the question emerges of the significance of these connections for recent mathematics education research and for the stories produced about the field. Tracing the networks of mathematics education is an investigation strategy in which we (e.g., Boistrup & FitzSimons, in press; Valero, 2017) and others (e.g., Andrade-Molina, 2021; Ziols & Kirchgasler, 2021) have previously engaged. With this strategy, we explore the controversy surrounding the justifications for mathematics education that emerge in research related to OECD's PISA, given its current salience in locating mathematics education at the centre of educational governing (Popkewitz, 2022).

Researching connections and controversies in mathematics education research

As we will illuminate, there have been a variety of positions over the years in the field of mathematics education research, as revealed when authors connect to international comparisons by OECD. Some have justified the relevance of mathematics through the existence of such international comparisons, while others have been more critical towards their presence and effects. Even when taking a critical perspective towards PISA (or the connected PIAAC, the Program for the International Assessment of Adult Competencies, a form of PISA adapted for adults aged sixteen to sixty-five), there are different positions adopted. For instance, it is possible to take a critical stance as to how PISA/PIAAC limits what mathematics might be conceived as. In Boistrup and FitzSimons (in press), this kind of critique is expanded, with inspiration from Latour's (2018) way of conceptualising globalisation. Boistrup and FitzSimons take Latour's two versions of globalisation, minus and plus, as a starting point for discussing globalisation in relation to matters concerning vocational mathematics education. The authors illuminate how PIAAC, particularly in the construction of survey questions for text takers, is a clear example of globalisation minus, in line with the following quote:

> The term is used to mean that a single vision, entirely provincial, proposed by a few individuals, representing a very small number of interests, limited to a few measuring instruments, to a few standards and protocols, has been imposed on everyone and spread everywhere. It is hardly surprising that we don't know whether to embrace globalization or, on the contrary, struggle against it. (Latour, 2018, pp. 12–13)

In the chapter, the authors discuss how the limitations of PISA/PIAAC have affected local contexts of the world, such as how mathematics vocational education in Australia has undergone a shift towards a restricted and limited view, far from acknowledging the complexities of mathematics in workplace contexts. Their conclusion is that even if the data from OECD's international assessments may be used to gain some interesting insights – which has been challenged by, for example, Anna Tsatsaroni and Jeff Evans (2014) and more recently by Chiara Giberti and Andrea Maffia (2020) – the negative political effects still outweigh any benefits of such international comparisons.

Alexandre Pais and Paola Valero (2014) in their commentary on a special issue on social theory and research in mathematics education also address PISA/PIAAC critically, when pointing out that it is not enough for a critical (or social, as they put it) approach to mathematics education to criticise the misuses to which both teachers and different policies put this school subject. They argue that mathematics itself 'has to be problematized by means of understanding its importance, not in itself – problem solving, utility, beauty, cultural possibilities, and so on

– but in terms of the place this subject occupies within a given societal arrangement' (p. 5).

Giberti and Maffia (2019) have, similarly to us, an interest in how OECD's PISA is used in mathematics education research, and they present a comprehensive literature review. They address the relevance of critical research into the effects of PISA: 'As a conclusion, we suggest that critical research into the effect of PISA can be developed further, especially in those countries that have joined the OECD survey in recent years' (p. 266). When reading further into the article, it becomes clear that what these authors mainly focus on is not the field in general vis-à-vis PISA, but how, de facto, the test and data from PISA are being used in research. Among their findings they present a list of topics, in order of occurrences in the articles analysed, where the PISA test and data were utilised for the purpose of analysis:

- comparative studies at national level;
- teacher education;
- comparative studies on tests;
- curriculum development;
- gender;
- affect and motivation;
- modelling;
- technology;
- equity;
- language;
- textbooks;
- lifelong education;
- other.

On the one hand, the authors address critical discussions of PISA, mainly when they refer to Clive Kanes, Candia Morgan and Anna Tsatsaroni (2014), and how technologies produced by the OECD can be understood as constituting the 'PISA mathematics regime'. On the other hand, Giberti and Maffia (2019) did not include the article by Kanes et al. when composing their identified list of topics, since these authors did not statistically analyse data from PISA. We infer that the kind of critical research into PISA that Giberti and Maffia call for would concern comparisons of, for example, gender differences in PISA outcomes. This means that our interest in this section of the chapter is quite different from the interest of the comprehensive study by Giberti and Maffia. We rather want to understand the field of mathematics education research by tracing how PISA has been discussed over the years in published mathematics education research, and what claims regarding mathematics and mathematics education have resulted from these discussions, in terms of connections and controversies between different human and non-human actants.

Tracing research controversies

The data used in this study are derived from a selection of published research where PISA has a central role. The selection started with a full text search of the word 'PISA' in the journal *Educational Studies in Mathematics* (*ESM*) up to, and including, the year 2020. *ESM* was chosen as one of the broadest international journals in the field of mathematics education. The result was 101 articles. Editorials and commentary texts were excluded. We then selected the articles with four or more mentions of PISA in the text, excluding the references. The criterion of four entries was chosen after examining a number of articles, which revealed that three or fewer entries appeared in articles where PISA was not addressed in a significant way. The result then was twelve full articles.

In a second stage, for each of the twelve articles, we selected the paragraphs where PISA is mentioned. We also added related paragraphs that explain the reasoning connected to paragraphs mentioning PISA. When pasting these paragraphs into one document, including titles and abstracts, the total data set consisted of almost 30000 words.

For each article we analysed the selected paragraphs, addressing the following analytical questions:

- How is PISA mentioned in the text? For instance, PISA results may be used to justify the relevance of a study.
- What claims in relation to PISA are possible to read from the text? For instance, PISA results can be regarded as telling the

truth about the quality of the teaching practices in mathematics in a country.

- What connections do the authors make between different actants involved? For example, the PISA tasks, governments, media, researchers.
- What controversies do the authors address between actants etc.? For instance, are there key tensions or disagreements, such as PISA being seen as embodying a good type of education, and traditional school mathematics as representing a bad type.

For all articles we identified connections and controversies among the twelve analysed articles, and between actants addressed in the articles. Following Latour, we have aimed to stay close to the data to avoid creating a presumed 'social'. Instead, we focus on how the authors address PISA, while tracing associations among statements.

Connections and controversies around PISA in ESM

We start by briefly presenting the twelve articles following a timeline of publication. This has the purpose of giving voice to each of the publications, while simultaneously providing the reader with some overview of the content of the analysed articles. We then articulate a network of connections and controversies identified in the data set, also addressing the roles of different actants, as construed in our analysis. We have chosen to do this in the form of a play, where the actants, human and non-human, are the characters in a play, displaying glimpses of connections and controversies.

Articles addressing PISA in ESM

The first article addressing PISA in *ESM* is by Uwe Gellert (2004), who critically reflected on the use of didactic material in mathematics classes. A PISA task is here presented as an example of non-inclusive tasks, which are best solved putting everyday knowledge aside (like how to share a pizza). A year later, Anna Sfard (2005) drew heavily on PISA when presenting the results of a Survey Team study at the International

Congress of Mathematics Education (ICME-10), on the relations between mathematics education research and practice. A significant claim is that the mathematics education research field has much to gain from adding quantitative analysis drawing on PISA to the more frequent qualitative studies. Four years later, César Sáenz (2009) presented an analysis of the difficulties Spanish student teachers have in solving the PISA 2003 released items. Sáenz adopted the PISA methodology, through the use of tasks, but also the conceptualisation of mathematical competence developed in the PISA framework, and its testing procedures.

Oduor Olande (2014) also drew on the PISA methodology when examining Nordic students' school performance on items containing graphical artefacts. This article by Olande is the first of several during 2014, in which PISA was addressed. The article by Paul Andrews, Andreas Ryve, Kirsti Hemmi, and Judy Sayers (2014) has its main focus on PISA in a critical analysis of the successful Finnish PISA results compared to an analysis of the authors' own interview and classroom data. The authors also base their argumentation on the fact that the Finnish results on another international comparison Trends in International Mathematics and Science Study (TIMSS) were rather mediocre. Throughout the article, the authors problematise the taken-for-granted view of the Finnish PISA results as a sign of the quality of the teaching.

In a special issue on social theory and research in mathematics education, two articles focus on OECD's international comparisons. Kanes et al. (2014) adopted theoretical tools from Basil Bernstein and Foucault to analyse the 'PISA regime', comprising both the knowledge structures produced by the regime but also the ways in which students, teachers and other agents may be produced as subjects. They propose critical research on how to better understand the forms and the mechanisms of PISA in different local contexts, rather than using the PISA shock in society and media for justification of research on how to enhance practice. Tsatsaroni and Evans (2014) also adopted a framework based on Bernstein and Foucault to study PIAAC, while also addressing PISA in their writing at some points. On the one hand, they argue that the version of mathematical competence in PIAAC is far from the complexities of mathematics in adult life, and that PIAAC/PISA require serious consideration and debate in mathematics education research with a focus on power relations. On the other hand, they advocate for the use of PISA/PIAAC data in further studies, for example related to demographic data. Ariyadi Wijaya, Marja van den Heuvel-Panhuizen, and Michiel Doorman (2015) adopt the PISA methodology when seeking the explanation in the national context (as reflected in textbooks) for the low Indonesian PISA result on context-based mathematics tasks.

The above studies are followed by three studies which all address gender differences vis-à-vis mathematics in PISA. A study by Zvia Markovits and Helen Forgasz (2017) draws on PISA results on gender differences in performances as part of the background of the study. The study is then carried out on different data. Yan Zhu, Gabriele Kaiser, and Jinfa Cai (2018) make use of PISA data to carry out a secondary analysis on the Chinese PISA 2015 data to examine gender equity in Chinese students' mathematical achievement. They focus on societal aspects at the individual level (e.g., students' socio-economic status) and systemic aspects. Trine Foyn, Yvette Solomon, and Hans Jørgen Braathe (2018) describe in the introduction how the Norwegian PISA results display no gender differences in mathematics performances, as opposed to results in other contexts. PISA then paves its way into the data set, in a focus group interview, where girls discuss a newspaper article about the PISA survey with the headline 'Norwegian Girls Have Maths Anxiety'. The girls in the study described the boys in the high ability group as more self-confident in mathematics.

The final article in our data is Merrilyn Goos and Sila Kaya (2020). They presented a comparative review of research on understanding and promoting students' mathematical thinking. They analyse papers from *ESM* during two periods: 1994–1998 and 2014–2018. Their review is guided by an analysis of conceptualisations of 'mathematical thinking' proposed in the research, wherein the PISA 2021 assessment framework is one part.

Actants and actors in play

When going through the twelve articles from *ESM* which address PISA, we noticed that the authors bring in different actants (Latour, 2005). Some of these lean more towards what Latour labels non-human, for example the PISA tasks, PISA framework, education systems, and media, while others are human, in the sense of different kinds of actors, such as researchers, politicians, teachers, leaders, and students.

We organise the account around the main groups of actants in the data for which there are connections and controversies vis-à-vis other actants. We now also start to introduce the play; for each actant, we also provide a description in the form of its role as a character in a theatrical play. The play is subsequently presented, reflected through a selection of scenes.

Actants – Actors	**Characters in the play**
PISA methodology refers to the overall framework of PISA, where mathematical competence is described. We also refer to test items that are made public, and hence possible for researchers to use in research. In the PISA methodology we include the data from PISA, which is possible, when permission is given, to use for reanalysis. In different ways, the PISA methodology is present in almost all of the twelve articles.	*PISA methodology*, with test items and assessment procedures, sometimes acts as a ghost affecting others while not showing itself. Sometimes it plays openly, declaring its concerns about essential mathematical content for students' adult life, or the desire for testing etc. It aims at becoming bigger and stronger.
PISA results refer to the results of the tests and questionnaires which are made public by the PISA administration. Most of the articles address PISA results, but in different ways.	*PISA result* is a character with a strong voice, almost yelling its important message around the world.
(*School*) *Mathematics* is present in about half of the articles when addressing how PISA connects to claims about what mathematics (e.g., school mathematics) is or should be.	*Mathematics* has different appearances, mainly as part of the stage design, with different versions of mathematics outlined in writing on screens. In certain scenes it is in the spotlight, other times it is backgrounded. This main character takes many shapes, similar but also very different.

Education systems refer to the diversity of state organised education systems in the PISA participating countries. Those systems are presented as being often quite stable over time, which is addressed in connection to PISA in around a third of the articles.	*Education system* is a powerful character, who moves and changes very slowly. It has much impact on many of the other characters. It fears PISA results.
Media (e.g., newspapers) is a significant actant in relation to PISA in about a third of the articles, often in the background, where the societal effects of PISA are described.	*The media* shouts out messages as a speaker for a variety of characters when it presents PISA results. Simultaneously this actor has a will of its own as it chooses what to shout out to the world, and what to keep quiet about. This character is driven by a wish to be seen and heard, even at the expense of creating a real stir in society.
Governments with politicians are addressed in a couple of articles as those steering education through policy in relation to PISA.	*Government with politicians* is a powerful character, representing a broad range of governments of the world. It is in charge of some of the other characters, such as the education system, leaders and teachers. Simultaneously, the government is afraid of PISA results. It is similar to education systems and belongs to the same family.
The practices of teaching and learning mathematics with leaders, teachers, and students. The articles address and connect to this group of actants in different ways. For example, the practice of teaching mathematics in a country may be connected to its PISA results.	*Leaders, teachers, and students* who practice and learn mathematics is a group of characters that communicate mainly among themselves. However, many other groups like to talk about this group.

Researchers and research fields. Researchers individually and as part of a field of research are actants. Through their writing they connect to each other and to other actants in different ways, representing a variety of research fields.

Powerful researcher speaks from a privileged powerful position, both acting and speaking on behalf of a significant research organisation, but also for arguing for what is necessary in a broad research field. This character speaks for a group of researchers that trusts PISA and mainly sees the benefits of PISA for mathematics and mathematics education.

Critical researcher represents a group of researchers who rather sees the PISA characters as threats to many of the characters in the play, including themselves.

Trusting researcher represents a group of researchers who wants to be friends with the PISA methodology and the PISA results, or at least tries to avoid acting in opposition to these characters. This character is a follower of the powerful researcher.

The chorus comments on the events on the stage, both foreseeing what will come and commenting on what has happened.

‘Tell us the truth, oh PISA, and we will follow’

Scene 0

The chorus (chanting as a remote incessant whisper, far away in the distance, not visible on stage):

Where is the truth to follow?

Where is the truth to follow?

Tell us the truth and we will follow.

Scene 1: The everyday and mathematics

Critical researcher: Look everybody! (pointing at different local contexts). Look at our world. Is it not quite remarkable, in all its complexities?

Government: Yes, maybe. But what has that to do with my people?

Education system: What does it have to do with my mathematics?

PISA methodology: Well, I think that this is really relevant. Look at our PISA tests. We have, finally, managed to grasp and measure young people's competence to do something with knowledge. That is what PISA testing is about, to test mathematics in use.

Mathematics: I have been for so long lost in the world of ideas, so hidden in the mind. But now (looking thankfully at PISA methodology) I get a true body: me in this complex world of everyday life. Me in use.

Trusting researcher: Wow! So great, so beautiful. PISA tests are created for the good of mathematics in everyday life, by powerful people. Hurray!

Critical researcher: But, hey, look at the test items, they are not about everyday life. If we really look at what they are about, they do not reflect everyday lives of real people.

Trusting researcher (not looking at the critical researcher, but in awe at PISA methodology): In my research I can rely on PISA. I will take the PISA items as authentic. Then I can trust that my research gets to have good quality.

The chorus (chanting, getting a little bit closer):

Tell us the truth and we will follow.

Tell us the truth about mathematics in everyday life.

Tell us the truth and we will follow.

[Scenes 2–4 omitted]

Scene 5: The quality of mathematics education research

(On a high pedestal, *PISA methodology* and *PISA result* stand holding one hand and lifting the other victoriously.)

Powerful researcher (Enters the scene. Walks slowly, with a straight back, to an elevated position on the stage. Turns to all present researchers): Hear what I have to say. The research in mathematics education needs to do better, and for that, we should learn from PISA. We cannot continue with all these small qualitative studies. Instead, we need more data, solid data, consistent data, laaaarge DATA.

The chorus (chanting, same distance as previously):

Tell us the truth and we will follow.

Tell us the truth about the need for more PISA data.

Tell us the truth and we will follow.

Critical researcher: But, hey, wait. First, we need to establish if the data is of good quality. What claims can we make if the PISA test does not bring out relevant data? Please let us not be hasty here. Actually, my colleagues…

Trusting researcher (interrupting the critical researcher): We should trust PISA! This is what I mean (looks at the powerful researcher)! I can use the data that PISA produces (looks at PISA methodology in awe), and by that do quantitative analyses, and then produce research that is counted as solid, good quality, secure research.

Government (turning to other governments, PISA methodology, and also teachers): Look, look, look. We… some of us are doing good. *We* (with emphasis in the voice and turning its back to some governments) are improving mathematics education and researchers are making good use of the PISA data.

PISA methodology (looking at all others): This is what we told you. This is what we wanted. Now more studies based on PISA can spread around the world, advocating for the one and only version of mathematical competence, the one that really matters for all around the world. Now we can really count!

The chorus (chanting, a little bit closer):

Tell us the truth and we will follow.

Tell us the truth about how PISA will save us.

Tell us the truth and we will follow.

[More scenes omitted]

Scene *n*: Effects of the debate around PISA

(*PISA result* whispers to *The media*.)

The media (runs frenetically around the stage, holding *PISA result* by the hand, shouting): I have news, great news: Now we know who the winners and losers are, in the competition game of mathematics! Breaking news, listen to me!

Governments together: Tell us! Tell us! Was my country successful? Are my people good? Did we win? Are we better in mathematics now?

The media (pointing at different governments): You are a winner; you are a loser; you are better than last time; you are worse than last time. You are just OK; you should try harder. And you… you have no hope.

Government A (looking at *Teacher A*): Look at the results from PISA! You need to be better, so our country will get a better result next time the PISA competition runs, sorry, I mean comparison, not competition.

Government B: And I mean that it is important that the students in our country learn better mathematics. Anyway, it is your responsibility (pointing at a teacher)! And yours (pointing at school leader), and especially yours (pointing at *Student B*). Anyway, you all go and FIX IT!

Mathematics (placed behind *Teacher A* with both hands on her shoulders): How difficult can I be? Me in use, me for competition, me for a better world. Just fix it!

Teacher A (looking down): I am doing my best… (puts an arm around *Student A*'s shoulders)

(*Student A* looks up at *Teacher A* and sighs.)

Trusting researcher (to other researchers): Have you thought about all the fuss that PISA creates in media. Should we not address this?

Critical researcher: Yes, I agree. PISA actually restricts how we view mathematics and the PISA shock that spreads around the world is not really relevant. Instead, we should problematise the effects of PI…

Powerful researcher (interrupting critical researcher): Well, well, well my little friend… We acknowledge the sometimes-non-beneficial attention PISA gets in media. But we should rather celebrate the large attention and interest in mathematical matters. It is not only we, researchers in mathematics education, who care about this important subject area of mathematics, it is everybody. We are thriving well! (Takes PISA methodology and mathematics by the hand, smiles and looks around.)

Trusting researcher: Yes, you are right. And look at all the data that is there free to use. I will tell my colleagues that this is the way forward to a good career and good research, to make all our dreams come true.

The chorus (entering the stage):

Tell us the truth that we can follow.

PISA tells us the truth and we will follow.

PISA tells us the truth and we will trustfully (4/5 of the choir sings) follow.

PISA tells us the truth and we will critically (1/5 of the choir sings) follow.

Stories of power of/in a research field of controversy

What constitutes mathematics education, as a domain of research, is a question to which one can respond in many ways, through different stories about the people, the practices, the materialities, and institutions that support ideas and the concrete everyday activities of the many actants involved. Even though it is not so controversial anymore to state that such stories are political – in the sense that they carry with them particular directions about the whole series of elements and connections that form part of the field, and also in the sense that such stories agentively effect and bring to life the very same relationships, objects, and phenomena that they study – there is still a discussion, almost a kind of controversy, in mathematics education research about how to think and how far to go when conceiving of the network of mathematics education as political. Such controversy revolves around a very core issue, namely what counts as mathematics for the education of people and what justifies its prominence in contemporary, state-governed school curricula.

Many of the stories about the field that we mentioned at the beginning of this paper have more or less explicit positions about how political the field is, and why. Concomitantly, each of these stories articulates a position on the question above. The answers to this question have broadened since the publication of the ICMI volume *Mathematics Education as a Research Domain: A Search for Identity* (Sierpinska & Kilpatrick, 1998). Eva Jablonka et al. (2013) included more sites and practices to count as part of mathematics education research, including the study of 'the social, economic, and political conditions and consequences of those practices' (p. 43). As a result of an overview of the growth around the turn of the twentieth century of theories to study the social, cultural, and political dimensions of mathematics education, the authors concluded that:

> From our interrogation we see signs of a shift away from cognitive psychology and evidence of critical questioning, of the creation of new ideas, and new ways of doing things, as well as a tolerance for multiplicity. All of these observations will contribute to the development of a body of professional knowledge in our discipline, informed by theory rather than driven by policy. We believe the international research community holds the reins of exciting potential for further development of leading edge knowledge in mathematics education. (p. 62)

The impulse that Jablonka et al. identify towards multiplicity of identities – or different competing stories, sometimes in controversy – can be supported nowadays. Indeed, our attempt to tease these stories of the field from a Latour-inspired perspective brought us to focus on the distributed network of relationships within which mathematics education unfolds. The question of what counts as mathematics for education and how it is justified can be then addressed tracing the connections between a variety of actants and figuring out what comes to be stated as stories and what becomes disputed, in other words, which controversies emerge in such a network.

While many of the stories of mathematics education as a field of research tend to delimit the network of actants that define it narrowly around the people and materialities more directly linked with teaching and learning in classrooms, a Latourian move brings us to open up the network in search of other significant actants in the network. In previous research, we have argued that the striving to understand the conditions and consequences of mathematics education practices brings us outside of the comfortable space of didactical and pedagogical relationships to locate research in the field of cultural politics, including the governing dispositives of our time (e.g., Boistrup, 2017; Valero, 2018). The entanglement of mathematics education and the striving for economic growth is to be traced in the close ties between economic agendas, the increasing governing of school mathematics education, curricular reforms across and within countries, and the very same research stories that the field produces.

In our empirical investigation we set out to explore the controversies present in published research as we examined how researchers have related to OECD's PISA program. Since its launch in 2000, PISA and its series of materials, functioning, and institutions has become an authoritative voice in the governing of mathematics education. Thus, its connections to research in mathematics education would show important aspects of the stories about the field at this moment. When going through the twelve articles from *ESM* published between 2004 and 2020, which address PISA, we could distinguish an assemblage in which the authors bring in different actants. Some of these lean more towards what Latour (2005) label non-human – the PISA tasks, PISA framework, education systems, and media – while others are human actors such as researchers, politicians, teachers, leaders, and students. As it was shown above, these actants, non-human and human, have different kind of roles in the assemblage and in the controversies.

In our tracing of a network of mathematics education, we focused on controversies within the twelve articles, which allowed us to create a play that intends to make explicit some of the actants and relationships present in the examined research text. In relation to the question of what counts as mathematics for education and what justifies its prominence in the curricula of education systems, the play grasps different controversies in mathematics education, where some researchers take on a critical perspective vis-à-vis international comparisons such as PISA, while other researchers – a larger number – adopt PISA as a truth teller, embracing the important role of mathematics that PISA advocates for. One controversy is about PISA items in relation to the real world. While critical researchers (henceforth, CR) address how the test items neither reflect any contextual reality in a relevant sense, nor any cultural, local aspects, more trusting researchers (henceforth, TR) take the PISA framework for granted and accept PISA's claims of testing mathematics in everyday life.

Another controversy in the analysed texts revolves around the opportunities of quantitative studies adopting PISA methodology with respect to the diversified trend of smaller, qualitative studies. Following TR, PISA as a source for research should be embraced, since mathematics education practices are in need of improvement. CR, on the other hand, question the 'PISA regime' and its effect on the research field. Yet another controversy concerns the relationships between PISA, teachers, and the media, and whether teachers are to be blamed or not for PISA results. CR call for a mathematics education field which 'feels for' the teacher, while TR use the PISA results to evaluate teachers' work. Included in this controversy is whether to trust and build on (or not) connections between teachers' subject knowledge and teaching effectiveness as measured by PISA, or between PISA results and the state of teaching practices in a country. The controversy around mathematics is also present as PISA-defined mathematical knowledge appears as 'good' and desirable, and traditional school mathematics as 'bad' and in need of change. Following TR, PISA gets the role of telling the truth about what school mathematics should be. CR questions this and advocates for PISA as a threat to a view of mathematics as a plurality of mathematical practices incorporating cultural and contextual aspects.

Finally, a larger controversy that becomes evident in the analysis and as a result of the whole paper is the ties between mathematics education and capitalism. The push for mathematical qualifications to be central for the economic growth and development of the individual, communities, and nations has become a central point of controversy around what counts as mathematics education and why it is important, and OECD's PISA has become a clear actant here. Several recent studies have paid attention to this issue and have drawn pointed to the benefits and dangers of the link between mathematics education and growing capitalism—and its associated, brutal in(ex)clusions. For example, Mark Wolfmeyer, in Chapter 16 of this volume, examines the 'assessment spread' connected to TIMSS and its related technologies and institutions and shows the connections that sustain a global view for generating a consumerist trained human capital through mathematics. The clear emphasis on a critique of mathematics education (research) to serve particular economic organisations is a way of exploring how power is effected within the networks that constitute mathematics education practices. Our Latourian exploration binds us in connection to the larger network that constitutes the narratives of our field, which we cannot ignore.

References

Andrade-Molina, M. (2021). Narratives of success: Enabling all students to excel in the global world. *Research in Mathematics Education*, *23*(3), 293–305. https://doi.org/10.1080/14794802.2021.1994453

Andrews, P., Ryve, A., Hemmi, K., & Sayers, J. (2014). PISA, TIMSS and Finnish mathematics teaching: An enigma in search of an explanation. *Educational Studies in Mathematics*, *87*(1), 7–26. https://doi.org/10.1007/s10649-014-9545-3

Artigue, M., & Winsløw, C. (2010). International comparative studies on mathematics education: A viewpoint from the Anthropological Theory of Didactics. *Récherches en Didactiques des Mathématiques*, *30*(1), 48–82. https://revue-rdm.com/2010/international-comparative-studies

Barwell, R., & Abtahi, Y. (2019). Mathematics education in the news: Introduction. *Canadian Journal of Science, Mathematics and Technology Education*, *19*(1), 1–7. https://doi.org/10.1007/s42330-019-00043-z

Boistrup, L. B. (2017). Assessment in mathematics education: A gatekeeping dispositive. In H. Straehler-Pohl, N. Bohlmann, & A. Pais (Eds.), *The disorder of mathematics education: Challenging the socio-political dimensions of research* (pp. 209–230). Springer. https://doi.org/10.1007/978-3-319-34006-7_13

Boistrup, L. B., & FitzSimons, G. E. (in press). Vocational mathematics and competence: Effects of and resistance to globalization. In A. Chronaki & A. Yolcu (Eds.), *Troubling notions of global citizenship and diversity in mathematics education*. Routledge.

Boistrup, L. B., & Hällback, M. (2022). Designing and researching vocational mathematics education. In L. B. Boistrup & S. Selander (Eds.), *Designs for research, teaching and learning: A framework for future education* (pp. 61–81). Routledge. https://doi.org/10.4324/9781003096498

Cantoral, R. (2020). Socioepistemology in mathematics education. In S. Lerman (Ed.), *Encyclopedia of Mathematics Education* (pp. 790–797). Springer. https://doi.org/10.1007/978-3-319-77487-9_126-4

De Bock, D., & Vanpaemel, G. (2019). *Rods, sets and arrows: The rise and fall of Modern Mathematics in Belgium*. Springer. https://doi.org/10.1007/978-3-030-20599-7

De Freitas, E. (2016). Bruno Latour. In E. de Freitas & M. Walshaw (Eds.), *Alternative theoretical frameworks for mathematics education research: Theory meets data* (pp. 121–148). Springer. https://doi.org/10.1007/978-3-319-33961-0_1

Diaz, J. D. (2017). *A cultural history of reforming math for all: The paradox of making in/equality*. Routledge.

Elam, M., Solli, A., & Mäkitalo, Å. (2019). Socioscientific issues via controversy mapping: bringing actor-network theory into the science classroom with digital technology. *Discourse: Studies in the Cultural Politics of Education*, *40*(1), 61–77. https://doi.org/10.1080/01596306.2018.1549704

Foucault, M., & Faubion, J. D. (2000). *Power*. New Press.

Foyn, T., Solomon, Y., & Braathe, H. J. (2018). Clever girls' stories: The girl they call a nerd. *Educational Studies in Mathematics*, *98*(1), 77–93. https://doi.org/10.1007/s10649-017-9801-4

Gellert, U. (2004). Didactic material confronted with the concept of mathematical literacy. *Educational Studies in Mathematics*, *55*(1), 163–179. https://doi.org/10.1023/B:EDUC.0000017693.32454.01

Giberti, C., & Maffia, A. (2020). Mathematics educators are speaking about PISA, aren't they? *Teaching Mathematics and its Applications*, *39*(4), 266–280. https://doi.org/10.1093/teamat/hrz018

Gispert, H. (2014). Applications: Les mathématiques comme discipline de service dans les années 1950–1960. In D. Coray, F. Furinghetti, H. Gispert,

B. Hodgson, & G. Schubring (Eds.), *One hundred years of L'Enseignement Mathématique: Moments of mathematics education in the twentieth century* (pp. 251–270). L'Enseignement Mathématique.

Godino, J. D., Batanero, M. d. C., & Font, V. (2019). The onto-semiotic approach: Implications for the prescriptive character of didactics. *For the Learning of Mathematics*, *39*(1), 38–43.

Goos, M., & Kaya, S. (2020). Understanding and promoting students' mathematical thinking: A review of research published in *ESM*. *Educational Studies in Mathematics*, *103*(1), 7–25. https://doi.org/10.1007/s10649-019-09921-7

Inglis, M., & Foster, C. (2018). Five decades of mathematics education research. *Journal for Research in Mathematics Education*, *49*(4), 462–500. https://doi.org/10.5951/jresematheduc.49.4.0462

Jablonka, E. (2016). Mathematics education as a matter of achievement. In M. A. Peters (Ed.), *Encyclopedia of Educational Philosophy and Theory*. Springer. https://doi.org/10.1007/978-981-287-532-7_521-1

Jablonka, E., Wagner, D., & Walshaw, M. (2013). Theories for studying social, political and cultural dimensions of mathematics education. In M. A. Clements, A. J. Bishop, C. Keitel, J. Kilpatrick, & F. K. S. Leung (Eds.), *Third International Handbook of Mathematics Education* (pp. 41–67). Springer. https://doi.org/10.1007/978-1-4614-4684-2_2

Kanes, C., Morgan, C., & Tsatsaroni, A. (2014). The PISA mathematics regime: Knowledge structures and practices of the self. *Educational Studies in Mathematics*, *87*(2), 145–165. https://doi.org/10.1007/s10649-014-9542-6

Kwak, D.-J., & Park, E. J. (2021). Mediating process for human agency in science education: For man's new relation to nature in Latour's ontology of politics. *Educational Philosophy and Theory*, *53*(4), 407–418. https://doi.org/10.1080/00131857.2020.1838273

Lange, T. (2019). Unpacking the emperor's new policies: How more mathematics in early childhood will save Norway. *Canadian Journal of Science, Mathematics and Technology Education*, *19*(1), 8–20. https://doi.org/10.1007/s42330-019-00041-1

Latour, B. (1999). *Pandora's hope: Essays on the reality of science studies*. Harvard University Press.

Latour, B. (2005). *Reassembling the social: An introduction to actor-network-theory*. Oxford University Press.

Latour, B. (2011). Networks, societies, spheres: Reflections of an actor-network theorist. *International Journal of Communication*, *5*, 796–810.

Latour, B. (2018). *Down to earth: Politics in the new climatic regime*. Polity.

Lave, J. (1988). *Cognition in practice: Mind, mathematics, and culture in everyday life*. Cambridge University Press.

Lobato, J. (2006). Alternative perspectives on the transfer of learning: History, issues, and challenges for future research. *Journal of the Learning Sciences*, *15*(4), 431–449. https://doi.org/10.1207/s15327809jls1504_1

Markovits, Z., & Forgasz, H. (2017). 'Mathematics is like a lion': Elementary students' beliefs about mathematics. *Educational Studies in Mathematics*, *96*(1), 49–64. https://doi.org/10.1007/s10649-017-9759-2

Niss, M. (1996). Goals of mathematics teaching. In A. J. Bishop, K. Clements, C. Keitel, J. Kilpatrick, & C. Laborde (Eds.), *International handbook of mathematics education* (pp. 11–47). Kluwer. https://doi.org/10.1007/978-94-009-1465-0

Niss, M. (2019). The very multi-faceted nature of mathematics education research. *For the Learning of Mathematics*, *39*(2), 2–7.

OEEC. (1961). *New thinking in school mathematics*. OEEC.

Olande, O. (2014). Graphical artefacts: Taxonomy of students' response to test items. *Educational Studies in Mathematics*, *85*(1), 53–74. https://doi.org/10.1007/s10649-013-9493-3

Pais, A., & Valero, P. (2014). Whither social theory? *Educational Studies in Mathematics*, *87*(2), 241–248. https://doi.org/10.1007/s10649-014-9573-z

Popkewitz, T. S. (2022). International assessments as the comparative desires and the distributions of differences: Infrastructures and coloniality. *Discourse: Studies in the Cultural Politics of Education*, 1–23. https://doi.org/10.1080/01596306.2021.2023259

Prytz, J. (2020). The OECD as a booster of national school governance. The case of New Math in Sweden, 1950–1975. *Foro de Educación*, *18*(2), 109–126. https://doi.org/10.14516/fde.824

Rizvi, F., & Lingard, B. (2009). The OECD and global shifts in education policy. In R. Cowen & A. M. Kazamias (Eds.), *International handbook of comparative education* (pp. 437–453). Springer. https://doi.org/10.1007/978-1-4020-6403-6_28

Sfard, A. (2005). What could be more practical than good research? *Educational Studies in Mathematics*, *58*(3), 393–413. https://doi.org/10.1007/s10649-005-4818-5

Sierpinska, A., & Kilpatrick, J. (1998). *Mathematics education as a research domain: A search for identity*. Kluwer.

Sáenz, C. (2009). The role of contextual, conceptual and procedural knowledge in activating mathematical competencies (PISA). *Educational Studies in Mathematics*, *71*(2), 123–143. https://doi.org/10.1007/s10649-008-9167-8

Tröhler, D. (2015). The medicalization of current educational research and its effects on education policy and school reforms. *Discourse: Studies in the Cultural Politics of Education*, *36*(5), 749–764. https://doi.org/10.1080/01596306.2014.942957

Tsamadias, C. (2013). The mathematical capital and its economic value. In E. G. Carayannis & G. M. Korres (Eds.), *European socio-economic integration* (pp. 43–50). Springer. https://doi.org/10.1007/978-1-4614-5254-6_3

Tsatsaroni, A., & Evans, J. (2014). Adult numeracy and the totally pedagogised society: PIAAC and other international surveys in the context of global educational policy on lifelong learning. *Educational Studies in Mathematics*, *87*(2), 167–186. https://doi.org/10.1007/s10649-013-9470-x

Valero, P. (2017). Mathematics for all, economic growth, and the making of the citizen-worker. In T. S. Popkewitz, J. Diaz, & C. Kirchgasler (Eds.), *A political sociology of educational knowledge: Studies of exclusions and difference* (pp. 117–132). Routledge. https://doi.org/10.4324/9781315528533-8

Valero, P. (2018). Human capitals: School mathematics and the making of the homus oeconomicus. *Journal of Urban Mathematics Education*, *11*(1&2), 103–117. https://doi.org/10.21423/jume-v11i1-2a363

Valero, P. (2019). Mathematics education in the 'New Climatic Regime'. In L. Harbison & A. Twohill (Eds.), *Proceedings of the Seventh Conference on Research in Mathematics Education in Ireland* (pp. 7–13). Dublin City University.

Valero, P., & Ravn, O. (2017). Recontextualizaciones y ensamblajes: ABP y matemáticas universitarias [Recontextualizations and assemblages: PBL and university mathematics]. *Didacticae*, *1*(1), 4–25. https://doi.org/10.1344/did.2017.1.4-25

Wijaya, A., van den Heuvel-Panhuizen, M., & Doorman, M. (2015). Opportunity-to-learn context-based tasks provided by mathematics textbooks. *Educational Studies in Mathematics*, *89*(1), 41–65. https://doi.org/10.1007/s10649-015-9595-1

Zheng, L. (2019). A performative history of STEM crisis discourse: The co-constitution of crisis sensibility and systems analysis around 1970. *Discourse: Studies in the Cultural Politics of Education*, *42*(3), 337–352. https://doi.org/10.1080/01596306.2019.1637332

Zhu, Y., Kaiser, G., & Cai, J. (2018). Gender equity in mathematical achievement: The case of China. *Educational Studies in Mathematics*, *99*(3), 245–260. https://doi.org/10.1007/s10649-018-9846-z

Ziols, R., & Kirchgasler, K. L. (2021). Health and pathology: A brief history of the biopolitics of US mathematics education. *Educational Studies in Mathematics*, *108*(1), 123–142. https://doi.org/10.1007/s10649-021-10110-8