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Strong objectivity and mathematical knowledge production

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1. Introduction

Mathematics is traditionally viewed as a “secure, fixed, and objective” discipline (Greene et al., 2016, p.147), consistent with an absolutist epistemological belief that mathematical knowledge is universal, value-free, and independent of social or cultural influences. However, alternative perspectives challenge this notion by emphasizing the socially constructed, fallible, and context-dependent nature of mathematics (Greene et al., 2016). These competing epistemological positions reflect broader debates about objectivity in science, particularly as addressed in feminist theory and Science and Technology Studies (STS).

This epistemic tension is mirrored in longstanding discussions in mathematical logic and philosophy of mathematics. While the formalist and Platonist traditions aim to preserve mathematics as a timeless and universal enterprise, constructivist and fallibilist approaches argue that mathematical knowledge is deeply shaped by human activity, language, and historical context. From this standpoint, mathematics is not immune to the same social forces that shape other fields of knowledge (Heintz, 2000).

Such a view aligns with Donna Haraway’s (1988) concept of “situated knowledges”, which contests the ideal of a neutral, disembodied knower. Haraway argues that objectivity must be redefined to incorporate an awareness of positionality and the partiality of all knowledge claims. In this light, even mathematics, often portrayed as the epitome of detached rationality, must be examined through a lens that recognizes its embeddedness in specific social, cultural, and historical contexts. Feminist objectivity, therefore, does not reject rigor but reimagines it through accountability and transparency (Harding, 1996).

This framework resonates with the construction of sex and gender, a central theme in my study, drawing on the work of Judith Butler (1988) and Sandra Harding (1996). Both scholars illuminate how scientific practices are implicated in reinforcing normative binaries, and how the production of knowledge, including mathematical knowledge, can be exclusionary. In STS, feminist and decolonial critiques have been vital in challenging dominant narratives about who can produce knowledge, under what conditions, and with what authority.

Within this theoretical framing, my research engages with feminist and decolonial perspectives on knowledge production in mathematics. Specifically, I am interested in how epistemological beliefs, whether absolutist or fallibilist, shape the everyday practices, experiences, and identities of PhD students in mathematics in Vienna, Austria. I examine how these beliefs affect students’ perceptions of objectivity and legitimacy within mathematics, and how such perceptions intersect with broader issues of gender, authority, and belonging.

Ultimately, my research seeks to explore how different epistemologies influence the ways mathematical knowledge is produced and validated, and how these frameworks impact the inclusivity, or exclusivity, of the field. By situating mathematics within broader debates about knowledge production, I aim to

contribute to a more reflexive and equitable understanding of the discipline, particularly for women*[1] and other marginalized groups in Science, Technology, Engineering, Mathematics (STEM) subjects.
In doing so, I also interrogate the enduring cultural myth of the male mathematical "genius", often imagined as a young, isolated prodigy whose insights emerge from innate brilliance rather than collaboration or hard work (Keller, 1995). This myth not only obscures the collaborative and iterative nature of mathematical practice but also reinforces gendered and racialized exclusions. It perpetuates the idea that mathematics is only accessible to those who embody this narrow archetype, discouraging participation from those who do not fit the mold.
Mathematics also presents unique challenges for empirical study. Its abstract nature, formal language, and internal logic can obscure the social processes that shape its production. Its resistance to direct observation, reliance on symbolic reasoning, and emphasis on proof over experimentation make its practices less accessible to traditional empirical methods. Investigating the lived experiences of those within the field, particularly doctoral researchers, can help uncover how knowledge is constructed, negotiated, and authorized in practice.
In this thesis, I address the following research questions:
RQ1: *How do different kinds of mathematical knowledge and epistemological beliefs shape the situatedness of PhD students in mathematics and their objectivity within the field?*
RQ2: *How is mathematical knowledge defined and validated within academic institutions in Vienna, and who holds the epistemic authority in these processes?*
In approaching these questions, I am attentive to the ways in which terms like *gender* and *sex* are mobilized differently in academic discourse and empirical contexts. Throughout the thesis, I distinguish between these terms depending on the context: *sex* is used when referring to biological classifications as they appear in scientific discourse, while *gender* is employed to discuss identity, roles, and social constructs.[2] This distinction is particularly relevant when considering how individuals are positioned within mathematical spaces and how norms around gender and sex influence perceptions of competence, objectivity, and belonging.

Overview of the thesis

The remainder of this thesis is structured as follows. I begin with a literature review that outlines the state of the art in mathematical knowledge production, epistemological frameworks, and critiques of objectivity. This includes an exploration of key feminist and decolonial contributions to STS and

[1] In this context, I use the term 'women*' to refer to people who have been socialized as women, including individuals of various gender identities. This usage aligns with the German term *FLINTA* (Frauen, Lesben, intergeschlechtliche, nicht-binäre, trans und agender Personen), which encompasses women, lesbians, intersex, non-binary, trans, and agender individuals. While the term seeks to be as inclusive as possible, I acknowledge that such categorizations may not fully reflect the complexity and diversity of lived experiences and identities.
[2] I am aware that scholars such as Judith Butler (1988) critique the binary distinction between sex and gender. However, for the purposes of this thesis, I have chosen to adopt this distinction for clarity and consistency.

mathematics education and academia. Following this, I synthesize the main concepts and theories. I then present the research questions in greater depth and outline the methodological approach of the study. This includes a discussion of the semi-structured interview format, coding strategies, and the interpretative framework applied in the analysis.

The subsequent chapters present the empirical findings, organized around core themes that emerged from the data. These findings are then discussed in relation to the theoretical framework, highlighting how participants negotiate epistemological beliefs, disciplinary norms, and identity. In the final chapter, I offer a concluding analysis, reflect on the limitations of the study, and suggest avenues for future research.

2. State of the Art

In order to situate this study within existing scholarship, this chapter provides an overview of the literature on mathematical knowledge production and its broader implications. I begin by examining the concept of objectivity and abstraction, situating these debates within both mathematical and social science perspectives. This is followed by a discussion of different epistemological approaches to mathematics, including philosophy of mathematics, mathematical logic, and the social construction of formal systems. The chapter then turns to questions of diversity and visibilities in research, with particular attention to peer review and evaluation practices. I conclude by addressing feminist perspectives on epistemologies and situatedness, and by reflecting on the methodological limitations of existing studies of mathematics.

The background of this structures lies in the fact that mathematics is intertwined with philosophical inquiries, particularly regarding epistemology, ontology, and the nature of abstraction (Haraway, 1988; Heintz, 2000, 2007). Thus, the exploration of objectivity in mathematics lays open to view not only its conceptual complexity but also its entanglement with broader debates in philosophy of science and STS. Foundational discussions concerning the nature of numbers, mathematical truth, and epistemic authority have long been central to both mathematical and philosophical discourse, highlighting the constructed and historically contingent aspects of objectivity (Greene et al., 2016). Mathematics as an academic discipline is often broadly categorized into applied mathematics, pure mathematics, and logic (Gowers, 2002). This tripartite structure is reflected in institutional frameworks and, in some cases, academic curricula. For instance, the University of Vienna organizes its master's program in mathematics around categories such as "Algebra, number theory, and discrete mathematics" and "Analysis" (both generally classified as pure mathematics), "Applied mathematics and scientific computing," and "Mathematical logic and theoretical computer science" (Universität Wien, 2025). While the program includes additional research groups and subcategories, this structure illustrates the typical disciplinary divisions within mathematics. Pedagogical components and instructional design, though also significant, are not the focus of this thesis and will therefore not be addressed in detail. While logic has traditionally explored foundational questions concerning arithmetic and formal reasoning, most notably through the work of Gottlob Frege in mathematical logic and the philosophy of mathematics (Frege & McGuinness, 1984), these studies will be discussed further in Chapter 2.2.2, as they represent a substantial body of research on mathematical knowledge production. They are not the primary focus of this thesis, even though they provide important context for understanding the broader landscape of scholarship in this area. This thesis is concerned with the field of pure mathematics as it is practiced today. Although many of the epistemological and ontological issues raised here fall under the domain of philosophy or, more specifically, the philosophy of science, such questions are rarely addressed within mathematics itself. This is particularly notable given that mathematics is typically grouped within the STEM disciplines, where epistemological inquiry remains largely external to the discipline. Most critical or reflective studies on the nature of mathematical knowledge continue to be conducted from outside mathematics, meaning within philosophy, education, or STS, rather than from within the mathematical community itself. This makes mathematics a particularly interesting discipline to look at as this differs from the other STEM subject.

To begin, I will elaborate on the concepts of objectivity and abstraction in mathematics, tracing their historical development and examining how they have come to shape the discipline's self-understanding.

2.1 The concept of objectivity and abstraction

Objectivity is a widely debated concept across various disciplines, from philosophy and natural science to feminist theory and social studies (Daston & Galison, 2007). Much of the STS literature explores various dimensions of objectivity, such as historical shifts, material practices, and the role of instruments and visualization, these themes are discussed in works by Latour et al. (2013) or Lynch (1994). However, I aim to focus specifically on its development in relation to knowledge production. This means, that rather than treating objectivity as an immutable characteristic of knowledge, this thesis adopts a constructivist perspective, investigating how objectivity is enacted, negotiated, and legitimized in mathematical practice. This point will be further developed in both the theoretical framework and the discussion chapters.

Feminist scholars, such as Sandra Harding (1996), have critically engaged with the concept of objectivity, questioning its claims and relevance within diverse forms of knowledge production. This demonstrates that objectivity remains a contested and evolving concept, particularly within feminist scholarship, where traditional notions are reexamined and redefined. In similar vein, scholars have also explored how these debates play out within the domain of mathematics, where objectivity has long been perceived as central to the discipline's epistemic authority. Numerous studies have explored the concept of objectivity and its implications for numbers and scientific knowledge (Heintz, 2007; Daston, 1992, 1995). Heintz (2000), for instance, critically examines the concept of objectivity in mathematics, arguing that it is not an inherent trait but a historically constructed ideal. She traces its evolution through standardization, measurement practices, and institutionalized observation, showing how these processes reinforce epistemic boundaries. Heintz (2000) also highlights how objectivity has been used to establish scientific authority while simultaneously excluding alternative perspectives, particularly those of women* and marginalized groups. Drawing on Bourdieu's notion of *habitus*, she explores how disciplinary cultures shape what is considered legitimate knowledge, demonstrating that objectivity is both a methodological tool and a social construct (Heintz, 2007).

Given the central role of abstraction in mathematical knowledge production, it is essential to clarify its relationship with objectivity. While objectivity traditionally refers to a state of knowledge production free from individual bias, abstraction involves a process of conceptual generalization that strips away contextual or empirical details (Daston & Galison, 2007). This distinction becomes increasingly complex in advanced mathematical domains, where abstraction is not merely a methodological tool but a defining characteristic of the discipline itself. Scholars argue that one key tension lies in the epistemic authority granted to highly abstract mathematical structures which will be further elaborated on in the next subchapter (Greiffenhagen, 2008).

Instead of empirical verification and reproducibility, abstract mathematics operates in a domain where such criteria are not always applicable. Mathematical abstraction relies on internal consistency, formal proof, and shared conceptual frameworks, raising questions about how knowledge is legitimized in the absence of direct empirical grounding (Heintz, 2000). Yet, in practice, the production of the formal proofs, especially by hand, is often complex or infeasible. A result Greiffenhagen (2008) shows is that mathematicians frequently rely on a "system of trust" to validate arguments, drawing on shared conventions, reputational credibility, and communal norms. This system is not limited to accepting results published in the literature but also operates in everyday research settings where many steps are assumed, abbreviated or even entirely omitted. In this way, both Greiffenhagen and Heintz reconceptualize objectivity: they show that mathematical knowledge is inseparable from the social practices and epistemic trust that underpin its communication and validation.

Lorraine Daston (1992) further problematizes objectivity by discussing how the pursuit of a "view from nowhere"[3] in science reflects an attempt to eliminate subjectivity yet remains deeply embedded in cultural and historical contexts. Daston (1992) argues that objectivity is historically contingent, shaped by changing epistemic virtues and scientific practices. In another study, Daston (1995) introduces the concept of the "moral economy of science," where scientific norms and values influence what counts as objective knowledge, reinforcing hierarchical structures within academia. These perspectives align with feminist critiques of science, which question the assumed neutrality of knowledge production and emphasize the role of power in shaping epistemic norms which will be further elaborated on in the next subchapter.

Thus, although abstraction and objectivity are often treated as distinct epistemic ideals, their intersection in mathematical practice shows a more nuanced relationship. The process of abstraction enables mathematicians to construct highly generalizable theories, yet the claim to objectivity within these frameworks depends on community consensus, disciplinary norms, and the epistemic virtues upheld within mathematical culture (Greiffenhagen, 2014). This discussion will be further developed in the subsequent section, situating mathematical objectivity within these broader epistemological debates.

Building on these perspectives, this thesis adopts a specific working definition of objectivity, one that emphasizes the absence of subjective bias while acknowledging the constructed and historically variable nature of objectivity. This understanding is informed by the work of Padovani et al. (2015), who provide a comprehensive overview of objectivity in scientific discourse. In their book, they cite authors such as

[3] The notion of a "view from nowhere" has been made popular through Thomas Nagel (2022), where he critiques the limits of subjective experience and argues for a perspective that transcends individual standpoint in order to achieve true objectivity.

Harding and Galison to trace the epistemological evolution of objectivity. Their analysis highlights how notions of objectivity are shaped by scientific practices, institutional structures, and broader sociotechnical contexts, rather than existing as fixed or purely epistemic ideal.

Applying these insights to my research, I aim to uncover and interrogate the visibilities and invisibilities within the field of mathematics, particularly concerning the experiences of women* and other marginalized groups. By looking at these dynamics, my research seeks to challenge dominant narratives and to highlight the diverse contributions and perspectives that may have been overlooked or marginalized. Moreover, by critically examining the processes of knowledge production and representation, I would like to contribute to broader conversations about equity, inclusivity, and social justice within the scientific community.
As before mentioned, scholars like Daston and Galison (2007) show that objectivity is historically contingent and tied to epistemic virtues. Perhaps what is considered "objective" in mathematics is influenced by whose work is visible and whose remains unseen. The concept of visibilities and invisibilities offers a valuable lens through which to analyze and understand the complexities of knowledge production, representation, and power dynamics within the field of mathematics. This will be further elaborated on in the subchapter on visibilities, linking it to peer review and evaluation studies.

Despite the rich body of STS literature on scientific practice, research on academic mathematical practice remains relatively limited. Compared to the extensive sociological studies on laboratory work in the natural sciences, mathematics has received far less attention (Greiffenhagen, 2008). Books like "Epistemic cultures: how the sciences make knowledge" by Knorr-Cetina (1999) which could be seen as an overview over epistemic cultures within all the natural sciences somehow only briefly touch upon mathematics. This gap underlines the need for further study of mathematical epistemic cultures, a gap this thesis tries to address.

2.2 Mathematical knowledge production

In exploring the current state of sociological research on mathematics, two key scholars emerge: Bettina Heintz and Christian Greiffenhagen. Both have made significant contributions to understanding the social dimensions of mathematical knowledge production, albeit with different emphases. Heintz (2000, 2007) examines the historical construction of mathematical objectivity, arguing that mathematical knowledge is shaped not only by logical rigor but also by social conventions, processes of standardization, and institutional frameworks. Her ethnographic case study at the Max Planck Institute for Mathematics in Bonn, Germany, provides insights into how pure mathematics[4] operates as both a socially embedded and epistemically autonomous discipline. Heintz ultimately tries to answer the

[4] Heintz uses the term 'theoretical mathematics'.

question of whether mathematics is socially constructed, with both yes and no. While she acknowledges the deeply internal logic of mathematical practice, she also highlights how the discipline has historically developed as a "technology of trust"[5], a system of rules and procedures that can guarantee reliability and objectivity beyond individual credibility. Rather than being merely a discipline that uses such a technology, mathematics itself has become one: it produces universally accepted results by enforcing shared standards or rigor and proof. This process reflects broader societal dynamics in which trust between individuals is neither always feasible nor sufficient. What is interesting about her book is also that she traces historical, cultural and other contextual narratives of mathematics behind this development which has not been covered by other scholars before.

Her analysis draws on both internalist and externalist perspectives; approaches that examine, respectively, the formal reasoning within mathematics and its broader social and historical contexts. This dual perspective is particularly relevant and will inform the framework of my own discussion. One notable limitation of Heintz's study, however, is its minimal engagement with issues of gender and inclusion. Despite Heintz's established background in gender sociology, her analysis only briefly mentions the underrepresentation of women in mathematics, largely relegating such remarks to footnotes. Given the gendered history and structure of the field, this represents a missed opportunity to address how authority and visibility in mathematics are also shaped by gendered dynamics which has mentioned by Lengwiler in a critique of the book (2000). Studies that do focus on this will be further elaborated on in one of the following subchapters of the state of the art.

Greiffenhagen, on the other hand, examines the social practices of mathematicians, particularly in collaborative settings, demonstrating how mathematical reasoning is embedded in interactional and communicative processes (Greiffenhagen, 2008). These perspectives highlight the extent to which mathematical knowledge is not merely an abstract pursuit but is deeply intertwined with social, cultural, and epistemic structures. He has conducted several case studies on the practices of mathematics, focusing on mathematics departments and research seminars at universities in the United Kingdom (Greiffenhagen, 2014, 2024).

Through video-based ethnographic studies, Greiffenhagen has examined how mathematical reasoning is not purely abstract but deeply embedded in social interactions, gestures, and material practices, such as writing on a board or discussing proofs in collaborative settings (Greiffenhagen, 2008, 2014). He argues that mathematical work is distinctive in its reliance on writing, which plays a central role in both individual reasoning and collective knowledge production. This reliance on material practices challenges conventional perceptions of mathematics as a purely cognitive or symbolic discipline and suggests that mathematical knowledge is, in part, created through the embodied and material act of

[5] This "technology of trust" can be explained as the substitution of personal credibility with objective procedures. As Porter (1995) notes, "objective rules [that] serve as an alternative to trust" (as cited in Heintz, 2000, p. 272). By embedding such rules into mathematical practice, the discipline is able to function as a system of epistemic authority that transcends individual subjectivity.

inscription. This insight aligns with Heintz's (2000, 2007) argument that mathematics, often regarded as the epitome of abstract and objective knowledge, is in fact shaped by historical, institutional, and material constraints.

These findings indicate that the production and dissemination of mathematical knowledge cannot be fully understood without considering its material and interactional dimensions.

While much research has focused on the pedagogy of mathematics, academic mathematical practice itself remains understudied. Fasheh (1980) critiques conventional mathematics education for its emphasis on technical proficiency at the expense of cultural and contextual relevance. He argues that mathematical knowledge is not neutral but is shaped by social and cultural factors, a perspective that resonates with broader STS critiques of objectivity in scientific knowledge production. Although Fasheh's work primarily addresses mathematics education, his insights can be extended to academic mathematical practice more broadly. If mathematical knowledge is influenced by cultural, institutional, and material conditions, then its production within professional settings must also be examined through this lens.

A central concern in this discussion is the nature of mathematical proofs[6] and their claim to objectivity. Proofs serve as the primary mechanism through which mathematical statements are validated, yet their epistemic status raises important questions: What makes a proof objective? To what extent does the mathematical community's consensus determine the legitimacy of a proof? These questions have been addressed by scholars in the philosophy of mathematics and STS, who emphasize that proofs are not simply formal sequences of logical deductions but also social constructs that gain acceptance through peer validation and disciplinary conventions (Lakatos et al., 1976; Netz, 1999).

2.2.1 Logic and philosophy of mathematics

The foundational question, of what constitutes mathematics, not only shapes theoretical debates but will also inform the formulation of my research questions. In particular, understanding how the nature of mathematics is defined and negotiated provides a necessary conceptual basis for analyzing how mathematical objectivity, epistemic hierarchies and validation practices are constructed within the field. The following subchapter will build on this foundation and will connect the study of philosophy of science with the practice of mathematical logic. It will explore how proofs and abstraction rely on the claim of mathematics on objectivity.

Before delving into the specifics of proofs and their role in mathematical objectivity, it is crucial to first examine the broader question: *What defines mathematics?* This seemingly simple question has been widely debated across disciplines, yet no singular, universally accepted answer has emerged.

[6] Mathematical proofs can be understood as the basis of validation instead of empirical arguments. (Heintz, 2000)

Mathematics is often distinguished by its high degree of formalization, its reliance on deductive reasoning, and its abstraction from empirical reality. However, as various scholars have pointed out, the boundaries of mathematics are historically contingent and shaped by shifting epistemic norms (Ferreirós Domínguez, 2016; Resnik & Kitcher, 1985).

Ferreirós Domínguez (2016), a scholar in logic and philosophy of science, emphasizes that the concept of mathematics has evolved significantly across different traditions and historical periods. He highlights that "modern mathematics", characterized by formalization, abstraction and increasing specialization, is the product of cultural and epistemic shifts. Rather than viewing mathematics as a timeless and purely rational discipline, Ferreirós Domínguez shows how over time mathematical practices have been contingent upon institutional, technological and social developments. This is particularly relevant for my thesis, as it helps to understand how current conceptions of mathematical objectivity have emerged, not as self-evident truths but much rather as constructs shaped by a confluence of institutional, technological and social processes.

Similarly, Resnik and Kitcher (1985) argue that mathematics has social and communal aspects. Both are scholars of philosophy of science. They propose that mathematical knowledge is not discovered, adding to findings by Greene et al. (2016). According to them, mathematics is actively constructed and maintained through the collective practices of mathematical communities. Their work situates mathematics within broader epistemological frameworks that acknowledge the role of social negotiation, consensus-building and institutional authority in shaping what is valid mathematical knowledge. Greene et al. (2016) work within the field of mathematics education, however, their perspective challenges the notion of mathematics as purely objective and culture-free, a tension that is central to the analysis in my thesis. While their focus is on education, the issues they raise resonate with broader academic contexts.

To further understand how objectivity and validation emerge in mathematics, it is crucial to explore the role of mathematical logic. Often regarded as the most abstract and formal dimension of the discipline, mathematical logic is nevertheless shaped by social, historical and institutional contexts (De Toffoli, 2021; Putnam, 1975). Mathematical logic is commonly perceived as a realm of rigorous proof and formal certainty. However, the nature of proof itself is more varied, encompassing a spectrum from formal proofs, which are strictly symbolic and more step-by-step derivations with axiomatic systems, to informal proofs or "hand-wavy" arguments that rely more on intuition and the communication of heuristics (Gowers, 2002). The boundary between these is not rigid but socially negotiable.

The concept of rigor in mathematics has evolved over time, reflecting the shifting standards of mathematical communities and influenced by both cultural and institutional factors (Gowers, 2002). For example, the introduction of computer-assisted proofs, such as the proof of the Four-Color Theorem, challenges traditional ideas of mathematical rigor (Parshina, 2024). These proofs rely on extensive computations that are often infeasible to verify by hand, raising questions about the nature of mathematical truth and acceptance within the community. This evolution highlights how proof standards are embedded in social practices, reflecting a collective agreement rather than an immutable ideal.

The development of formal systems has been deeply influenced by social and institutional needs. For example, efforts to standardize mathematical language and methods, such as those led by the influential *Bourbaki group*, a collective of 20th-century mathematicians aiming to reformulate all of mathematics on a rigorous, formal foundation, demonstrate that formalism in mathematics is not purely driven by logic or internal necessity (Gowers, 2002). As Greiffenhagen and Sharrock (2011) argue, these formal structures are shaped by broader social factors, including educational goals, institutional research priorities, and the norms established within the mathematical communities. This perspective reveals what they call the "sociology of formalism": that even the most abstract and formal parts of mathematics are influenced by the contexts in which they are developed and used.

The work of Knorr-Cetina (1999) on epistemic cultures further illuminates how scientific communities establish and maintain distinct knowledge practices. These practices shape not only the development and interpretation of their respective disciplines but can also be applied to understanding how formal systems are constructed and sustained.

2.2.2 Ontological debates in mathematics

Building on the discussion of abstraction and proof, this section introduces an important conceptual distinction in the philosophy of mathematics: the divide between fallibilist and absolutist perspectives, which correspond in part to the divide between Platonism and constructivism. While a detailed theoretical discussion follows later in this work, it is crucial here to note these terms for clarity and coherence. This distinction addresses how mathematicians conceive of the existence of mathematical objects; whether as independent, eternal entities (Platonism) or as mental constructions dependent on explicit proof (constructivism) (Greene et al., 2016). Understanding how these philosophical positions translate into practical approaches to proof, definition, and abstraction provides insights in mathematical practices. Additionally, to further complicate the idea of mathematics as a purely objective and complete system, foundational results in mathematical logic underscore the limits of formal systems. Gödel's incompleteness theorems (1992) and Turing's work on computability (1937) demonstrate that no reasonable formal system can fully encapsulate all mathematical truths[7]. These findings directly challenge the notion of mathematics as a fully self-contained and logically complete enterprise, reinforcing the view that mathematical knowledge, too, is shaped by epistemic boundaries. These results also emphasize the interplay between logical abstraction and the practical realities of mathematical knowledge production.

[7] Both theorems describe fundamental limitations of formal systems. They demonstrate that no single formal system can encompass all mathematical truths, as there will always be true statements that cannot be proven within that system. This insight highlights inherent epistemic boundaries in mathematics.

In summary, mathematical logic is not only a study of abstract symbols and formal rules but also a socially embedded practice influenced by historical, philosophical, and institutional forces. This perspective prepares the ground for a deeper analysis of the social construction of formal systems and the dynamic nature of mathematical knowledge.

2.3 Diversity within mathematics

In this subchapter I will focus on the studies that have been conducted on the topic of diversity within mathematics. As H. [8] and Kremakova (2023) discuss, examining the intersectional challenges faced by underrepresented groups in mathematics can reveal the complex interplay of gender, race, class, and identity in knowledge production. Additionally, the intersection of motherhood and technology, as explored by Holden et al. (2023) in the context of Ugandan computing, offers a perspective for understanding systemic barriers to participation in mathematical and scientific fields. Although their study focuses specifically on computing and chronopolitics[9] in Uganda, it is relevant here because it reveals how gendered responsibilities, particularly those related to care and reproduction, are structurally entangled with access to and success within STEM disciplines. This line of inquiry moves beyond individual interest to examine structural inequities that shape who is more likely to pursue and thrive in mathematics (H. & Kremakova, 2023).

The work of Jochen Gläser offers insights into how institutional diversity contributes to epistemic diversity. Gläser et al. (2006) ask to what extent variations across institutional settings foster diversity in the content and methods of scientific research. They define epistemic diversity as “the diversity of empirical objects, methods, problems, or approaches to solving them” (Gläser, Heinz & Havemann, 2015, p. 1006). Their main argument is that institutional diversity through variations in organizational goals, funding structures, evaluation criteria, and research cultures creates space for different epistemic practices to flourish (Gläser, Heinz & Havemann, 2015). This, in turn, shapes not only what kinds of questions are pursued but also the identities and roles of scientists within their respective communities. In the context of mathematics, promoting institutional and epistemic diversity could enable the discipline to broaden its problem spaces, foster methodological innovation, and make the field more inclusive of diverse intellectual traditions.

Building on this broader framework, feminist science studies have long interrogated how knowledge production is shaped by power, identity, and positionality. Foundational insights such as Butler’s concept of performativity and Haraway’s notion of situated knowledges offer tools for understanding the status of women* in STEM fields. The exploration of this topic has become a key concern within

[8] Dr. Piper Harron, a mathematician, publishes under the mononym “H.” and writes publicly under the name “Piper Harris” on their blog “The Liberated Mathematician” (https://www.theliberatedmathematician.com). The citation used reflects their preferred authorship style.
[9] Politics of time

the literature given the historical underrepresentation and systemic barriers faced by women* in these disciplines. Most of this research is being conducted in countries of the Global North[10] whose first language is English, such as the US, UK, and Australia (ANU, 2024; Golbeck et al., 2020; Jebsen et al., 2022). These studies often highlight issues such as gender bias, lack of mentorship, and unequal opportunities. For example, Golbeck et al. (2020) analyze authorship and citation data in computer science, revealing gendered disparities in visibility and recognition. Jebsen et al. (2022) focus on the lived experiences of women in engineering departments, identifying microaggressions, isolation and unequal access to advancement within their field. The Australian National University (ANU) (2024) report highlights structural interventions, such as inclusive hiring, programs for mentoring practices and institutional accountability mechanisms aimed at improving gender equity.

In contrast, there are fewer studies with a focus on German-speaking academic cultures. Nonetheless, important contributions exist, such as reports on the status of women* in mathematics (Kausch et al., 2022). Kausch et al. (2022) report on the structural challenges and the cultural construction of mathematical ability as masculine. There are institutional approaches to gender equity in science, exemplified by initiatives at the Max Planck Institute, including dual-carrer support, bias-awareness training and flexible career trajectories (Max-Planck-Gesellschaft, 2024). There is limited comparative analysis between these English and German academic cultures, as well as others with different language backgrounds. This gap may be due to the lack of translation of relevant studies into English or German.[11]

In sum, understanding diversity within mathematics requires attention both to the social identities of mathematicians and to the institutional and epistemic structures that shape the field's knowledge production. Integrating feminist insights with broader analyses of epistemic diversity provides a more comprehensive picture of how inclusion or its absence affects the development of mathematical knowledge.

This discussion of diversity and epistemic practices provides an important foundation for the following section, which examines how processes of peer review and research evaluation influence the visibility, recognition, and valuation of different forms of mathematical work.

2.4 Visibilities in research: links to peer review and evaluation studies

This section examines how authority is constructed within mathematics, focusing on the role of visibility, understood as the degree to which researchers and their work are recognized within structures

[10] When I refer to the Global South, I am specifically addressing the global periphery. Conversely, the term Global North refers to the global core (Quijano, 2000).

[11] It is important to consider whether these differences are primarily linguistic or cultural. Rather than suggesting that problems like gender bias are absent in German-speaking contexts, I argue that they are differently articulated and institutionally embedded. Language plays a role in shaping discourse, but it is deeply intertwined with academic cultures and disciplinary traditions. For example, the Anglo-American context tends to integrate feminist critique more directly into science policy and institutional rhetoric.

of power, privilege, and value attribution. These dynamics are central to processes of peer review and other forms of academic evaluation, which serve not only to assess but also to legitimize scientific work. Scholars such as Martin Reinhart (2012) have discussed how peer review contributes to the visibility and perceived value of research, reinforcing hierarchies and norms within academic disciplines. A case study specifically on the peer review of mathematics has been conducted by Greiffenhagen (2024). He shows that although mathematicians recognize that peer review does not guarantee absolute correctness, they nonetheless consider it valuable, arguing that it adds certainty, especially compared to papers shared only on preprint servers like arXiv[12]. During review, disagreements may arise not only over a result's significance but also over whether a submitted argument constitutes a valid proof, including concerns about substantial gaps. Acceptance often hinges on whether a result survives the scrutiny of the broader mathematical community over time. More broadly, Greiffenhagen argues that peer review in mathematics should be viewed as an exception within the natural sciences, since the discipline relies on deductive proof rather than empirical testing. He emphasizes the growing role of platforms such as arXiv, which function as informal communities for knowledge sharing and validation. While peer review does offer a sense of epistemic stability, it is not unquestionable. This reveals how trust and legitimacy are socially constructed, not inherent properties of mathematical knowledge.

Other studies by Reinhart (2012) show how sociologically and academically, research only functions through its forms of institutions. In his book, Reinhart (2012) argues that analyzing how peer review is functioning in individual disciplines it becomes an analytical tool for examining visibilities and invisibilities within the field. Thus, not only is it a relevant topic to study in the realms of knowledge production but it can also be an indicator of evaluation and valuation of knowledge. This will be important for my own work when analyzing diversity, access and fairness within different mathematical communities.

In mathematics, authority and trust are produced in unique ways. Heintz (2000) explores how mathematical practices resist typical sociological scrutiny yet still participate in broader mechanisms of trust production within scientific communities. Through "technologies of trust", Porter (1995, as cited in Heintz, 2000, p. 272) focused on statistics and the social sciences, Heintz (2000) applies similar insights to the internal dynamics of mathematics. Her work is significant because it demonstrates that even in this seemingly self-evident and purely rational domain, trust is cultivated through shared conventions, formal rigor and collective validation practices that function analogously to Porter's bureaucratic mechanisms.

Additionally, a national case study which has focused on this is one conducted by Valenzuela et al. (2024). Here, scholars have analyzed the evaluation metrics of mathematical research in Chile. They have found that Chile's approach to measuring excellence in mathematics relies heavily on standardized bibliometric indicators, such as publication counts, citation rates, and impact factors, which are all

[12] https://arxiv.org/archive/math

embedded in national policy and institutional reward systems. These metric assemblages, while promoting international visibility also introduce tensions: they foreground certain forms of mathematical inquiry while marginalizing locally relevant, theoretically driven research that may not score as well on standardized scales.

In line with this, publication practices in mathematics further highlight its distinct culture. Compared to other sciences, mathematicians tend to publish fewer papers, and the process from research to publication is often slower due to the discipline's emphasis on substantial theoretical contributions rather than time-sensitive findings (American Mathematical Society, 2015; Valenzuela et al., 2024). These patterns reinforce the idea that in mathematics, research is evaluated more for its quality and depth than for sheer volume, underscoring the discipline's unique approach to academic recognition and peer validation.

Beyond formal publication practices, communication within mathematics relies heavily on non-verbal modes such as gestures, symbols, and written inscriptions rather than spoken explanations, as highlighted by Greiffenhagen (2014). This connects to the notion of "hand-wavy arguments," a concept relatively common within mathematics to describe informal, intuitive reasoning.

Taken together, the construction of authority in mathematics hinges not only on formal mechanisms like peer review and publication metrics but also on more implicit cultural norms. These include how knowledge is communicated, which forms of research gain visibility, and how trust is collectively maintained. Together, these processes create a distinctive framework of academic legitimacy. They have been critiqued through the aforementioned models of scientific evaluation and highlight the importance of perspectives that are specific to the discipline when studying knowledge production, as already discussed in chapter 2.2.

Thus, the concept of visibility in scientific research extends beyond mere representation to encompass broader questions of power, legitimacy, and epistemic authority, raising important parallels with debates on objectivity in mathematics. While objectivity is often framed as an ideal of neutrality and detachment, it is equally shaped by social structures that determine whose contributions are recognized and whose remain invisible within mathematical knowledge production. Research in the history of science has increasingly focused on the experiences of women* in laboratory settings, with key contributions from scholars such as Evelyn Fox Keller (1995) and Londa Schiebinger (1999). These studies have illuminated the challenges women* face in these environments but often remain limited to empirical case studies without connecting to broader theoretical frameworks. By situating my research within these discussions, I aim to extend this work through exploring the interplay between social factors, disciplinary boundaries, and individual identities within the mathematical community. This approach not only addresses gaps in the current literature but also offers new insights into how gender and science co-evolve in these settings.

Drawing on the concept of visibilities and invisibilities in research, as articulated by Garforth (2012) and Beaulieu (2010), I will examine the dynamics at play within the field of mathematics. Garforth (2012) elucidates how certain individuals or groups are made visible or invisible within scientific discourse and practice, extending beyond mere representation to encompass the ways in which power, privilege, and biases shape who and what is seen as significant within scientific narratives. Beaulieu (2010) further explores visibility within the context of digital technologies and data practices, emphasizing the complexities of visibility and the nuanced ways in which knowledge is produced and disseminated.

2.5 Epistemological beliefs

This subchapter provides an overview of current research on epistemological beliefs. For the purpose of this discussion, epistemological beliefs are defined as "beliefs about the nature and acquisition of knowledge" (Lammassaari et al., 2024, p.784). They play a foundational role in shaping how knowledge is produced and validated within scientific communities. This chapter builds on prior research that explores how such epistemological beliefs are formed, shared, and maintained collectively, focusing specifically on their influence within the field of mathematics. Thus, existing studies highlight how epistemological beliefs are embedded in disciplinary cultures and influence the practices and identities of researchers.

An important contribution in this regard is Gläser's (2006) analysis of scientific production communities. Moving beyond abstract models of scientific collaboration, Gläser et al. (2010) offer a detailed sociological account of how knowledge production is coordinated across individuals and institutions. He demonstrates that such communities emerge through shared epistemic commitments, task structures, and informal mechanisms of coordination, rather than merely through formal institutional affiliations or disciplinary boundaries.

These production communities provide the social framework through which epistemological beliefs are both embedded and enacted. Gläser (2006) describes how they foster mutual reference, establish shared systems for defining and integrating research tasks, and address coordination and motivation through socially structured practices. In this view, epistemological beliefs are not solely individual cognitive orientations but are collectively produced and stabilized within particular knowledge cultures. This framework is particularly useful for situating mathematical epistemologies, such as absolutist versus fallibilist stances within broader academic and institutional contexts.

This sociological perspective on epistemological beliefs is further enriched by feminist epistemologies, which foreground how power relations, gender, and social location shape what counts as knowledge and who is authorized to produce it. While Greene et al. (2016) emphasize the role of social interaction in shaping epistemological beliefs, feminist scholars have drawn sustained attention to the ways in which these processes are also structured by dynamics of inclusion, exclusion, and identity (Haraway, 1988; Harding, 1996; Knorr-Cetina, 1999).

2.5.1 Feminist literature on epistemologies

Feminist scholars have made significant contributions to understanding the gendered nature of STEM fields, as well as major contributions to the understanding of epistemologies in science and mathematics (Haraway, 1988; Harding, 1996; Knorr-Cetina, 1999). Building on the insight that epistemological beliefs are socially and culturally embedded (Greene et al., 2016), feminist theorists have developed powerful frameworks for analyzing how knowledge production is shaped by gender, power, and social context. Rather than treating mathematical knowledge as neutral or universal, feminist epistemologies emphasize its situatedness, examining how systemic biases and exclusions affect both the content and the practice of mathematics. This section reviews key feminist contributions that inform a more critical and reflexive understanding of epistemological beliefs and knowledge production in mathematical contexts.

Judith Butler's theory of gender performativity provides a framework for examining the construction of mathematical identities, suggesting that gender is not a fixed trait but rather something that is continuously enacted through behavior and societal expectations (Butler, 1988). This framework has been instrumental in feminist and gender studies for revealing how identities, including those within mathematics are actively performed and regulated by prevailing gendered expectations. In the context of mathematics, Butler's framework helps to understand how mathematicians' identities are shaped by and, at times, constrained by gendered institutional norms, challenging assumptions about mathematics as a neutral or genderless domain. Similarly, Gloria E. Anzaldúa's work offers valuable insights into the complexities of identity formation in STEM through her concept of borderlands and mestizaje[13], which explores how individuals straddle multiple, often conflicting, identities (Anzaldúa, 2012). While mestizaje could be used metaphorically to describe the layered and intersecting positions of mathematicians, this thesis draws more directly on the concept of borderlands, which offers valuable insights into the complexities of identity formation within the context of STEM fields. It highlights the fluidity and multiplicity of identities that existed at the intersections of race, gender, sexuality, and culture even within disciplines like mathematics that often present themselves as neutral or universal. Drawing on Anzaldúa's work alongside Butler's theory of gender performativity, both offer a more comprehensive understanding of how mathematical identities are constructed and negotiated within diverse social and cultural contexts, particularly through their interpretations of gender in these contexts.

[13] In the context of Gloria Anzaldúa's work, "mestizaje" refers to the cultural, racial, and ethnic mixing that occurs, particularly in North and South America, resulting in individuals or communities with mixed ancestry. Anzaldúa often used the concept of mestizaje to describe the hybridity of identities and cultures that emerge from the blending of indigenous, European, African, and other cultural influences in both continents. Mestizaje encompasses the idea of cultural hybridity and acknowledges the complex and diverse identities that arise from such cultural mixing (Anzaldúa, 2012).

Similarly, Donna Haraway's concept of 'situated knowledges', emphasizes the importance of context in shaping knowledge production, providing a framework for understanding the situatedness of mathematical practices (Haraway, 1988 as cited in Hoppe, 2022). Haraway's (1988) notion not only problematizes subject and object but also advocates for a dynamic understanding of knowledge production, inviting critical reflections on the role of context, power, and agency in shaping epistemological frameworks within feminist discourse and science studies. The text that I will be referring to the most will be her essay "Situated knowledges: The science question in feminism and the privilege of partial perspective" (Haraway, 1988). One of her main arguments is based on the concept of objectivity which will be further elaborated on in the theory chapter.

Sarah Traweek's "Beamtimes and lifetimes" (1988) serves as a valuable example. In her ethnographic study of high-energy-physics, a core STEM field, she examines how gender, culture and power shape participation in scientific communities. They reveal how scientific knowledge is embedded within social and cultural norms, highlighting how these norms privilege certain identities while marginalizing others. Her work exemplifies how marginalized perspectives challenge dominant epistemologies and expose the relationship between identity and scientific practice. Traweek's analysis aligns with standpoint theory, which will be further discussed in the next chapter.

The idea that identity influences knowledge production may not be controversial in general, it becomes more nuanced when applied to mathematics, a field often depicted as disconnected from these discussions (Greene et al., 2016). Building on the insights from this literature review, exploring the role of situatedness in shaping mathematical knowledge becomes more relevant. In the first chapter of her book "What can she know? Feminist theory and the construction of knowledge", Lorraine Code (1991) comes to the conclusion that the sex of the knower[14] of a certain knowledge is epistemologically relevant. She critiques traditional epistemology for its assumption of a universal, neutral knower, exposing how this standard often privileges masculine perspectives while marginalizing others. Code (1991) argues that knowledge is always situated, meaning it is shaped by the specific social, cultural, and gendered context of the knower. She advocates for feminist epistemology, which seeks to validate marginalized experiences and interrogate the power structures embedded in dominant ways of knowing. Harding (1996) underscores the interplay between feminist research methodologies and the broader socio-environmental contexts within which mathematical knowledge is situated.

2.5.2 Colonial legacies of numbers

In alignment with H. and Kremakova's (2023) exploration of the societal significance of mathematics, my research aims to unravel the myth surrounding numbers by delving into the socio-cultural dimensions of mathematical knowledge production. H. and Kremakova highlight the entanglement of

[14] I choose to adopt the terms used in the literature within the context of knowledge production. While they may appear similar, I believe they can represent different concepts depending on the context. For Code's theory, I prefer the term 'knower' to better align with their framework.

mathematics with power relations, educational systems and collective meaning-making within societal structures

A growing body of critical literature has also interrogated the perceived objectivity and universality of mathematics, drawing attention to the power dynamics and historical contexts that shape mathematical knowledge. For example, Quijano (2000) has highlighted the colonial legacies embedded in numerical systems and mathematical practices, demonstrating how Eurocentric frameworks have been historically dominated and marginalized other ways of knowing. This line of critique problematizes the notion of mathematics as an impartial and culturally neutral domain.

Helen Verran's study on mathematics teaching in African schools challenges the notion of the universality of mathematics, highlighting the importance of considering diverse cultural perspectives in mathematical pedagogy and practice (Verran, 2001). This perspective builds upon the idea that there is no singular way of doing mathematics, especially not solely Eurocentric.

Building on these insights, feminist and decolonial scholars argue that assumptions about mathematical objectivity obscure the ways in which mathematical practices are situated within broader structures of power, inequality and colonial histories. While much of this critical work has yet to be systematically integrated into mainstream mathematical epistemologies, it opens important avenues for rethinking the cultural and political dimensions of mathematical knowledge production, an area where further research is needed.

2.5.3 Situatedness

Situating mathematical research involves the interaction of academic and non-academic practices, highlighting the diverse contexts in which mathematical knowledge is produced. This perspective challenges the traditional view of mathematics as an objective and universal domain and instead underscores its embeddedness in social and cultural environments. Studies exploring the link between situated knowledge and teaching in mathematics underscore the importance of considering the socio-cultural context in pedagogical approaches. Hodgen's (2011) work on connecting situated knowledge and teaching, along with Palmer's (2010) examination of situated mathematical research, offer valuable insights into the complexities of mathematical practice and the influence of context on knowledge production. These studies suggest that mathematical practices cannot be isolated from the social and cultural environments in which they are embedded, making it essential to view mathematics as a situated practice rather than an objective, universal truth. Hodgen draws on the notion of situated cognition to explore how mathematical knowledge is constructed and negotiated within classroom interactions. Situated cognition is a theory which describes knowledge within educational environments to be tied to the context in which it is learned and used. By analyzing examples from secondary mathematics classrooms, he demonstrates how what counts as mathematical knowledge is shaped by local practices and the expectations of teachers and students. This further supports the argument that mathematical knowledge is not simply transmitted but co-constructed in context.

From my perspective, the dynamic nature of defining a mathematician underscores the significance of adopting an STS lens as it is not a static concept but rather varies across disciplines and contexts. This approach emphasizes the socio-cultural and interdisciplinary aspects of scientific practice, recognizing how external perceptions shape disciplinary boundaries and identities (Harding, 1996; Heintz, 2007). As I have observed through my own mathematical study, interdisciplinary research, exemplified by Brilliant-Mills (1993), challenges conventional definitions of mathematicians by offering diverse viewpoints from different disciplines, expanding our understanding of mathematical identity. This notion resonates with the before mentioned feminist epistemologies and sociologies of science (Haraway, 1988; Thompson, 2015).
However, despite these contributions, there is still a noticeable gap in research within academia that addresses the situatedness of mathematical knowledge outside of pedagogical contexts. While much has been done to explore situated knowledge in teaching and learning environments, less attention has been paid to how mathematics is situated in other academic fields, particularly in relation to research practices. Further studies are needed to investigate how mathematical knowledge is produced and understood within the broader academic landscape, including in interdisciplinary research and across different mathematical subfields. This gap presents an opportunity for my research to expand the understanding of mathematical practices in academic contexts beyond traditional teaching methodologies and to explore how knowledge is situated and produced in diverse research environments.

Bourdieu’s theoretical framework (1977) provides valuable insights into the dynamics of scientific fields and their respective habitus. By examining the social structures and power relations within the mathematical community, according to Maton (2008) Bourdieu’s concepts of field and *habitus* offer a nuanced understanding of how disciplinary cultures shape the production and dissemination of knowledge within mathematics. Heintz (2007) similarly draws on Bourdieu’s concept of habitus to analyze how mathematical cultures stabilize not only epistemic practices but also the dispositions, behaviors, and unspoken norms that define what it means to “be” a mathematician. Through her ethnographic study, she shows how mathematicians internalize shared aesthetic values such as elegance, conciseness and formal rigor, as part of a cultivated professional identity. This embodied habitus reinforces a collective sense of objectivity and legitimacy in mathematical work while simultaneously shaping the field’s social boundaries and hierarchies. Feminist critiques highlight the gendered nature of mathematical practices, shedding light on issues of representation, access, and participation within the field (Burton, 1990).

By incorporating diverse cultural perspectives into my analysis, not only by attending to how mathematical epistemologies may differ across national, institutional or linguistic contexts, but also by considering how researchers’ social and cultural positions inform their epistemic assumptions, I aim to gain a clearer understanding of how social structures and cultural contexts shape mathematical practices and influence the production of mathematical knowledge. This approach allows me to explore how different cultural backgrounds affect the ways mathematics is taught, learned, and applied, and highlights the role of cultural and social factors in shaping mathematical ideas and practices. Diversity in mathematics involves recognizing and valuing the varied backgrounds and perspectives that individuals bring to the field. Embracing diversity not only enriches mathematical discourse but also, hopefully, fosters innovation and creativity (Gläser, 2006). By combining intersectionality, critical theory, and STS concepts, my research seeks to create a comprehensive framework that addresses the multifaceted nature of identity, power, and knowledge production in mathematics. These theoretical foundations will be further elaborated in the following chapter. This approach advocates for a mathematics that is not only inclusive and diverse but also critically engaged with the social and cultural contexts in which it is situated.

Overall, this state of the art chapter highlights how recent scholarship across sociology of science, feminist epistemology, and mathematics education converges in viewing mathematical knowledge not as purely abstract or universal, but as socially situated, institutionally mediated, and shaped by power relations and cultural contexts. This body of research provides a rich foundation for analyzing how epistemological beliefs, identities, and knowledge practices are formed and negotiated within contemporary mathematical communities. However, less attention has been paid to how these dynamics unfold specifically within academic mathematics beyond educational settings, an area this thesis tries to explore.

3. Theories and sensitizing concepts

Understanding the dynamics of mathematical knowledge production requires embracing theoretical frameworks that unveil the interplay between mathematics and society. This chapter serves as an introduction to the essential theoretical perspectives and sensitizing concepts that provide a foundation for my analysis of mathematical practices within their social and epistemological contexts.

3.1 Epistemological beliefs in mathematics

Mathematics is often divided into two primary epistemological beliefs: the absolutist and the fallibilist. The absolutist perspective views mathematical knowledge as certain and unchanging, while the fallibilist perspective recognizes it as dynamic and influenced by social processes and human interpretation (Greene et al., 2016).

To begin addressing the types of epistemological beliefs relevant to this thesis, it is first necessary to define what is meant by epistemological beliefs and how such beliefs operate within the broader framework of (mathematical) knowledge production. Epistemological beliefs refer to implicit or explicit assumptions about the nature of knowledge, meaning how it is constructed, justified, and evaluated within different frameworks. These beliefs shape how individuals within a field engage with knowledge claims and how they position themselves within their disciplinary cultures. They also guide what is considered valid evidence, how uncertainty is dealt with, and what counts as a legitimate research question or method. Together with these, they have an impact on the motivation for individuals, their choices of topics and its processes (Greene et al., 2010).

Knorr-Cetina's concept of "epistemic cultures" (1999) shows how epistemological beliefs are not merely personal attitudes but are socially embedded and cultivated through disciplinary norms and institutional practices. According to Knorr-Cetina (1999), epistemic cultures are the "machineries of knowing" that characterize different fields of science, each with its own methods, standards of proof, and interpretive repertoires. These cultures shape the cognitive and material practices through which knowledge is produced, and they vary significantly between disciplines such as high-energy physics and molecular biology, a point that becomes especially relevant when thinking about mathematics.

Understanding epistemological beliefs in this way, thus as socially situated, culturally reproduced, and epistemically consequential, provides the necessary groundwork for examining the specific beliefs that circulate within mathematics. In what follows, I outline the key distinctions between *absolutist (Platonist)*, as well as the *fallibilist* and *constructivist* epistemological framework, which offer contrasting visions of how mathematical knowledge is understood, produced, and legitimated. These distinctions have been primarily made before in the analysis of epistemological beliefs within mathematics by Greene et al. (2016).

3.1.1 Absolutist (Platonist) perspective

Within absolutist (Platonist) perspective of mathematics individuals "[…] assume mathematical knowledge to be secure, fixed, and objective. They believe that mathematical objects are real and exist outside the human mind." (Greene et al., 2016, p.147) Part of this believe is also the distinction between the discovery and the invention of knowledge. Here, knowledge is being discovered, as it exists with or without the existence of the knower (Ernest, 1991). Building on Greene et al. (2016) there are different types of epistemological beliefs within mathematics. Their theories are based on the beliefs of teachers within mathematics but can be generalized in order to understand the belief system a bit better. Thus, they differentiate between 1) a Platonist, 2) an instrumentalist and 3) a Problem-solving approach. These three perspectives overlap with the broader binary distinction between absolutist and fallibilist epistemologies. Meaning that 1) mathematics is something that can be discovered, specifically because of its structured nature and immutability. 2) Mathematics can be seen as an assemblage of rules, theories and methods, in short: instruments which can be used in order to navigate the world of mathematics. This is described very similar in Knorr-Cetina's (1999) where she highlights the absolutist perspective as one that views knowledge as objective, universal, and discoverable through the correct application of standardized methods, particularly prevalent in fields like high-energy physics. 3) Highlights that mathematics is a chain of reasoning and ideas and the focus should be on them rather than the end-product (Greene et al., 2016). This is more connected to the fallibilist and constructivist perspective which will be further elaborated on in the next subchapter.

3.1.2 Fallibilist and constructivist perspective

Adherents of the fallibilist and constructivist perspective view "mathematics as the outcome of social processes, […] seen as fallible and open to revision. […] focus on doing mathematics - within the social conventions in a particular context - and its human side." (Greene et al., 2016, p.147)

Social constructivist perspectives emphasize the socially mediated nature of knowledge and the role of language, culture, and social interaction in shaping cognitive processes. Within mathematics, social constructivism posits that mathematical knowledge is not discovered but rather constructed through social processes (Ernest, 1991). This perspective invites us to consider how mathematical concepts and practices are negotiated and contested within communities of practice (Lave & Wenger, 1991). Because of this, social constructivism challenges the traditional view of mathematics as an objective and universal body of knowledge by highlighting the ways in which social context, interaction, and cultural norms influence mathematical understanding and development.

Interestingly, poststructuralist theories further problematize the relationship between language, power, and knowledge, emphasizing how discourse constructs and regulates social reality. Poststructuralism, with its focus on the deconstruction of texts and the critique of metanarratives, offers tools to examine the ways in which mathematical knowledge is discursively produced and maintained. Within the context of mathematics, discourse analysis by scholars like Skovsmose (2012) provides a critical lens through which to examine how mathematical ideas are not merely discovered truths but are discursively constructed, circulated, and legitimized within specific power structures. Skovsmose argues that a mathematical "model does not *represent, but re-presents;* that it is not objective, but that it invents its objects; and that it is not descriptive, but performative" (Skovsmose, 2012, p.773). This perspective underscores the performative nature of mathematical practices and the role of language in shaping what is considered valid mathematical knowledge (Hodgen, 2011). This will be further elaborated on in subchapter 4.3, dealing with (gender) performativity.

By integrating social constructivist and poststructuralist perspectives, I will work on uncovering the underlying power dynamics and exclusions embedded within mathematical discourses. This combined approach reveals how mathematical knowledge is shaped by social and cultural contexts and how it serves to reinforce or challenge existing power relations. It provides a critical examination of whose voices are included or excluded in the construction of mathematical knowledge and how these dynamics affect the broader understanding of mathematics as a discipline. Furthermore, this integrated approach aligns with contemporary critical theories such as the ones mentioned in the next subchapter that seek to bridge the gap between knowledge production and social justice. By doing so, it opens up possibilities for more inclusive and socially responsive forms of mathematical academia and practice.

This leads me to introduce more feminist epistemology together with standpoint theory. As scholars critique traditional epistemology for its assumption of a universal, neutral knower, exposing how this standard often privileges masculine perspectives while marginalizing others.

3.2 Feminist epistemological beliefs and standpoint theory

Recognizing the significance of the social and cultural contexts in which mathematics operates is crucial. In this context, feminist epistemological perspectives provide valuable insights into the social construction of knowledge and the power dynamics inherent in knowledge production processes. Feminist epistemology challenges traditional notions of objectivity by arguing that knowledge is inherently situated. Haraway's concept of 'situated knowledge' (1988) critiques the idea of neutral, disembodied knowledge, emphasizing that all knowledge is produced from specific social locations. According to Hoppe (2022), Haraway's aim is to highlight that research is situated within specific contexts, shaped by various interests and passions, and to make this positioning explicit. This theoretical perspective is particularly relevant for mathematics, as it questions the presumed universality of mathematical knowledge and highlights how knowledge is embedded in specific cultural and historical contexts. As Harding notes: "For almost two decades, feminists have been engaging in complex and contentious discussions about objectivity: debating which forms of knowledge production can claim objectivity, which cannot, and why not; whether the many different feminisms need objectivity and, if so, why they need it; and, if objectivity is possible, how it can be achieved." (Harding, 1996, as cited in Hoppe & Vogelmann, 2024, p. 305). Building on these debates, Harding introduces the concept of 'strong objectivity', which I will explore in relation to the social situatedness of knowledge producers and its implications for mathematical knowledge production.

3.2.1 Strong and weak objectivity

As previously mentioned, Harding (1996, as cited in Hoppe & Vogelmann, 2024, p. 305) reconceptualizes objectivity by distinguishing between *weak* and *strong* objectivity. Weak objectivity refers to traditional notions of neutrality and detachment, often assumed to be free from social or political influence. In contrast, strong objectivity calls for a critical examination of the researcher's social location and the power structures embedded in knowledge production. It emphasizes reflexivity and the inclusion of marginalized perspectives as essential components of more robust and accountable knowledge.

Harding's notion of strong objectivity aligns closely with a fallibilist epistemological stance in mathematics. Rather than assuming mathematical knowledge to be absolute or detached from context, this perspective acknowledges that such knowledge is produced within specific social, historical, and institutional conditions and is therefore open to revision and contestation.

3.2.2 Intersectionality

Standpoint theory, as developed by scholars such as Haraway (1988) and Harding (1991) and further elaborated by other feminist scholars, argues that individuals positioned at the margins of society may offer unique perspectives that challenge prevailing epistemologies. This perspective will further inform my analysis of how marginalized viewpoints can influence dominant understandings in the field of mathematics. For example, Traweek's ethnographic work (1988) illustrates how gender and cultural norms shape the lived experiences of physicist, revealing how social identities influence participation and knowledge production in STEM fields. By centering perspectives historically excluded from mathematical knowledge production, standpoint theory enables a critical interrogation of how power and privilege shape epistemic authority within the discipline (Code, 1991; Quijano, 2000).

Additionally, intersectionality theory emphasizes the interconnectedness of social categories such as race, gender, class, and sexuality, and their cumulative impact on individuals' experiences and identities. In the context of mathematics, intersectionality invites us to consider how multiple axes of identity intersect to shape mathematical participation, knowledge creation, and achievement (Nasir & Hand, 2008). By attending to the diverse lived experiences of mathematicians, I hope to gain a better understanding of the social dynamics at play within the field. Through my research, I try to encompass intersectionality by considering how these intersecting identities influence mathematical engagement and outcomes, thereby highlighting the diverse and complex realities faced by individuals within the mathematical community.

This research is informed by critical theories that foreground issues of power, inequality, and emancipation, offering a framework for understanding and challenging systems of oppression. In the context of mathematics education, critical pedagogy advocates for transformative approaches that empower learners to critically engage with mathematical knowledge and its social implications (Skovsmose, 2012). By integrating critical theory, my research aims to uncover and challenge the structural inequalities and power imbalances that exist within the field of mathematics through the lens of Skovsmose's concept of critical mathematical literacy. This perspective emphasizes the need for a critical examination of the role mathematics plays in societal structures and power dynamics and leads me to introduce the concept of performativity as the next subchapter as this will help to understand the intersectional issues at heart of the discussion within mathematical knowledge creation.

3.3 (Gender) Performativity

Building on intersectionality and standpoint theory, this thesis employs Butler's theory of gender performativity alongside Anzaldúa's concept of borderlands to examine how mathematical identities are actively constructed and negotiated in everyday practice. This layered theoretical approach provides the tools to analyze empirical data on identity formation within mathematics.

Judith Butler's theory of gender performativity offers a transformative view of identity, suggesting that gender is not an inherent trait but rather a series of performances shaped by societal expectations (Butler, 1990). For me, this perspective is crucial for analyzing how mathematical identities are formed and understood within STEM fields. Gloria E. Anzaldúa's concept of borderlands (Anzaldúa, 2012) provides a complementary perspective by highlighting the fluidity and multiplicity of identities at the intersections of race, gender, and culture. Anzaldúa's exploration of mestizaje and the borderlands challenges fixed notions of identity and offers valuable insights into how these intersections influence participation and identity in mathematics. Combining Anzaldúa's insights with Butler's theory of gender performativity allows for a deeper understanding of how mathematical identities are constructed. While Butler's framework addresses the performative nature of gender, Anzaldúa's focus on borderlands emphasizes the lived experience of navigating multiple, intersecting identities, adding nuance to understanding challenges and opportunities in mathematical discourse. Applying these integrated theories can inform practices in STEM education and institutional policies by recognizing the diverse and intersecting identities of individuals. This approach promotes inclusivity and equity, fostering environments where varied perspectives are valued and addressed. My future research could further explore how these theoretical frameworks intersect to shape experiences and identities in mathematics. This theoretical framework is particularly valuable for this thesis, as it offers tools to understand how identities are not only shaped within the discipline of mathematics but also actively performed in response to external perceptions and internalized norms. Drawing on Butler's theory of performativity and Anzaldúa's concept of borderlands, it becomes evident that identity formation in mathematics involves a complex negotiation of multiple, intersecting boundaries of gender, race, language, and epistemic legitimacy. These performances are shaped both by dominant narratives about who is seen as a legitimate mathematical subject and by the embodied experiences of those navigating the field. The combination of Butler and Anzaldúa highlights that what is being negotiated and performed within mathematics goes far beyond gender; it includes broader dynamics of power, marginalization, and resistance, which are deeply embedded in the processes of mathematical knowledge production.

4. Research questions

Mathematics is often imagined as the one universal language, believed to be as precise and objective as possible, free from cultural and social influence. This perception is shaped by the historical and cultural context in which mathematics has developed, emphasizing its logical structure and empirical verification. The educational system reinforces this view by teaching mathematics as a set of fixed principles and truths discovered rather than constructed. Additionally, the absolutist perspective on mathematical epistemology, which views mathematical knowledge as certain and unchanging, contributes to this imagination (Greene et al., 2016). However, adopting Haraway's notion of not having an innocent objectivity (Haraway, 1988, as cited in Hope, 2022), this overlooks the fallibilist perspective, which recognizes mathematics as a dynamic and evolving discipline influenced by social processes and human interpretation, which becomes evident in the knowledge it produces. Understanding these dual perspectives allows me to grasp the complexity and diversity of mathematical knowledge production.

The recognition of the influence of context on the shaping of mathematical knowledge underscores the imperative of understanding situatedness in this discipline. Drawing upon the insights of feminist theorists like Butler (1988) and Haraway (1988), I seek to interrogate the processes of knowledge production within mathematics and their implications for gender dynamics.

To start, I would like to investigate this subquestion: *How do historical and cultural contexts shape the perception of mathematical knowledge as objective or constructed?*

This question is critical because it addresses the foundation upon which mathematical knowledge is perceived and taught. Understanding the historical and cultural influences helps reveal why certain mathematical principles are considered immutable and universally valid. This can shed light on the often unacknowledged biases and assumptions inherent in the field. Answering this question will provide a contextual background that is essential for understanding the perceived objectivity of mathematics. It will help explain how these perceptions have been shaped over time and how they continue to influence contemporary mathematical practices.

This raises the main research questions (RQ):

RQ1: *How do different kinds of mathematical knowledge and epistemological beliefs shape the situatedness of PhD students in mathematics and their objectivity within the field?*

RQ2: *How is mathematical knowledge defined and validated within academic institutions in Vienna, and who holds the epistemic authority in these processes?*

In other words: In what ways is mathematical knowledge defined and validated within various epistemological frameworks, and how do these frameworks situate the authority and inclusivity of decision-making in the field?

5. Methodology and data collection

My thesis employs qualitative semi-structured interviews with PhD students in mathematics, aiming to understand how they experience and negotiate mathematical knowledge and epistemic authority. As part of the preparation, the bibliographies and selected published papers of the interviewees were reviewed, a process that can be understood as a form of document analysis (Bowen, 2009). This methodological framework allows for the exploration of both textual and discursive aspects of mathematical knowledge production, while trying to attend to the broader socio-cultural contexts within which mathematics is situated. Aligned with the principles of contextualized, partial, and socially situated knowledge emphasized by my theories, these methods were chosen to critically engage with the situated nature of epistemic practices. Additionally, reflexivity and positionality will be central to the research process, as I acknowledge my own situatedness and biases in relation to the study topic in the next paragraph. By integrating these methodologies, the research aims to analyze the interplay of identities and power structures that shape mathematical practices and discourses. Regular reflective sessions were used in order to complement data collection, trying to ensure a thorough understanding of emergent issues.
My coding approach combines constructivist grounded theory (Charmaz, 2006) and Kuckartz's qualitative content analysis (Kuckartz, 2014), balancing structured thematic analysis with openness to emergent insights. This is particularly important given my focus on how these social dynamics intersect with epistemological beliefs and power structures within mathematics.

As said, in conducting this research, it is crucial to acknowledge my own situatedness and positionality: As a female, upper-class, person of color, and second-generation immigrant in Germany, my perspective is shaped by my background and experiences. My academic training in mathematics at the University of Münster in Germany and at the Technical University of Lisbon (TECNICO) in Portugal has provided me with a strong foundation in the field of mathematics. However, this training has also made me aware of the social biases and gender performances present among my peers at both universities, offering practical insights that shape the personal relevance I see within my study. Despite the privileges that come with my financial position, my race and gender have often been significant factors in my experiences. By situating myself within the research, I aim to show how to produce more nuanced and inclusive scholarship, in line with Haraway's (1988) concept. Recognizing the partiality of my perspective allows me to contribute to a more comprehensive understanding of my thesis, acknowledging the diversity of experiences and viewpoints that exist. Particularly applying this to the methods I want to use, this means that I will try to reflect on how my prior studies influence the way I interact with my interview partners.

5.1 Semi-structured interviews

This section outlines the semi-structured interviews used to collect data, detailing the practical process of conducting the interviews (5.1.1) and the methodological rationale and iterative approach underlying (5.1.2).

5.1.1 Conducting the interviews

To explore experiences within academic mathematical cultures, I conducted semi-structured interviews with PhD students in the field of mathematics. This method, commonly used in qualitative educational and social research (Perera, 2021; Roulston, 2010), enabled a flexible engagement with their perspectives. My main focus was on academia, rather than broader educational settings. Initially, I considered limiting the interviews to women*, but to gain a broader understanding of diverse perspectives on the objectivity and inclusivity within mathematics, I have decided to include participants of all genders. This allowed for a more comprehensive exploration of how different experiences and identities shape epistemological beliefs and the validation of mathematical knowledge. I focused on PhD candidates who are actively engaged in research at the University of Vienna and the Technical University of Vienna (or related institutions). I anticipated that these individuals, at rather early stages in their academic careers, could offer insights into how authority, knowledge, and inclusivity are negotiated within academic mathematics. I approached my potential participants through relevant academic networks, starting with the *Vienna School of Mathematics*[15] (VSM). The association provides a point of entry, particularly through its student list available on their website. I reached out via email, introducing my research, explaining its aims, and inviting them to participate in the interview process. Additionally, I tried to ensure that potential participants understand the voluntary nature of the study, the confidentiality of their responses, and how the data will be used; for this I provided informed consent sheets. In total I reached out to 29 PhD students, getting 12 responses, all of which were positive.

Building on the approach discussed by Perera (2021) regarding power dynamics in elite interviews, I aimed to remain conscious of the shifting power relations during the conversations. Additionally, the semi-structured format was modeled after Roulston's (2010) guidelines for interviewing, allowing flexibility for follow-up questions and in-depth exploration of key themes. This approach tried to ensure that while I guided the interview, the participants' perspectives remain at the forefront, hopefully enabling a more natural and insightful conversation. By utilizing a semi-structured interview format, I aimed to maintain a balance between guided inquiry and allowing participants to freely express their perspectives. The initial idea was that this approach might enable me to delve into their personal experiences, while also exploring the broader themes of epistemology, inclusivity, and authority in mathematical knowledge creation. At the same time, the semi-structured format allowed for a degree of

[15] https://www.vsmath.at/

comparability across interviews, as each interviewee was asked a similar set of questions. This consistency provided a necessary basis for identifying differences and recurring patterns across individual narratives.

However, as this was my first formal interview experience, I approached the process with respect. The interviews were done mainly in English, I did offer the option for having it in German for one person who did not feel comfortable speaking English. However, they ultimately chose to proceed in English. Seven of the interviews took place in person, either at a room in the STS department, mathematical department of the University of Vienna or the Technical University of Vienna. Two interviews were conducted online, using the platform ZOOM[16].

In line with the informed consent provided to participants, all quotes from the interviews will be used in a pseudonymized form (Gerrard, 2021). Pseudonyms will replace participants' names and any other identifying details to ensure confidentiality, however the pseudonyms were chosen in order to match the gender-identity of the interviewee. All nine interviewees are PhD candidates within mathematics, primarily working in the realm of pure mathematics[17]. Most are affiliated with the VSM, while a few are pursuing their PhDs at other non-related institutions. One of the nine interviews was a pilot (or mock) interview conducted with a colleague who is also pursuing a PhD in mathematics in a different city.

Here is an overview of the interview participants:

Pseudonym	Field of study	Interview Date
Roman	Pure mathematics/ Applied mathematics	November 25th, 2024
Jack	Pure mathematics	November 28th, 2024
Nils	Pure mathematics	February 3rd, 2025
Helen	Pure mathematics	February 4th, 2025
Paul	Pure mathematics/ Applied mathematics	February 4th, 2025
Mika	Pure mathematics/ Applied mathematics	February 5th, 2025
Nora	Logic	March 11th, 2025
Chris	Pure mathematics	March 12th, 2025
Ben	Pure mathematics	March 13th, 2025

[16] https://www.zoom.com/de?lang=de-DE

[17] I explain this in the introduction of my thesis where I divide mathematics into applied mathematics, pure (or sometimes called abstract) mathematics and logic (more connected to philosophy of mathematics).

Throughout the following chapters, interview material is incorporated directly into the analysis. Interviewees are referred to by name, and the date of the interview is provided where appropriate. The interview questionnaire, which can be found in the appendix, was structured around three main themes: (1) epistemological beliefs and mathematical objectivity, (2) authority and validation in mathematical knowledge, and (3) situatedness and inclusivity in mathematics.

5.1.2 Semi-structured interview methodology

I chose semi-structured interviews as my primary method because they allow for an in-depth exploration of the individual experiences, perspectives, and epistemological beliefs of PhD students in mathematics. Given that my research questions focus on how these individuals perceive mathematical knowledge, objectivity, and their own position within the discipline, interviews offered the most suitable approach to access this nuanced, subjective data.

The data collection phase for my thesis, which consisted of conducting semi-structured interviews, spanned a period of five months (November 2024 - March 2025). Throughout this time, the process turned into a somewhat iterative and fluid manner, organized into three general phases: (1) preparing, (2) conducting, and (3) improving. These phases were not strictly linear, as each stage often overlapped and influenced the others, reflecting the evolving nature of qualitative research.

The preparation phase was crucial before each interview, where I engaged in what I refer to as a "document analysis" of my interviewees. This stage involved gathering background information about the participants by researching their academic profiles, previous publications, and their roles within the field of mathematics. This process was not aimed at evaluating their work, but rather at building a context for our conversations, allowing me to tailor my questions and approach in a way that felt more relevant and grounded in their individual academic experiences. By entering the interviews with this prior knowledge, I hoped to allow for more thoughtful and informed discussions about the topics central to my research, such as epistemological beliefs, objectivity, and inclusivity in mathematics. This felt particularly important because I employed a format, which allowed me to not only follow a set of predefined questions but also engage in dynamic conversations. In order to make the interviewees feel prepared as well, I was sending out an information sheet prior to the interviews together with my email asking for interview participation. I called the sheet "Interviewee Information - Strong objectivity and mathematical knowledge production". I explained my thesis topic, its aim, gave three example questions and provided a bit of information about myself.

During the interviews, I began to reflect how my questions were received and where clarification was needed. This reflective process was part of my learning and allowed me to continuously adapt my interview questionnaire. For instance, I had initially assumed certain terms or concepts, such as "epistemological belief," would be understood by my participants without issue. However, through my conversations, I quickly realized that these terms often required explanation, and I adapted my approach accordingly. This ongoing process of the interview helped me not only clarify my own thinking but also ensured that the questions remained accessible (to a certain extent) and meaningful for the participants. In this way, the process was far from static. It was inherently reflexive, as I constantly adjusted my approach based on the insights gained from each interview. The feedback loop between preparation, conducting, and refining the interviews allowed me to work on my research questions and better align them with the lived experiences of my interviewees, rather than imposing preconceived notions of what I expected to find.

After all interviews were completed, I entered a more formal reflection phase. I revisited notes and transcripts to consider which interview strategies had worked effectively and which could be improved.

5.2 Coding of the interviews

In this section, I outline the coding strategies employed for analyzing the interview data in this thesis. The aim is to describe the analytical approach without delving into the actual findings. The process draws on a hybrid methodology that combines elements of qualitative content analysis (Kuckartz, 2014) and constructivist grounded theory (Charmaz, 2006), allowing for both structured thematic exploration and emergent, interpretive insight. I chose this method as it felt the most natural to me as a researcher and allowed for a better flow within the coding process. It enabled me to remain open to unexpected themes while still engaging with theory informed categories relevant to my research questions. While conducting the initial coding of the interview data, I engaged in both deductive and inductive processes, simultaneously drawing on existing literature to develop the state of the art section of the thesis. This parallel process was helpful in deepening my understanding of the key debates and controversies within the field. During and after the transcription phase, I began constructing a preliminary analytical framework, which was further refined as the theoretical framework evolved.

Interview transcripts were produced using aTrain [18] and Descript [19] as transcription tools and subsequently imported into MAXQDA[20], which served as the primary platform for organizing and coding the data. Initially, Descript was used for the first two interviews, including a mock interview and the first formal interview, as I was not yet aware of its cloud-based and commercial nature. After discovering this, I switched to aTrain, an open-source and fully offline transcription program. This decision aligned with my commitment to ensuring the highest possible level of data privacy in compliance with General Data Protection Regulation (GDPR) standards, which governs information privacy across the European Union.

The entire interviews lasted for 478 minutes, being about an hour long on average. This does not include the mock interview. All interviews were transcribed verbatim and, where necessary, lightly edited for clarity meaning the removal of filler words or false starts that did not affect meaning. As the interviews

[18] https://business-analytics.uni-graz.at/de/forschung/atrain/
[19] https://www.descript.com
[20] https://www.maxqda.com/de/

did not involve heightened emotional content or interactional dynamics requiring fine-grained linguistic analysis, verbatim transcription was the most appropriate choice for supporting thematic analysis while maintaining the integrity of participants' responses. In cases where English was not the interviewees' first language, minor grammatical errors were left unchanged unless they hindered comprehension. MAXQDA facilitated a systematic and reflexive coding process, supporting ongoing revision, categorization, and memo-writing throughout the analysis.

The coding proceeded through two phases: an initial deductive phase, guided by theoretical constructs relevant to the thesis, particularly the situatedness of knowledge, peer-review processes and theories on epistemic cultures, and a subsequent inductive phase, which remained open to emergent themes and categories arising directly from the data (Bücker, 2020). This combined approach allowed me to apply and critically test existing theoretical lenses, while also creating space for the generation of new concepts grounded in participants 'narratives.

Following Charmaz's (2006) constructivist grounded theory approach, the process was intentionally flexible and iterative, recognizing that meaning is co-constructed between researcher and participant. The use of memos throughout the process helped to trace conceptual developments, capture analytical insights, and critically reflect on my own role in interpreting the data.

5.2.1 Preliminary Coding Framework

Before the interviews began, I developed a preliminary coding framework based on existing literature and theoretical concepts related to objectivity, situated knowledge, and power relations in mathematical knowledge production. This framework included themes such as epistemological beliefs and mathematical knowledge; authority and research processes, as well as inclusivity and, and served as a starting point for the deductive coding process. While this framework provided initial structure and focus, it was treated as tentative and adaptable, subject to ongoing revision as new insights and codes emerged from the data during analysis.

As said before, the interview questionnaire, which can be found in the appendix, was structured around three main themes, aiming to answer the research questions in the best way possible:

1: Epistemological beliefs and mathematical objectivity

2: Authority and validation in mathematical knowledge

3: Situatedness and inclusivity in mathematics

These three themes served as the foundation for the initial coding framework.

Here are examples of how the codes were attached to the three primary themes from the interview questionnaire:

1: "objectivity in research", "mathematical certainty", "bias in mathematics"

2: "peer review process", "research authority", "validation of knowledge"

3: "personal experience in research", "contextual influences", "access to resources in academia", "diversity in mathematics"

I try to explain my approach in the following table in order to make my research process more transparent and understandable.

code/ theme	why	what it will tell me	derived from
objectivity (definition)	main theme of my thesis	how do different interviewees define objectivity specifically with regards to mathematics	Daston & Galison, 2007
objectivity (context)	do the interviewees connect it to themselves? - find differences between the conceptual and situated definition	does the definition matter depending on the context	Harding, 1988
fallibilist perspective	to contrast two epistemological beliefs	“mathematics as the outcome of social processes, […] seen as fallible and open to revision. […] focus on doing mathematics - within the social conventions in a particular context - and its human side.” (p. 147)	Greene et al., 2016
absolutist perspective	to contrast two epistemological beliefs	“[…] assume mathematical knowledge to be absolutely secure, fixed, and objective. They believe that mathematical objects are real and exist outside the human mind.” (p. 147)	Greene et al., 2016
bias in mathematics	to examine implicit or explicit assumptions about who belongs in mathematics (as a discipline but also within research groups) and how these influence perceptions of objectivity	may reveal how power, gender, and other positionalities shape notions of mathematical neutrality	Daston & Galison, 2007
mathematical certainty	to find out, if there is good or bad mathematical knowledge or if the differentiation is made between true or false (with certainty)	the way research is being done, proofs, what makes this certainty?	Interview guide
AI in the context of	does this influence the way authority is created?, unsure how much this will be used	possibly help with answering RQ2 to a minimal extent	

code/ theme	why	what it will tell me	derived from
mathematical certainty			
validation of knowledge	to learn more about authority	answer RQ2 concerning authority and how this shapes the way knowledge is being defined	Interview guide
research authority	authority relations in research are highly field-specific due to differences in epistemic conditions; the nature of knowledge production in each field	how is epistemic authority created specifically when it comes to mathematical knowledge (field-specific)	Gläser et al., 2010
peer review process	mechanisms by which disciplines control standards and access (is this only institutional?)	link it to authority in mathematical knowledge production	Reinhart, 2012
access to resources in academia	to investigate structural inequalities in access to funding, mentorship, or institutional support and how these shape epistemic authority	could show how unequal access impacts participation within knowledge productions and who is seen as epistemically credible	Harding, 1996
diversity in mathematics	for studying inclusion, perspective variation, or disciplinary norms	how diversity is seen from people within the field	Interview guide
personal experiences in research	to capture personal narratives (reflect positionality) and meaning-making aspects in mathematical identities	can help link structural dynamics to lived experience; may support concepts of situated knowledge	Haraway, 1988; Harding, 1988
the social vs the epistemological	to explore tensions between how interviewees separate (or maybe blend) social identity and mathematical knowledge	maybe function as a bridge between theoretical frame works and lived disciplinary norms	Greiffenhagen & Sharrock, 2011
contextual influences	to understand how broader institutional, historical or cultural factors shape mathematical knowledge production	could reveal how "objectivity" and legitimacy are shaped by more than individual beliefs	Knorr-Cetina, 1999

Thoughts that I had during the creation of this table were centered around the levels of analysis. I thought about organizing these themes into three levels of analysis: Individual (personal experiences, epistemological stances), institutional (authority, resources, peer review)and disciplinary (objectivity, diversity, certainty). However, I decided to keep this table and imported the themes into MAXQDA. I used the column “why” as a first memo, which was later edited in the further coding process. Another thought that came up during this process was if research authority be connected to teaching authority in the book by Greene et al. (2016). I tried to keep that thought in my head but decided against putting an extra code in which would focus on pedagogical approaches as they are not central or relevant to my research.

5.2.2 Actual framework and strategy

Following the completion of the interviews in March 2025, the preliminary coding framework was revisited, refined, and finalized. The coding strategy evolved based on the insights gained from the interview data. This section details how the framework was adjusted as the analysis process progressed, reflecting an iterative approach to data interpretation.

As the coding process unfolded, the framework was adjusted to better capture emerging patterns and insights from the interview data. This included both deductive coding, based on the original themes, and inductive coding to identify new, unexpected themes.

The final coding framework includes both the original categories from the preliminary framework, such as “objectivity,” “authority,” and “inclusivity,” as well as new themes that emerged during the inductive process. The flexibility of this approach allowed for a more nuanced understanding of how participants’ perspectives on these themes evolved and interacted.

By revising the framework in response to the interview data, I tryed to ensure that the final analysis was comprehensive, grounded in the data, and responsive to the participants’ unique viewpoints. This iterative process allowed for a deeper exploration of the complexities and nuances that emerged throughout the duration of the interviews. I also used a code called “code later” which was only used couple of times. For instance, this code was used in the following context: “*I actually think that the knowledge is actually extremely useless but I think that the tools that gives you* […] *the way it teaches to like process information and think about things I think that's the important thing, not the knowledge itself.*” I had the impression that the quote held significant value towards my research questions but did not fit any of these codes.

Each of my codes was applied to specific interview excerpts that were relevant to the research themes. For example, the code “objectivity (context)” was assigned to segments where participants discussed the nature of objectivity in mathematics, including any factors that may influence or challenge its perceived neutrality.

In MAXQDA, I also used the memo function to document my reflections and insights as I coded the data. These memos provided a space to record initial interpretations, emerging patterns, and any shifts in my understanding of the data as the analysis progressed. This helped ensure that my analysis remained dynamic and responsive to both the theoretical framework and the nuances in the data.

The coding table can be found in the appendix and provides an overview of my coding framework as it developed after all interviews had been coded. During the active coding phase, I included an additional column labeled "What does this tell me about my research questions?" This column was primarily for my own use, helping me to structure my thoughts and make early analytical connections. Although it was later removed to avoid redundancy with the analysis chapter, it played an important role in linking individual themes and shaping the overall narrative that guided both this and the following chapter.

In the process of improving my coding framework I also got rid of several codes. All codes that were used less than five times were automatically deleted, some were coded more often but were seen as irrelevant for answering the research questions. All the deleted codes will be listed here with an explanation or reason for this:
The code "mathematical bias" was deleted because what I was describing as mathematical bias was somewhat more intertwined with what other scholars would describe as performativity (of gender in the case of Butler (1990) or other forms of performing).
The code "AI and proof assistants" was created during the coding process, used eight times but deleted as the coded segments seemed to not answer the research questions.

After completing the coding of the interview transcripts, I returned to the column in my coding framework labeled "What does this tell me about my research questions?" This reflexive step helped create a smooth transition from data coding to thematic analysis. As a result, the structure of the analysis reflects both the order of the coding framework and the logic of my research questions, ensuring that the analytical narrative remains closely tied to the overall aims of the thesis.

5.3 Reflection on the interview and coding process

This was my first research project involving multiple interviews with different participants, and I approached this method with a sense of respect and responsibility. Initially, I was a bit apprehensive about conducting interviews, as I wanted to ensure I was engaging participants thoughtfully and ethically. However, as I progressed, I found that transcribing and coding the interviews, while time-consuming, were tasks I genuinely enjoyed. These activities allowed me to immerse myself in the data and begin noticing patterns and themes that helped my understanding of the research questions.
After each interview, I made a conscious effort to document reflections before and after the session. I was uncertain about maintaining a formal research diary but decided to try it as a way to support my reflexivity throughout the process. Over time, I realized that this approach wasn't the best fit for me; I often struggled to revisit and effectively use these notes. Nonetheless, this experience was valuable in helping me recognize my preferred methods of reflection and data engagement. It highlighted the importance of finding a reflective practice that feels natural and sustainable for me.

5.4 AI usage table

This table was put together by the STS teaching assistants based on the "Documentation Table" developed by the Writing Center of the University of Graz (2024). I chose to include this table in my methodology chapter as it fits well into my reflexive approach.

AI Tool	Work Phase	Prompts/How was the AI used?	Reason for Usage	Comment and Reflection on the Results
aTrain (OpenAI's Whisper transcription models)	transcribing the interviews	I put in the interview audio, selected the number of speakers to be two and chose the language. The program transcribed the interview.	I used aTrain in order to save time in the process of transcribing. Also, because it is a open-source, offline and free tool.	The output was good. Mostly, I only had to go over the interview one more time. Most of the mathematical technical vocabulary was misspelled. Especially the detection of the two speakers had some flaws sometimes. However it greatly improved the time that I had to spend transcribing the interviews.
Chat GPT	transcribing the interviews	I asked Chat GPT to help me with understanding the technical vocabulary within the interviews, using prompts like "My interviewee says something along the lines of X but I don't understand it, what mathematical concept could they be describing?"	I did not understand some words and after searching for similar sounding words online, this was the quickest method to find the concept they were explaining.	The output was really good. It helped me a lot with understanding what my interviewees were talking about and also provided a short explanation of the concept.

AI Tool	Work Phase	Prompts/How was the AI used?	Reason for Usage	Comment and Reflection on the Results
Chat GPT	writing	I asked Chat GPT to better structure my arguments.		
Descript	transcribing the interviews	I put in the interview audio, then I had to listen to three audio snippets and assign the speakers.	I used Descript in order to save time in the process of transcribing.	The output of Descript was not as good as the one provided by aTrain. I had to go over the interview more than once. More specifically I think that it was not familiar with any sort of accent in English which made it more time consuming than aTrain.
Deepl	writing, refining	I used Deepl sometimes to translate my thoughts from German into English.		I thought it was very helpful as it provided me with translations of texts that I was reading in German into English, as it knew the terms specific to the discipline.

5.5 Methodological considerations and limitations

One limitation concerns the access points used to select participants. The study's focus on PhD students and early-career researchers at the University of Vienna and the Technical University of Vienna, while providing valuable insights into academic practices, may introduce biases tied to the specific institutional and academic cultures of these universities. Although this selection ensures a relatively homogeneous participant group, it may not fully capture the diversity of experiences and perspectives within the broader mathematical community.

What became apparent after finalizing the methodological framework is that mathematics is a particularly challenging field to study empirically. This difficulty is reflected in other scholars 'attempts, some of whom have adopted more quantitative approaches to capture epistemological beliefs within mathematical communities more broadly. While such quantitative methods might yield more representative findings across diverse universities and research groups, the qualitative approach chosen here offers a different and valuable angle on these issues.

Nevertheless, the nature of the field itself presents significant methodological challenges. This complexity is acknowledged in the literature and has been highlighted by scholars such as Heintz (2000, 2007) and Greiffenhagen (2014; Greiffenhagen & Sharrock, 2011). Furthermore, the relatively limited number of interviews conducted, given the scope of this study, constitutes another limitation. As will become evident in the analysis and discussion chapters, this research alone cannot fully address the existing gaps in the empirical study of mathematical epistemologies, underscoring the need for further research in this area.

6. Analysis and results

Following the previous chapter, I begin by briefly revisiting the coding framework used in the analysis, outlining the main themes that emerged and their relevance to the research questions. A recurring theme throughout the interviews was the perception of mathematics as a discipline detached from cultural or societal influence. Many participants described mathematics as inherently objective, universal, and unaffected by the social position or identity of those producing it. This view often surfaced in statements that emphasized the neutrality and universality of mathematical reasoning.

What proved particularly interesting, however, was that despite these assertions of objectivity, subtle indications of situatedness did emerge in the interviews. These moments revealed the different ways in which personal experience, institutional context, and disciplinary norms influence how mathematical knowledge is produced and understood.

Accordingly, this chapter presents the analysis of the empirical data and is structured around key themes that aim to address the central research questions. The analysis will be paired with the theories which were introduced prior to this chapter. It begins by examining the dual perception of mathematics as a domain of individual “genius” versus mathematics as a collaborative, team-based effort. This section explores how these contrasting narratives shape the experiences and identities of those working within the field. The second theme focuses on diversity and inclusion within mathematical knowledge production, as perceived by the interview participants. Here, particular attention is paid to how gender, background, and disciplinary culture affect access, recognition, and participation. The third section delves into the concept of epistemic hierarchy, gradually transitioning into a discussion of epistemic authority, that is, who is seen as having the right to define, validate, and disseminate mathematical knowledge. Following this, the chapter explores the variety of epistemological beliefs held by my interview participants. This includes an analysis of absolutist and fallibilist perspectives, their implications for mathematical practice, and how individuals navigate or conform with these differing perspectives. The chapter concludes with a reflection on how mathematical knowledge itself is understood and defined within the community.

To follow the logic of moving from the external to the internal dimensions of epistemology in mathematics, this chapter begins by exploring how mathematics is perceived both from the outside and within the academic community. It examines how cultural narratives, public images, and disciplinary myths, such as the figure of the “math genius”, shape broader perceptions of the field. These outer views often influence how mathematicians understand themselves, their work, and their place within the discipline. Through an analysis of participants’ experiences, this chapter explores how identity, belonging, and epistemological positioning are performed, contested, and negotiated in the context of mathematical knowledge production.

6.1 Outer perceptions of mathematics

This subchapter explores how historical and cultural narratives shape the outer perception of mathematics. Drawing on both existing literature and empirical findings, I examine how these external views influence perceptions of who can "do" mathematics, and how they contribute to persistent myths surrounding mathematical ability and identity.

A recurring theme in the data was the tension between two dominant imaginaries: mathematics as a field reserved for individual "geniuses" versus mathematics as a collaborative, team-based effort. Many interviewees described public perceptions of mathematics as tied to exceptional intellectual ability, often embodied in the figure of the (typically male) mathematical genius. These narratives stood in contrast to their own experiences of working within collective, often interdisciplinary, however, rarely diverse environments.

This analysis draws on the interview codes "mathematical science community", "contextual influences" and "idea of a math genius / perception of math from the outside." What emerged strongly was a sense that mathematics is widely regarded as a discipline only accessible to a select few, those considered innately "smart." Participants often expressed feelings of inadequacy or of never being enough, suggesting an internalization of this external hierarchy. As someone who has also studied mathematics, I found these accounts deeply resonant. They raised an important question for me: How do individuals in the field navigate this perceived inferiority? Is there an implicit acceptance of exclusion, or even a normalization of self-doubt? These reflections open up a further analysis of how naturalized hierarchies, grounded in the genius myth, shape not only access to mathematics but also the ways in which people within the field perceive themselves and others.

This chapter critically engages with whether the binary between "genius" and "team effort" is as distinct as it appears, and whether these external perceptions actively inform internal epistemic cultures within mathematics. To analyze the data presented in this chapter, the theories of Butler (1988) and Anzaldúa (2012) will be particularly important in explaining how mathematical identities are constructed, both through external cultural narratives and internal disciplinary norms.

6.1.1 The narrative of the male genius

Helen describes: "*maths is considered as like really difficult*". This was similarly described by Nora as they mirrored their own experience as "*it was more like, wow, this is hard. I'm not sure if I can do it, but also do I want to do something that's so hard?*" Nora also states: *"before I started my bachelor's, I* […] *had this picture of my like, yeah, maths people are male and they're weird and they're nerds.*" Paul also states: "*I very much think that no one has any idea of what math is except for mathematicians.*"

These quotes reflect both how mathematicians are perceived from the outside and how individuals internalize or resist those images. They also explain "*a lot of mathematicians think that* [mathematics is] *this completely distinct thing you can never explain to anyone.*" (Helen, personal communication, February 4th, 2025). While the quote by Nora also describes the lack of diversity of the field what becomes obvious is that there is one preexisting notion of what a mathematician is supposed to look like and a common idea of how mathematics is perceived. Even though several interviewees stated that they wished more people would understand what mathematics is about, there is no contradiction. Thus, there is a common idea of what mathematics is, namely a distinct, hard, black box of a subject. But once you are part of this, once you are seen as one of the few, this black box disappears. Chris described this moment of transition, explaining: "*very fancy things that are super abstract, and nobody really understands, and I kind of also learned that, you know, all these things are understandable, right?*" This dynamic becomes even more apparent when situated within broader theoretical and institutional contexts.

According to Chris mathematics is seen as "*something which a few select people can do.*" They go on explaining: "*this is something really deep and something that you know like mysterious and maybe something that not a lot of people can do and understand.*" Later during the interview, they state "*I would really like to change this, this appearance that mathematics is only something that geniuses can do. That is really problematic.*"

Drawing on Butler's (1990) concept of performativity, we can understand the figure of the mathematical genius not as a fixed identity but as a role that is continually enacted and reinforced within disciplinary norms. Similarly, Anzaldúa's (1987) concept of borderlands offers a way to theorize the in-between spaces occupied by those who do not fully align with the dominant image of the mathematician, those whose gender, cultural background, or epistemic stance positions them at the margins of the field. Thus asking how the image of the one mathematician is constructed. The scope of the thesis does not allow for a deeper analysis of the social processes that happen in school, the social environment before university or even academic work, however what is important and will also be analyzed is the way these identities are further constructed and upheld within academia. Here, most of the interviewees agreed on a stereotype. When talking about their subfield specifically Helen stated that "*the* […] *people are much more like the typical mathematician. Way fewer women. Now, I don't see so many women anymore, no cool people, like I don't really see people at conferences or anywhere and I'm like, wow, you're so cool, I want to be like you.*" This comment suggests that certain images of what a mathematician "typically" looks or behaves like still circulate within the community, often associated with gendered and social norms. Here, "cool" seems to point toward valuing broader social competencies or diversity of identities that are perceived to be underrepresented in this space. This narrative is further strengthened by a comment of Nora stating: "*Lots of males in my, in my office or , um, in my area. Um, and I would say that the people are weird in a way. Mm-hmm. And shy and, but not the male thing, but in , the, the other thing I really appreciate because I feel like people can just be who they are.*" While this comment positively frames acceptance of difference, it simultaneously references stereotypes about mathematicians as socially withdrawn or "weird."

Also, Chris states: "*I do see that mathematics is also a place that might be considered as a safe haven for people who do not feel comfortable with social interaction and communication.*" While offering a potentially inclusive view of the field, this comment reinforces an image of mathematics as particularly suited to individuals who do not conform to normative expectations of sociability. It is important to emphasize that these views reflect perceptions and discourses within the field, rather than objective descriptions of who mathematicians are. Nevertheless, the persistence of such narratives can shape both the sense of belonging and the identity work that occurs within mathematical communities.
On the contrary Paul states "*I think strong mathematicians don't know anything except mathematics.*" Additionally, Paul describes the outer view on mathematics as "*It's like an intrinsic, uh, picture of like, uh, male so it's definitely like some sort of like consequence of education in society.*" This suggests that mathematics is deeply shaped by societal education and cultural narratives. This reflects a broader tendency to locate objectivity in the result of mathematical work, as a rule describing something that exists independently of human influence. Recognition and acceptance, especially when aspects of the process remain opaque or not fully understood depend heavily on the social and institutional contexts framing mathematical practice. This will be explored further in the discussion through the lens of Harding's (1996) concept of weak objectivity.

However, one interviewee also noted a positive aspect of the outer perception of mathematics: "*if some subject has, um, the reputation that it's very, very difficult, and that it's very, very somehow hard to, yeah, penetrate, then it's, then a lot of people are drawn to it, or some people, you know, are drawn to it because of that.*" (Chris, personal communication, March 12th, 2025). The earlier quote by Nora further illustrates this dynamic. They acknowledged that mathematics is a hard subject but had somewhat this ambiguous relationship with it. It can be interpreted as being drawn to the challenge of it. This resonates with my experience of mathematics as well. Even though I felt like I was not good enough and the workload was hard, I somehow thought I needed to prove to myself mainly, not to others that I was capable. This is a narrative that I found in a lot of other interviews as well, not only with the female participants.

6.1.2 Belonging and identity

Building on the previous discussion of the "male genius" narrative, this subchapter explores how feelings of belonging and exclusion emerge in mathematical communities. These dynamics often arise when an individual's identity does not align with prevailing stereotypes of who a mathematician is or should be. Belonging in this context is not merely social but also epistemic: it influences how individuals participate in knowledge production and how their contributions are received.
This is where theoretical insights become particularly relevant. Belonging, as I understand it in this analysis, is not a fixed state but a process shaped by disciplinary norms, social context, and epistemological assumptions. As discussed by scholars like Anzaldúa (2012), identity and belonging are

negotiated in *borderlands,* in-between spaces where individuals hold multiple, sometimes conflicting, positionalities. These blurred boundaries are precisely where epistemological beliefs and researcher identities are constructed.

Mika observes that "*mathematics does not develop from a single person, it develops from a small community.*" While a later chapter will explore the nature and structure of these communities, this section focuses on the role of collaboration and the affective dimensions of belonging. While the stereotype of the solitary genius persists, several participants describe mathematics as a collective endeavor. This shift, perhaps reflecting broader changes in the field, suggests that belonging is not only shaped individually but also co-constructed through group dynamics. As such, this chapter examines how collaborative identity formation influences who feels entitled to take part in mathematics, and how these feelings of inclusion or exclusion affect the epistemic culture of the field.

Even though the focus of the interviews was on seeing mathematics as a "team effort" there were occasions where the community was seen as "toxic" or problematic in other ways. This will be further elaborated on in the next subchapter on diversity and inclusivity within mathematical knowledge production. Of course, this also ties into the last subchapter of the analysis on the role of authority within mathematics.

"*Because mathematics is so kind of, you, you rely so much on heuristics and on abstractions that are so kind of, they have so much behind them that they are, you think about them in a very simple way, but they are ultimately very complex. So it's very, very hard to do alone.*" "[Mathematics] *is a social thing and it's not something you can really do alone.*" (both Nils) These quotes highlight how mathematics is fundamentally collaborative. When seeing mathematics as a discipline where only singular, lonely geniuses can achieve something, it leaves out the rest of the mathematical community within the analysis but at the same time also the space and role of other individuals to find their space within the community if it is not on the top. When looking at the theory of Butler (1990) and their perception of performativity this all comes into play. Not only does the image of the genius perform itself but more it is performed from people within the community. This then projects a certain imagine into the outer perception of mathematics. Combining this with Anzaldúa's concept of borderlands (2012) this can be understood as several intersecting identities that are negotiated within the field.

I would like to use this theory in order to explain how certain images of mathematics are performed from within and from the outside. What is the perception of a mathematician and how is this performed by the PhD students in the mathematical community. Here the focus will also be on gender, what is the perception of men, women* or non-binary persons in the mathematical community and how do they participate in holding up this image or not. This was a narrative that could not fully be captured throughout the interviews.

What was also interesting was the role the VSM played for some of the interviewees. Nora describes it as: "*I feel like the university is a place, or at least like my university environment, is where you can decide a lot about yourself, how involved you wanna be. And how not involved you wanna be. So for me it was important to be like part of the female network*[21]*, part of the VSM. So just that I feel like I belong here. Like I connect to people. But then others like in my office, they, they are very not, not involved in everything. And I think they also, because they wanna do it this way.*" It becomes apparent that institutions and groups, at least for this interviewee, are part of the identity formation and getting a sense of belonging there as well. Before stepping into university, Helen describes her initial prejudice as "*I can't see myself as a mathematician like none of these people are like me but then when I went to university, there were a lot of people like me.*" The absence of role models will further be described in the subchapter dealing with diversity and inclusivity. It fits in this subchapter as well as the lack of reference points can also lead to a feeling of not belonging. As Ben states: "*Even if you see many female professors, you still know that it's a male-dominated field somehow.*" Again, this is further elaborated by Nora, commenting: "*I think that like insecurities that I have also come from the fact that I am female in a male dominated field, um, it's not, it does have an influence.*"

6.1.3 Performing the mathematician

This theme emerged in the interviews through reflections on the challenge of aligning one's identity with the dominant image of the mathematical community. Many interviewees did not explicitly articulate a defined sense of belonging or exclusion but described subtle tensions in how they fit in within the field. Initially, I attempted to trace this through a code labeled "bias in mathematics," but ultimately removed it, as these dynamics often manifested in less direct, more complex ways that were not easily captured by the concept of bias alone.

Helen describes this tension: "*I've never really related to the men* [within mathematics] *because I think the main difference for me, for women is that women are much more sociable and they tend to have other hobbies or at least like a family on the side or whatever, whereas I think a lot of mathematicians in general but even more so men, only have maths and don't do anything.*"

What became clear is that there is no singular identity of a "mathematician." Rather, identities in mathematics are socially constructed, discussed, and lived through engagement with the discipline. Instead of fixed characteristics, what emerges is the repeated use of stereotypes that both shape and constrain how individuals see themselves and others within the field. Butler's theory of gender performativity offers a framework for interpreting these patterns. Butler (1990) suggests that identity (particularly gender) is not an innate trait, but something produced and reproduced through repeated performances in line with social norms. This perspective is particularly useful in analyzing how

[21] Nora refers to one of the feminist networks at the Technical University of Vienna (https://www.tuwien.at/en/tu-wien/organisation/central-divisions/gender-equality-office/fix-the-institution/feminist-networks-at-tu-wien).

identities in mathematics are enacted, resisted, or internalized in relation to dominant disciplinary expectations. Again, complementing this, Anzaldúa's concept of *borderlands* (2012) emphasizes the fluid, intersectional, and often contradictory nature of identity. Her framework is useful for understanding those who exist at the margins of the mathematical field whether due to gender, culture, race, or epistemological positioning. Together, Butler and Anzaldúa allow for a deeper reading of the ways in which mathematical identity is not only performed but also navigated and negotiated at the intersections of multiple forms of difference.

This theoretical lens becomes visible in participants' comments on their perceived novelty or marginal position within the field. For example, Jack remarked, *"I probably can't speak to this, I'm new in this field…*", reflecting a kind of epistemic modesty and deference that also hints at perceived limits of legitimacy. This humility is not unique to early-career researchers but also reflects a broader consensus that mathematics is a vast, difficult field one in which no one can ever fully "master" everything. In contrast to other scientific disciplines where reproducibility is the primary standard of rigor, mathematics is often framed as inaccessible not due to reproducibility issues, but because of the intellectual opacity of its content.

Thus, the genius narrative is not only perpetuated by outsiders but also sustained internally. The idea that only certain types of people, often perceived as innately brilliant, can fully access or understand mathematics reinforces both implicit and explicit boundaries around who belongs. Yet, at the same time, some participants highlighted the importance of diversity in academic settings, particularly in improving the experiences of students and increasing representation. These comments were often brief, but they indicate a desire to shift the field toward a more inclusive understanding of who a mathematician can be.

Helen remarked: "*Older people and professors just do know so much more,*" a sentiment that was repeated by Nora, who shared: "*I don't really know what the other PhD student of my group is doing. I mean, we can talk about it, but I can't help him. Definitely not."* Additionally, as many interviewees expressed hesitation or humility when reflecting on philosophical or epistemological questions, often situating themselves as too junior or inexperienced to speak authoritatively. It could also be interpreted through Harding's lens as a manifestation of the disciplinary culture itself (Harding, 1996). The reluctance to critique or even comments on the epistemic foundations of mathematics may also reflect internalized norms about what kinds of discourse are permissible or valued within the field, especially for those still in training.

6.2 Diversity and inclusivity within mathematical knowledge production

This subchapter emerged from the codes "diversity in mathematics", "contextual influences" and "personal experiences within mathematics". It is also used to identify different social and cultural influences within mathematics. It builds on the chapter before as the outer and inner perceptions of what a mathematician is does have an influence on the cultures and practices in the discipline.

"It doesn't matter who writes down the proof […], *you can follow the logic.*" It "*makes* [mathematics] *more objective than fields where background matters more to the argument."* "[Mathematics] *is very objective. It's not subjective at all. It doesn't matter if I write down the proof, it doesn't matter if you write down the proof, it doesn't matter if, I don't know male, female, German, Austrian, Chinese person, whatever.*" (all Jack, personal communication, November 28th, 2024)
These statements reveal a strong internalized belief in the purity of mathematics and align with dominant narratives that frame mathematical knowledge as existing outside of culture, politics, or human subjectivity. While this framing reinforces the idea of mathematics as a "universal language," it also risks obscuring the social and institutional structures that shape who gets to participate in mathematical knowledge production, and ultimately how that knowledge is legitimized.
Nils remarked: "*People who are not from European countries or Western countries in general and also some Asian countries are very underrepresented in math. So, so there's this sort of paternalism toward African communities somehow. That, uh, they are very not privileged."*
However, even those who valued diversity often framed it as external to the production of mathematical knowledge itself. For example, diversity was seen as beneficial for mentoring, inclusion, finding role models and support, but not as something that might influence the epistemological frameworks or methodologies used in mathematics. For me, this distinction is crucial, as it points to a disconnect between the social composition of the field and the assumed neutrality of its epistemic practices.
This tension reflects ongoing debates in the philosophy and sociology of mathematics which have been mentioned in the chapter covering the state of the art: Is mathematics truly culture-free, or is that belief itself a culturally situated construction? The idea that "anyone" can verify a proof may be true in principle, but in practice, access to the language, tools, and communities of validation is often shaped by educational background, institutional affiliation, and even linguistic and cultural fluency. As such, the "myth" of universality may mask real barriers to entry and participation, especially for those from underrepresented or marginalized groups. This is connected to the epistemological beliefs which I identified within the data which will be further analyzed in the following subchapter.

One interviewee stated: "*at least our institute is rather good on the quota female to male, I guess. Also, I don't know it does not really make any difference to be honest.*" (Mika, personal communication, February 5th, 2025). This was not a common experience. As Chris noted: "*we have a lot more men than we have women, especially at* […] *senior levels.*" Nora states: "*I wouldn't say* [mathematics is] *diverse. It's like too male dominated to say that. And also. Yeah, I mean white.*" "*There are not a lot of women in mathematics.*" (Jack, personal communication, November 24th, 2024) Most of the comments on diversity during the interviews focused primarily on gender-based diversity. Several interviewees expressed a general wish for more diversity, but these reflections were often vague and rarely linked to epistemic concerns. Interestingly, while there was a recognition that greater diversity would improve representation and student experiences, few participants articulated how it might enrich mathematical knowledge itself. This disconnect resonates with Gläser's (2006) question of whether institutional diversity is a prerequisite for epistemic diversity. In a field like mathematics, where evaluation criteria and epistemic norms are highly standardized, simply increasing demographic diversity is unlikely to foster epistemic diversity unless institutional mechanisms also change. Without systems that actively recognize and reward different forms of contribution, the space for epistemic innovation remains limited. Chris reflected on this potential dynamic: "*Yes, mathematics will be different if it were more, if there were more, if there was more diversity*." They further explain: "*that's a problem because, uh, somebody who might not, uh, have this point of identification, like, have a role model in* […] *the field, then will feel much less compelled to* […] *try it.*" When asked about how the lack of female role models affected their experience, Nora stated: "*I would say that's a reason to do math as a woman. Yeah!*"

Other participants expressed more neutral or skeptical views about the relevance of diversity to the epistemic core of mathematics. Mika stated: "*Mathematics are the same, persons are different anyways.*" Nora added: "*The pure math, I think it can't be feminist or not feminist or sexist*." Similarly, Helen commented: "*if you're a good mathematician people still like value you for the maths, um and I don't think they care so much where you're from or whatever but I do think in social situations a little bit of a problem.*" Ben stated: "*I don't know how much it reflects on the mathematics, in sense, in the sense that, if they publish an article, I don't think that, people are looking at, the, the author is, a female author, and so, it's worth less, I don't think that, this is happening*" Jack speaks from his own experience: "*I can't imagine. Reading a proof and seeing, yeah, this is definitely written by a woman or whatever. I don't feel that would be possible. Just again, because you can't you, you don't write a long text or whatever.*"

Jack had another similar comment: "*More diverse people in positions of power, such as a position of a professor would be beneficial for mostly young students and not necessarily for the mathematical knowledge because just, as long as they they are of the same quality as the other people in this positions, the mathematical knowledge will still stay the same.*"

These remarks highlight a common view: while diversity is appreciated on a social level, it is not generally seen as epistemically relevant to the practice of mathematics itself. Paul's perspective adds another layer to this discussion: "*I think the percentage of men and women are, is not the same but I think that doesn't really doesn't really relate to the fact that it's not inclusive.*" This reflects a broader tension: while most participants acknowledged that mathematics is not demographically diverse, few described it as an exclusionary field in an active sense. The prevailing belief was that mathematical ability is valued above all else, a view that may itself obscure how implicit norms and structural barriers affect participation. This is describes by Nora as: "*I wouldn't say it's inclusive, but it's like the people* *who are here can be how they are. More like in terms of personality, I would say, than in terms of diverse background.*"

Interestingly, one interviewee described diversity as a skill that requires learning and growth: "*It's, you know, being comfortable in a diverse environment and being able to communicate differences between people, like culturally, and all, that requires, like, some sort of sensitivity and training and it's not easy for everyone, not always. Like you need to learn it and you need to grow comfortable with it."* (Chris, personal communication, March 12th, 2025)

As previously discussed, mathematics does not currently offer a particularly diverse research environment, neither epistemically nor demographically. However, many interviewees did not perceive this as a problem of inclusivity, which points to a more subtle hierarchy of values within the field. This brings me to the next topic: epistemic hierarchy within mathematics, where the mechanisms of inclusion and exclusion operate not only at the level of identity but also through assumptions about what constitutes legitimate mathematical knowledge.

6.3 Epistemological beliefs within mathematics

This subchapter aims to answer my first research question: *How do different kinds of mathematical knowledge and epistemological beliefs shape the situatedness of PhD students in mathematics and their objectivity within the field?*

To address this question, the analysis is structured into three thematic subchapters. The first explores epistemic hierarchy and authority, examining how power and legitimacy are constructed within the field of mathematics and how these shapes perceptions of objectivity and participation. The second subchapter focuses on intuition and mathematical certainty, analyzing how participants navigate tensions between formalism, intuitive reasoning, and the quest for certainty in mathematical practice. The third subchapter examines the presence of absolutist and fallibilist epistemological beliefs within the data and considers how these belief systems shape the definition and validation of mathematical knowledge.

This structure allows for a layered understanding of how mathematical objectivity is perceived, enacted, and contested, moving from questions of institutional power to epistemic practices and, finally, to underlying belief systems.

6.3.1 Epistemic hierarchy within mathematics

This subchapter emerged from the code "subfield specific" and was later on connected with the code "authority in research". Additionally, the findings from the codes "fallibilist perspective" and "absolutist perspective" were integrated. It can be seen crucial to answering the research questions on epistemological beliefs as through establishing their individual subfields, the researchers mostly also

distinguished themselves from other (natural) sciences. Through this, a related theme that emerged was the hierarchical distinction between pure and applied mathematics. Several participants made subtle or explicit references to pure mathematics as the “real” or “higher” form of mathematical knowledge. This hierarchy often placed applied mathematics in a more utilitarian or instrumental role, while pure mathematics was described as more abstract, elegant, and closer to the “essence” of the discipline.
This distinction further reinforces the idea of mathematics as isolated from context: pure mathematics is valued precisely because it is *not* tied to real-world applications, making it easier to frame as objective and context-free. However, this framing also raises more questions: Who defines what counts as “pure” or “real” mathematics? And how might those definitions reflect historical and cultural biases, institutional power structures, or academic traditions that privilege certain kinds of knowledge over others?
In this light, many of the responses can be read not just as reflections of personal belief, but as reproductions of disciplinary norms, what Bourdieu might describe as the *habitus* of mathematics (Bourdieu , 1977). *Habitus* refers to the system of durable and embodied dispositions, this includes ways of thinking, perceiving and behaving, that individuals acquire through socialization within particular fields. It is not merely individual preference or conscious choice but a product of one’s position and experience within structured social spaces (Bourdieu, as cited in Heintz, 2007). In the context of mathematics, this includes implicit norms around communication, authority and epistemic legitimacy. The before mentioned humble tone adopted by many participants (“*I probably can’t speak to this, I’m new to the field…*” (Jack, personal communication, November 28th, 2024)) may not only reflect genuine modesty, but also a sense of caution or deference toward speaking on topics that lie outside the traditionally accepted boundaries of mathematical discourse shaped by this disciplinary *habitus*. This raises further methodological considerations: To what extent did my participants feel empowered to reflect critically on their discipline, and how might their academic positioning have constrained what they felt comfortable expressing? However both forms reflect a distancing from the dominant genius narrative and may suggest a fallibilist or relational approach to mathematical knowledge.

When commenting on diversity, Jack stated: “*They’re still established societal or yeah, hierarchies or whatever with the inherent discrimination that comes with hierarchies of any kind. Of course, I wouldn’t say it has nothing to do with societal issues or whatever. But I feel like it is as disjoint as one could hope for a field.*” When analyzing this quote, it can be read as a comment on either institutional hierarchies or epistemic hierarchies. “*So, there are some results which are probably, well, there’s no application for it, and still, um, the proofs are so elegant, and, uh, the result is so elegant that people care about it*.” (Mika, personal communication, February 5th, 2025) On the contrary, “*there is like even like a small seed of proudness of being completely useless*.” (Paul, personal communication, February 4th, 2025)
When Chris describes their research, they state: “*We do things that are so removed from, you know, anything that relates to our personal identity or to our everyday life.*”

Overall, these reflections have led me to reconsider the assumptions embedded in my research questions and interview guide. While I originally sought to explore how epistemological beliefs shape perceptions of objectivity and authority in mathematics, I now see that these beliefs are not just held by individuals. they are structurally reinforced by the disciplinary culture of mathematics itself. Moving forward, a key task will be to link these findings more explicitly to the broader literature on epistemic cultures and academic authority, in order to draw more nuanced and critical conclusions.

6.3.2 Intuition and mathematical certainty

Another recurring theme in the interviews was the role of intuition in mathematical practice. Often contrasted with formalism and axiomatic reasoning, intuition was described as a central, yet a hard to define, component of doing mathematics. Axiomatic reasoning describes the practice within mathematics where you before going further with the proof decide on a fixed set of axioms that works as a basis for the reasoning.

This framing reinforces the idea that mathematics is inherently intuitive for some and inaccessible for others, echoing the genius narrative and potentially obscuring the years of training, effort, and socialization that make such "intuition" possible. Helen describes it as: "*it's still subjective because you still need to agree on these axioms that you follow which, yeah, it's true. But I think you always need to agree on something to have any sort of discussion so I think any sort of like philosophical debate is always about relations between things and you always have to, to start something otherwise, yes, then you can't know anything and you can't argue about anything. I agree with that statement but it just doesn't get us anywhere because then we can't have conversations.*"

As Chris put it: "*It's much more about intuition than axioms.*" This aligns with Heintz's (2004) observation that while mathematical formalism is idealized, much of real-world mathematical work relies on intuitive, experience-based reasoning, something difficult to formalize and even harder to teach. Jack deepens this perspective: "*You sometimes need the experience or background knowledge to have a feeling that it should work.*"

Interestingly, Jack stated later: "*for the mathematics that I'm doing you just need books and pen and paper, you don't need a lot of resources that could gatekeep certain people but still of course, it's done in universities.*" Even though he mentioned this when talking about access to resources, I think it highlights an important tension: Not a lot is needed for mathematics, just pen and paper and intuition. These reflections highlight a kind of epistemic authority grounded not in formal correctness but in experiential knowledge, something similar to a "feeling for the math" that becomes recognized as legitimate over time. As Gläser (2006) suggests, authority in scientific communities often stems from repeated performance and accumulated credibility, rather than from static hierarchies or formal credentials alone. While this "feeling of being on the right track" may be common across many scientific disciplines, in mathematics it holds significance due to the distinctive role and negotiation of intuition within the field.

This also links to questions of certainty and truth in mathematics. Helen remarked: "*I don't think we actually can know for sure that something is 100% correct just because we as human beings are flawed and we might be assuming wrong.*" This skeptical stance complicates the assumption that formal proof guarantees certainty. Ben offers a contrasting absolutist view: "*If you start with these assumptions and these rules, then this holds in every case.*"

What emerges here is a central analytical tension: Is mathematical certainty equivalent to truth? Or is it a product of epistemic frameworks, shaped by the tools, contexts, and assumptions of those producing the knowledge?

Most of my interviewees also implicitly raised distinctions between "true/false" mathematics and "good/bad" mathematics. The former refers to logical correctness, while the latter may relate to elegance, usefulness, or originality. Nora describes it as: "*I would say there is good and bad proof. Or like elegant and ugly or. Uh, tedious and smart or whatever. But yeah, I, no, I think it's just, um, the nicer a proof is the more knowledge was there to be used for the proof, but it's not good or bad, it's just, it grows and then when it grows, it gets nicer.*" Jack was a bit more hesitant: "*I wouldn't say that there is a cutoff line that you say, okay, if you don't know this concept, then you have bad mathematical knowledge.*"

This code is especially relevant in the context of seeing intuition as part of an epistemological belief. These distinctions suggest that epistemological beliefs in mathematics are more layered than a simple absolutist/fallibilist binary, and that affect, aesthetics, and experience all play roles in how mathematical knowledge is judged and valued. I will however, go on and elaborate in the next two subchapters to what extent both of these epistemological beliefs can be found in my interviews and end with what this means for the context of knowledge production. This subchapter leads into the next, where I examine the presence of the absolutist perspective in my interviews and discuss its implications for understanding knowledge production.

6.3.3 Absolutist belief

This subchapter draws on the codes "absolutist perspective" and "objectivity (definition)" that emerged during the analysis.

Chris, for example, commented: "*Everybody thinks of mathematics as a very rigid science where everything is kind of clear and well-defined.*" This quote reflects a dominant external perception of mathematics, thus as fixed, unambiguous, and rule-bound. Similarly, this was said by Paul: "[There is this] *kind of big misconception of math being like this, big, perfect dawn thing of like pure objectivity.*"

Helen highlighted the emotional and expressive contrast between mathematics and other disciplines: "*I think art, like, aims to express, like, human emotions and connection and kind of wants to, to like express someone's personality, whereas maths actively does not want to do that.*" At a different point in the interview, they also stated: "*I think that maths has this claim to objectivity like it wants to distance itself as much as it can from people and it wants to be objective.*"

When asked about the objectivity of mathematics more directly, Helen elaborated: "*It still makes a difference how you choose to think about a problem, like which questions you choose to answer and how you approach it, um and, also how you present it because people present maths in very different ways. And while I agree with all of this, again, I think the output is just the same.*"

Helen's statement reveals an important tension. While they acknowledge the variability in approach, interpretation, and presentation, they still emphasize the fixedness of the result. This framing could be interpreted as leaning towards the Problem-solving approach described by Greene et al. (2016), where the process is subjective, but the outcome remains objective and universally valid. A similar stance can be seen in a comment by Ben: "*it's mathematics, it's, again, made by human, and so, it's, this plays a role, even though, it's, mathematics, per se, it doesn't, it doesn't care about all of this.*" Here, Ben is referring to questions of diversity and inclusivity in mathematics. His comment illustrates the belief that while social factors may shape how mathematics is practiced, the mathematical content itself remains untouched by such influences. This further reinforces the view that mathematical knowledge embodies a pure objectivity that transcends social context.

This pattern, the agreement on the objectivity of mathematics despite the diversity in how it is approached, was common across many of the interviews. It positions mathematics as a unique discipline: while most sciences strive for objectivity, mathematics is presumed to already embody it in its purest form. However, this presumption deserves critical scrutiny. What I aim to highlight in this thesis lies in the subtler layers beneath that assumption. Scholars such as Knorr-Cetina (1999) have examined knowledge production in the natural sciences, emphasizing local practices, tools, and social dynamics. Yet applying the same methods to mathematics proves challenging, as discussed in the methodology chapter. Mathematics does not appear to function in quite the same epistemic way; its claim to objectivity is not only methodological but also ontological.

Thus, returning to Greene et al.'s (2016) typology, these reflections, particularly Helen's, align closely with the Problem-solving perspective: while variation in method and communication is acknowledged, mathematical knowledge is still ultimately treated as converging on a single, objective truth.

While the Problem-solving perspective was particularly prominent among participants, other forms of absolutist epistemological belief were also present in the interviews. In particular, several interviewees expressed views that align with either the Platonist or Instrumentalist perspectives outlined by Greene et al. (2016), meaning that some viewed mathematical truths as existing independently of human thought (Platonism), while others saw mathematics as a practical tool developed to solve problems, with its meaning grounded in its utility (Instrumentalism). The following section explores how these orientations appeared in participants' reflections on mathematical knowledge and practice.

Mika articulated a view that aligns closely with the Instrumentalist approach: "*Mathematics provides, like, a kind of pure way to describe things*", they further elaborate: "*this pure reality, where you don't, but you, you remove all of the unnecessary and also annoying parts of it, and you stay, essentially, with*

[…] *this pur*e" Here, mathematics is seen not as a discovery of inherent truths, but as a tool for abstraction, a way of representing an idealized version of reality stripped of messiness. The focus lies on usefulness and clarity, which are core tenets of the Instrumentalist perspective.

Jack expressed a view more aligned with Platonism when asked about the influence of culture and identity on mathematics: "[It is] *as disjoined from cultural factors as anything could be.*" Ben adds to this, saying: "*I guess it's still the main idea behind math somehow, that it doesn't necessarily need to be so related to reality.*"

Nils was more reflective about the philosophical implications of this stance: "*I'm very fond of Platonism. I'm not a Platonist. But I do think that I have sort of philosophy of mathematics as you have, like, uh, I think it's, it's a good thing for a mathematician to pretend that their objects are real all the time. And it's, uh. There's also this very thing that this, this thing where you say all the time exists or there exists.*"[22]

Nils' comments reflect the performative dimension of Platonism in mathematics: while not claiming an ontological commitment to the existence of mathematical objects, they recognize the pragmatic and epistemic value of treating them as if they exist, a common practice in formal mathematical reasoning.

Further supporting this, Nils elaborated: "*the thing that some mathematician would do is usually, they would start from the theory instead of starting from some experiment or whatever. So, so they would usually think that, um, the thing that they're studying is just, um, this shell, which has been constructed from the whole theory from the beginning, and it has very specific properties and they don't care about whether these properties are satisfied by a real object or not.*" This view exemplifies the Platonist orientation toward the internal coherence of mathematical structures, rather than their empirical grounding.

A key theme that emerged across the interviews was the role of axioms in shaping objectivity. Participants acknowledged that the choice of axioms involves subjective judgment, but maintained that once a foundational system is chosen, objectivity is restored within that framework. Ben commented: "*The choice of actions, um I mean axioms is no*t [objective], *and then you can discuss, but then from there on, it is objective*." Mika adds to this: "*as a mathematician, I have my set of axiom, kind of, which I believe in, and I don't question it.*" This illustrates how conditional objectivity operates within the absolutist framework: while initial assumptions may be negotiable, the resulting knowledge is treated as fixed and objective within that system of assumptions. This pattern aligns with both the Problem-solving and Platonist perspectives, depending on whether the emphasis is on practical utility or ontological commitment.

[22] What Nils is referring to here is a common convention in mathematical proofs, where the existence of an object is assumed or asserted using formal language such as "there exists" or "for all". This reflects a standard way of reasoning in mathematics, where objects are treated as if they are real and well-defined within a given axiomatic system, regardless of their ontological status (Piatek-Jimenez, 2010).

Overall, elements of all three absolutist ways of being a mathematical knower, thus Platonist, Instrumentalist, and Problem-solving, were reflected in participants' accounts. What remained consistent across these perspectives was a rare questioning of the objectivity of mathematical knowledge itself. The process of doing mathematics was sometimes seen as subjective, but the outcomes were nearly universally treated as objective. As Nora succinctly put it: "*Math is objective. But doing math, maybe not*."

This quote provides a bridge to the next subchapter, which turns to the fallibilist perspective within mathematics, a view that challenges the assumption of fixed, universal objectivity and instead highlights the situated, evolving nature of mathematical knowledge.

6.3.4 Fallibilist belief

This subchapter developed from the codes "fallibilist perspective", "objectivity (context)", "contextual influences" and "(mathematical) science community" that emerged during the analysis.

Building on what has been said in the previous chapter, the analysis shows that fallibilist element were also present in many of the interviews. Several interviewees articulated the view that while mathematical results may be treated as objectively valid within a formal framework, the processes shaping mathematical knowledge and its production are influenced by social, cultural and institutional factors.

The fallibilist thread also runs through most of my interviews. Nora articulated this particularly clearly: "*A result of theorem is objective. Like if the proof works, if the, then it's just a true theorem. And then that's, it doesn't depend on who wrote the proof or where the proof is written, it's just there's a proof, there's a theorem. But I think it, like how it evolves, what kind of things are approved and what kind of things are like funded, what in which direction do people work? That's like, that depends on people. So it's not objective*." (Nora, personal communication, March 11th, 2025). Here, Nora draws on a critical distinction: while the formal correctness of a proof can and mostly is treated as objective, the social dynamics of mathematical knowledge production are explicitly shaped by human and institutional factors. This means what is valued, funded and further pursued. Broadly speaking, this aligns with fallibilist thinking.

Jack also connects this idea to questions of identity and representation in the mathematical community, returning to the important theme of role models: "*The mathematical results doesn't, don't change whether a female or male wrote it down but I felt, but I feel like it would be, or I've, I see that it's that it's encouraging for young female students if there are also a few female professors there to be an example.*" This comment highlights how the context of knowledge production matters, not in changing the value of mathematical results, but in shaping who participates in mathematics in the first place and how they experience the field.

Ben, who earlier expressed a more absolutist stance, also acknowledged the importance of the human side of mathematics, though only when prompted to reflect on changes and wishes for the field at the end of the interview: "*there are changes I would like to see more in the, more in the human side somehow, the community side of more, being more inclusive*".

Nils provided a more nuanced perspective on the human dimension of mathematics: "*there's a very human thing in doing mathematics in the sense that there's part of the human experience that can only be understood by doing mathematics and that people do it in their head*s." At this point, it is useful to connect these reflections to existing theoretical frameworks. The way Greene et al. (2016) describe adherents of the fallibilist and constructivist perspectives, aligns closely with the views expressed by interviewees such as Nora, Jack, and Nils. Similarly, social constructivist perspectives emphasize that knowledge is not developed in isolation but emerges through language, cultural contexts and social interactions, all of which shape individual cognition and communal mathematical practices.

In contrast to what Helen had said earlier about mathematics and art being very opposite of each other, Nils commented: "[mathematics is] *a very human thing. I think it's also somewhat of an art for a very reasonable definition of art.*" However, they also state: "*when it's abstraction and simple reasoning, it's math.*"

Later in the interview, Nils further reflected: "*I believe that you cannot have like a* [mathematical object] *without, um, the human element.*" This quote illustrates a key point: multiple epistemological beliefs can coexist within the same individual. Even participants who see mathematics as abstract and formal may also recognize the deep social, cultural, and human dimensions of mathematical practice. These seemingly contradictory stances often emerge simultaneously, highlighting the complexity of epistemological beliefs in mathematics.

This observation will be deepened in the discussion, which explores the duality of epistemological beliefs, how both absolutist and fallibilist perspectives can be held in tension by the same individuals, and how this shapes their understanding of mathematical knowledge.

6.4 Mathematical knowledge

This chapter aims to answer my second research question: *How is mathematical knowledge defined and validated within academic institutions in Vienna, and who holds the epistemic authority in these processes?* This subchapter builds on the analysis of epistemological beliefs presented in the previous section. There, it became clear that both absolutist and fallibilist perspectives are present within my interviewees' narratives. The question that now arises is whether, and in what ways, these beliefs influence how mathematical knowledge itself is defined, and conversely, how prevailing definitions of mathematical knowledge may reinforce particular epistemological positions. In other words, does the epistemological standpoint of mathematicians shape what counts as valid mathematical knowledge and who has the authority to define it?

The unique position of mathematics within the academic landscape has already been discussed by scholars such as Greiffenhagen (2023) and Reinhart (2012), particularly in relation to the role of peer review and processes of validation. Mathematics often differs from other fields in that validation does not rely on empirical testing or experimental replication, but instead on proof and the ability of results to "*stand the test of time*." (Helen, personal communication, February 4th, 2025) This dynamic also emerged in my interviews. Several participants referred to the role of preprint servers such as arXiv in disseminating mathematical results. As Helen noted: "*people kind of assume that if it stands like the test of time for a long time it will be correct.*" This highlights a distinctive feature of mathematical knowledge validation: temporal endurance and community acceptance play a key role in establishing correctness, often in place of empirical verification. The following subchapters explore how mathematical knowledge is defined and validated both within the mathematical community and in the context of science communication aimed at broader audiences.

6.4.1 Within the community

In this subchapter I will put my focus on how mathematical knowledge is defined, circulated, and validated internally, among peers, within research groups, or disciplinary networks. I examine peer review, conferences, informal exchanges, and institutional norms and their impact on shaping what is recognized as legitimate mathematical knowledge. This will help me further elaborate on the negotiation of epistemic authority and belonging within mathematical cultures.
This subchapter builds on the following codes: "research in general", "value of knowledge", "validation of knowledge", "research authority" and "peer review process". Together, these codes have been organized under the broader title of "authority and validation in mathematical knowledge production". Another code that has been used a lot for this was "idea of a math genius/ perception of math from the outside".

The aim of the three codes "research in general", "value of knowledge", "validation of knowledge" was to capture ways in which knowledge is being validated in relation to authority and how these processes shape definitions of mathematical knowledge. These codes also reflect broader experiences of being in academia, particularly around questions what counts as good or bad mathematical knowledge. The distinction between "validation of knowledge" and "value of knowledge" was important: while validation, for me, concerns the formal acceptance of knowledge (through mechanisms such as peer review), value also includes more personal or community-based judgements about the significance or worth of particular contributions.

To begin, I would like to introduce a comment of Mika, which highlights the relationship between communication and the perceived value of mathematical results: "*You cannot attribute good or bad to a mathematical result. It's just how good and how bad is it communicated to someone.*" Mika adds "*it's* *more* [about] *how you formulate things, and how you communicate this to others.*" This underscores the importance of presentation, precision and trust in shaping how the knowledge is received within the community. Mika also reflected on this dynamic in relation to academic hierarchies: "*As a PhD student, you have to be very precise and you have to be, um, you have to be, and also this is what my co-supervisor said, you have to be very precise and you have to be very good in communicating every single detail because people don't trust you.*" Here, the question of trust and experience becomes apparent, linking directly to the formation of epistemic authority within the field. Authority in mathematics is thus not solely tied to the correctness of results, but also to a mathematician's perceived credibility and their ability to communicate and defend their work.

This dynamic was echoed by several other interviewees in a similar way. Chris, for example, described their supervisor's authority as grounded in both experience and institutional power: "*I go to him now, it's because I benefit from his experience, from his knowledge. And so that is what gives him* […] *this kind of leverage and this kind of* […] *standing.*" Chris further connected this to questions of research funding and influence: "*Being able to* […] *write good applications for funding will give you more power. And, yeah, sure, in a way, this, I mean, really literally authorizes you to define what is interesting and what should be studied.*" "*These voices are usually, you know, people who are senior faculty who have a lot of experience in mathematics. I mean, on the other hand, it's authority that is based on your status and on the other hand also authority that is just based on your experience, your merit, that you have an overview, that you have studied this subject for, I don't know, 30, 40 years.*" Helen also emphasized the importance of experience in shaping authority: "*How like research works, how the community works, what is relevant. Like that's actually very not trivial and I think professors just have like a very broad view"*, continuing: "*I feel like they know a lot, they've seen a lot of different things, they know what different people work on. They've just like experienced so much more and I think that helps a lot.*" Ben made a similar point in relation to research collaboration: "*In the project with him, for sure he has more saying, but it comes more from the fact that he has more experience, so he knows that, I don't know, some path will probably not* [go] *anywhere.*"

All of these statements fall into a common narrative in which authority is tied to both experience and community recognition. This pattern aligns with Gläser's (2006) observations that within research communities, informal authority often emerges not from formal titles or positions but through the recognition of one's expertise and contribution by peers. In my data, this is evident as participants emphasize the importance of being acknowledged by their mathematical community and accumulating experience as key sources of authority in knowledge production.

Others, like Paul state: "*strong mathematicians are way more heard than like weak mathematicians but like and that makes sense.*" This proves to be an interesting quote as it does not make a distinction between experienced or unexperienced directly, but rather connects authority to skill, more specifically talking about strong and weak abilities. They further explain: "*I think it is like related to the research* *output or yes, in some way, in some way, like yes, uh, if you talk about like a research output and usually like prominence in mathematics*". More: "*You earn* […] *your power from showing up that you actually have something to say.*" (Paul, personal communication, February 4th, 2025)

Interestingly, some interviewees did not connect power and authority directly, here most of the power was given to the mathematical community, more explicitly rejecting the idea of centralized authority. Ben commented: "*There is not exactly some, some, I don't know, some broader authority that decides, ah, these are the topics that are interesting, there is still some, the community takes part, somehow, in this choice.*" (Ben, personal communication, March 13th, 2025). Nils similarly noted: "*I think some authorities determine what to study in certain very specific things, but in general, I think* [what is] *much more relevant* [is] *the result, the end result of the whole crowd, which is usually a small crowd also.*" These comments suggest that while individual authority is significant, there is also a shared belief in the collective authority of the mathematical community, a perception of the field as somewhat self-regulating and autonomous. This perception is particularly interesting in light of the low levels of diversity and reflexive awareness identified in my earlier subchapter on diversity and inclusivity. Despite these structural limitations, few participants questioned the inherent authority of the community itself, a finding that has important implications for how future definitions of mathematical knowledge may evolve.

6.4.2 Peer review

The theme of peer review further illustrates how community authority shapes the validation of mathematical knowledge. Nils remarked: "*if something doesn't get approved by the community, it's essentially not very useful because you wouldn't kind of be able to communicate it.*"

Jack similarly stressed the importance of readability and accessibility: "*It does not help if you write 300 pages of a groundbreaking result, and then no one can read it, because only you can understand what is actually written there.*" Mika gave an example: "*It was a Japanese researcher, I think professor,* [who had] *this groundbreaking result, but no one can verify it.*"

Helen also reflected on the limits of peer review, particularly in their subfield: "*First of all because some of these things are really complicated and some papers are really badly written so not that people actually not that many people can actually follow them enough to check them, um but, yeah, also just it's, yeah, it's hard and some things aren't necessarily all reviewed.*" They also add, that with mathematics, even peer review does not provide full certainty with the correctness of the result, as "*there's no like guarantee for that but then I guess if you publish in a journal there should be more of a guarantee because the editors kind of tell you, you know we checked this, it's correct. In reality, that's often not done because I guess the way that the papers get accepted is, they get sent to like two referees and then it depends on how well they read it.*"

Jack provided another example of the limitations of the system: "*there are these few people and there are also papers on the arXiv, which are 500 pages. That never got peer reviewed because they're so complicated and the only four people in the world who can read them and understand them are the people who wrote them.*" The arXiv is a (mathematical) pre-publishing server.
However, one interviewee stated that in their specific subfield they have established different practices in order to avoid misunderstandings and make the field more accessible. This can be seen as an effort to make peer review validation as a whole more transparent. Mika explained: "*Every paper in our field must have, and otherwise it's not published, a very long preliminaries. I don't even mean introduction, I mean preliminaries where you explain* […] *what you use and why.*" The aim is to ensure that papers are self-contained: "*I could understand everything because he's in his field and explained what he did beforehand.*" (Mika, personal communication, February 5th, 2025). In contrast, Nora highlighted the lack of accessible literature in other subfields: "*It would be very nice to have like more detailed literature. Maybe also more like not only producing something if you have something new, but a nice introduction to my topic in a nice, detailed book so that I don't have to rely on all my colleagues telling me with that, with that, that means that.*"
These reflections point to a structural feature of mathematics: knowledge often builds on complex, layered prerequisites, making verification difficult. The challenge of understanding and validating advanced results means that even groundbreaking work may remain largely unrecognized or unaccepted if it cannot be effectively communicated or verified by the community. In this way, authority, accessibility, and validation are deeply intertwined.

Mika reflected on the importance of persuasion and framing, especially in contexts such as funding: "*He can say it's interesting, yes, this is true, but he also has to convince other people that it's interesting.*" This highlights that mathematical knowledge is not simply accepted on the basis of formal correctness alone but also requires affective communication and social endorsement. Here, the previously discussed barriers such as language, gender, class or institutional background also come into play. Ben comments: "*It's important somehow before, in the sense that, for example, if you are from, I don't know, some very unknown university, or something, maybe you're with, and you publish, maybe alone, and so, you're not very known, or with other people, which are also not very known, maybe you are not able to publish on very high impact factor journals.*" In these comments, communication and institutional status, as well as visibility, emerge as key factors in determining what not only gets heard in academia but also which mathematical ideas end up reaching broader audiences. Nils added: "*You just have to make it interesting to the right people.*" This highlights the role of audience targeting, which can be done during conferences internally but through public narratives externally. This shapes what mathematical knowledge is seen as valuable or worthy of dissemination. Additionally, it shows how these narratives are not neutral but shaped by strategic choices about what to communicate and to whom.

Nils further noted: "*I guess it is not the culture that you are in but the mathematical culture you are in*," pointing to the existence of specific social norms and expectations within mathematical communities that govern knowledge production and validation.

In sum, this subchapter examines how mathematical knowledge circulates within the scientific community, particularly through practices such as peer review and informal validation. These practices are closely linked to broader institutional and academic power structures, shaping both the epistemic and social dimensions of mathematical knowledge production.

However, what has not yet been addressed is how these internal norms and practices connect to broader public perceptions of mathematics. The following subchapter will explore this dimension by focusing on science communication, how mathematical knowledge is represented, mediated, and potentially reinterpreted outside of academic contexts.

6.4.3 Science communication

In this subchapter, I explore how mathematical knowledge is translated for broader audiences, including through outreach, public talks, popular writing, and education. I also address tensions between abstraction and accessibility and consider how external narratives as the "math genius" get reinforced or challenged in public discourse. This will be linked to gendered representations of mathematicians and what counts as "real" mathematical knowledge to the public. The subchapter materialized through the code "science communication". In the interview data, several participants mentioned the need for better science communication. This was described as an issue not only in relation to the public understanding of mathematics, but also in terms of communication between subfields and even across disciplinary boundaries within academia.

As discussed in the first subchapter of this analysis, the outer perception of mathematics remains primarily dominated by the image of mathematics as an abstract, difficult and rather elitist field. The interviews showed a desire among some mathematicians to challenge this perception but also doubts about whether mathematics can be made more accessible. Chris states "*mathematics as a whole should become more open, more accessible.*" Another interviewee, Paul commented: "*I don't think there is a way to make it know more interesting or understandable. Like it's, like one thing built on another thing built another thing built another thing. If you don't know the, the basic structure it's totally impossible to see what happens like on the high side.*" Such statements reflect an underlying tension: while many interviewees expressed a desire to challenge misconceptions about mathematics, there was also a strong sense that certain forms of mathematics knowledge are inherently opaque to people outside of the field.

At the same time, some interviewees expressed skepticism about the possibility of broadening public understanding of advanced mathematics. Mika emphasized "*it's more, like, uh, how you formulate things and communicate this to others.*" Chris added depth to this point by saying "*As in any other field,* *also being a good storyteller is very important, and somehow, yeah, being able to convince other people that what you do is interesting, is very important."* However, this appreciation for effective communication was paired with a sense that it is undervalued in academic mathematics. Chris continued "*Not as much value is given to communication, not quite as much value is given to, like, giving good talks, for example or to teaching*."

Mika also pointed to the consequences of poor communication within the field: "*I don't understand what* [one mathematician] *writes because he communicates it not very nicely*." These insights underscore how communication skills are perceived as both essential and underrecognized within the discipline, even though they significantly impact understanding and collaboration.

Some participants went further, expressing the belief that improved public understanding of mathematics is crucial for the field's broader relevance. Ben noted: "*I think what we need is more people understanding what mathematics is, and mathematical thinking, more than mathematicians per se.*" Nils made a similar observation: "*It is not very well known what mathematicians do or what they think about, or what being a researcher in mathematics means.*" Nils even expressed a personal sense of responsibility, stating: "*I feel like a certain responsibility in my immediate circles now, to kind of, uh, engage in good science communication."*

This subchapter thus reinforces the broader finding, developed throughout the analysis, that mathematical knowledge is defined and validated not only within the mathematical community, but also in relation to external audiences and public narratives. The outer perception through, for example, the image of math genius continues to shape these, often reinforcing existing hierarchies and exclusions. Finally, this theme connects back to the first subchapter of my analysis which explored exactly this. Science communication plays a key role in whether these perceptions are reproduced or contested. Understanding how mathematical knowledge is translated, which imagines are projected, provided insights into the situated and contested nature of mathematical objectivity.

7. Discussion

This discussion chapter synthesizes the main findings of the analysis and situates them within the broader literature on objectivity, epistemology, and mathematical knowledge production. It critically engages with existing debates, particularly those informed by feminist and STS perspectives, and assesses the implications of epistemic practices in contemporary mathematical research communities.

My thesis is informed by Haraway's theory of "situated knowledges", which challenges the dominant epistemological framework in scientific disciplines, and by extension, mathematics, that assumes knowledge can be produced from a neutral, universal, or disembodied standpoint (Haraway, 1988). Haraway (1988) proposes a redefinition of objectivity not as a "view from nowhere" (Nagel, 2022), but as a more accountable, partial, and reflexive perspective that recognizes the embodied and contextual nature of all knowledge. This approach rejects the notion of objectivity as detachment and instead foregrounds the specificity of the knower's position within broader social, cultural, and institutional structures.

In parallel, Harding's concept of "strong objectivity" (1996) deepens this critique by turning attention toward the epistemic standpoint of the researcher. Harding argues that conventional notions of objectivity or what she terms "weak objectivity" obscure the ways in which dominant scientific paradigms are shaped by the social positions and institutional affiliations of those who produce them. In contrast, "strong objectivity" requires a systematic and critical reflection on how knowledge is socially situated and how power operates within the processes of inquiry and validation.

Applying these frameworks to the field of mathematics, often viewed as the most objective and culturally neutral of disciplines, opens space for an exploration of how knowledge is defined and legitimized. Many of the interviewees upheld a view of mathematical knowledge as universal and detached from individual identities or cultural influences. This perspective aligns with the dominant disciplinary narrative that mathematical reasoning is self-evident and accessible to all, independent of background or position. However, when analyzed through my theoretical lens, this view can be understood not as an inherent truth about mathematics, but as a culturally and institutionally reinforced belief, one that maintains the illusion of neutrality while masking the situated conditions of mathematical practice.

Moreover, while participants often emphasized mathematics' objectivity, they simultaneously acknowledged the importance of diversity within academic spaces. Diversity, however, was typically framed as relevant to the student experience or institutional culture, rather than as something that could influence the nature of mathematical knowledge itself. This separation between "the social" and "the epistemological" reflects a broader disciplinary logic that treats the structure of knowledge as untouched by the identities of those who produce it. This, however, is a position that Haraway (1988) and Harding (1996) explicitly challenge. From their standpoint, to ignore the influence of positionality is not to achieve greater neutrality, but rather to obscure the partial perspectives that inevitably shape what is seen as valid, rigorous, or valuable.

A related theme that emerged from the data was the recurring distinction between pure and applied mathematics, with pure mathematics often implicitly positioned as more legitimate or intellectually elevated. This distinction reinforces a hierarchy that privileges abstraction and detachment, aligning closely with the traditional image of mathematics as a field that operates outside of cultural or practical contingencies. Haraway's insistence on the situatedness of all knowledge (even the most abstract) invites to question such hierarchies, and to consider how institutional and historical factors shape what is defined as "real" mathematics.

In this context, the theoretical contributions of Haraway (1988) and Harding (1996) do not simply provide a critical frame for analysis; they also offer a methodological orientation. As a researcher only partly positioned outside the field of mathematics, I am mindful of how my own perspective shapes this inquiry. Rather than seeking a "neutral" account of how objectivity is perceived in mathematics, I aim to engage in a reflexive process that foregrounds the partial, situated, and contested nature of all knowledge, including my own. In the following sections, I will use these theoretical perspectives to frame three key aspects that emerged in the analysis: the persistence of weak objectivity, the epistemic duality of mathematical beliefs, and the role of authority and peer review in knowledge validation.

7.1 Epistemologies

Returning to the feminist epistemologies discussed in the state of the art, this section begins by revisiting key distinctions, particularly between the concepts of weak and strong objectivity. These frameworks are central to interpreting the empirical material presented in this chapter. For this reason, the chapter is structured accordingly: section 7.1.1 discusses weak objectivity as it appears in my interviewees' understanding of mathematical knowledge, while section 7.1.2 explores the potential limitations of applying strong objectivity to the field.

7.1.1 Weak objectivity

Many interviewees expressed the belief that, although the process of doing mathematics involves subjective choices, such as how to approach a problem, which questions to ask, how to present results, the outcome, that is, mathematical knowledge itself, is objective and universal. This reflects what Harding (1996) would describe as a weak objectivity stance: subjectivity is acknowledged only in the peripheral aspects of knowledge production, while the core "truth" is assumed to transcend social and cultural influences. In contrast, a strong objectivity perspective would demand a deeper interrogation of how positionality, disciplinary norms, and institutional structures shape not only the process but also the content of mathematical knowledge itself. The relatively unchallenged acceptance of weak objectivity among participants suggests that mathematics retains a particularly strong investment in the ideal of universality, one that may obscure the social dimensions of epistemic authority in the field. This echoes prior critiques by Harding (1996), who argues that such investments maintain the illusion of neutrality while reinforcing disciplinary power structures.

Coming back to this and drawing on Traweek's argument of the "culture of no culture", one can say that mathematics sustains its epistemic authority precisely by denying its own cultural and social embeddedness. By presenting itself as universally valid and context-free, the discipline constructs and image of neutrality that masks the institutional and disciplinary structures shaping its knowledge production. This aligns closely with Harding's notion of weak objectivity, wherein limited forms of subjectivity may be acknowledged at the periphery, but the core of scientific, and in this case, mathematical, knowledge is still treated as immune to social influences. In this sense, mathematics exemplifies how weak objectivity can serve to reinforce disciplinary power, legitimizing certain epistemic practices while rendering others invisible or irrelevant.

7.1.2 Does strong objectivity equal strong mathematics?

This duality of epistemological belief can also be understood through the lens of standpoint theory. As mentioned before, both Harding (1996) and Haraway (1988) argue that knowledge is always situated, meaning produced from specific social, cultural, and institutional positions. According to Harding's concept of strong objectivity, greater reflexivity about the standpoint of the knower is not a threat to objectivity, but rather a condition for producing more robust, accountable knowledge. Similarly, Haraway rejects the idea of a "view from nowhere" (Nagel, 2022) and instead calls for situated knowledges, recognizing that all knowledge is shaped by the positionality of its producers.

In the context of this study, the coexistence of absolutist and fallibilist beliefs among mathematicians can be seen as reflecting different standpoints within the field. While the external image of mathematics remains aligned with the absolutist perspective, internal practices and reflections reveal that many mathematicians are aware, explicitly or implicitly, of the social and institutional influences shaping their work. The recognition that "doing mathematics" involves human judgment, community norms, and cultural factors aligns with a standpoint-informed understanding of mathematical knowledge as partial, situated, and subject to revision.

This also helps to explain why participants could simultaneously hold both beliefs: on one level, they are trained to reproduce the myth of universal objectivity, while at the same time, their lived experience within mathematical communities exposes them to its constructed and contingent dimensions. Standpoint theory thus provides a valuable framework for understanding the epistemic tensions and negotiations visible in the interview data. This epistemic tension not only reflects internal negotiations about what counts as legitimate mathematical knowledge but also has implications for how mathematical authority is reproduced; both within the field and in its public representations.

As Anzaldúa (1987) describes in her theory of borderlands, occupying multiple, often conflicting epistemic positions is not a flaw but a generative insight. The mathematicians who I interviewed, who simultaneously uphold objectivity while acknowledging its social dimension, inhabit a kind of epistemological borderland, where they navigate the tension between disciplinary ideals and everyday practice. This aligns with the goals of strong objectivity, which calls not for epistemic purity but more for accountability to the complexity of one's standpoint.

7.2 Knowledge production and practice

This chapter follows back on the topics of power and practice in mathematical research by situating the empirical findings within broader theoretical debates. It is structured into two subsections: 7.2.1 explores the interplay of power, practice and diversity in mathematics, and 7.2.2 focusses on peer review practices and the construction of authority.

7.2.1 Power, practice and diversity in mathematical research

As discussed in chapter 2.2 of the state of the art, mathematics has often been portrayed as an objective and universal discipline, seemingly untouched by the social contexts that shape other scientific fields. However, both philosophical and sociological research, ranging from feminist epistemologies to studies of mathematical logic, have challenged this assumption, arguing that mathematical knowledge is also historically situated and produced.

This view was confirmed in the interviews, where multiple interviewees reflected on the internal hierarchies of mathematical research and how these impact access and participation. Practices such as collaboration networks and publication prestige all emerged as mechanisms through which power circulates the field. This supports the findings in chapter 2.3 which highlighted how diversity and inclusion in mathematics remain entangled with unspoken norms of excellence and credibility.

Interviewees also noted how certain topics and ways of working are privileged over others, often implicitly. For example, pure mathematics was sometimes seen as more prestigious, while applied work and educational research was seen as secondary. These perceptions have implications not only for career progression but also for the epistemic legitimacy of various forms of mathematical knowledge.

The tension between abstraction and accessibility, discussed in the analysis, can also be read as a marker of power. Who gets to define what counts as "real" or "important" mathematics is closely linked to institutional authority. This reinforces the need, raised in chapter 2.3 to pay attention to how diversity, in terms of gender, background or methodology, intersects with knowledge production itself. Not just who participates in mathematics but also what kinds of mathematics are legitimized.

7.2.2 Peer review practices and authority

These findings raise important questions about the role of science communication in mathematics. Although only a few participants explicitly addressed this topic, the interviews revealed a recurring desire for mathematics to be better understood by the public. The underlying motivations for this desire, however, remained vague. Rather than clearly defined goals or expected societal benefits, participants often expressed a general hope that public perceptions of mathematics might shift, perhaps away from its image as an elitist, isolated, or inaccessible discipline.

This discussion connects to the duality of epistemological beliefs in mathematics. As the interviews showed, epistemological beliefs among PhD students in mathematics are not unified. Participants often changed between absolutist framings of mathematics as objective and universal, and fallibilist views that acknowledged the role of intuition, institutional gatekeeping and social validation in knowledge production. This raises the question: What version of mathematical knowledge should be communicated to the public? If internal perspectives already reflect an interplay of individual experience, social norms and institutional power, such as peer review and visibility in high-impact journals, then communicating a purely objectivist view to the public risks misrepresenting how mathematical knowledge is produced and legitimized. Following Harding (1996), these epistemic dynamics are inherent to knowledge production itself.

Building on the state of the art and the works of Greiffenhagen (2023) and Reinhart (2012), mathematics has a relatively unique spot when it comes to peer review and its practices. Not only is the process of verifying different from other natural sciences, where experimental replication and observation are central. Since mathematics is not situated within a laboratory setting, this raises questions about what counts as empirical evidence in the field and consequently, the function that peer review serves. While peer review is important across disciplines, in mathematics it holds particular weight, yet its precise role remains unexplored. Notably, checking a proof can be seen as a form of peer review, similar to practices in philosophy where arguments' consistency is evaluated without empirical data. Furthermore, some studies of peer review in experimental studies suggest that what is often peer reviewed is less the experiment itself which may be inaccessible and more the rhetorical presentation of the publication. This complexity invites a broader reflection on how peer review functions differently depending on disciplinary epistemologies.

Additionally, this raises the question of why considerable epistemic authority is conferred on individuals and their publications, even in cases where the societal value or ultimate correctness of their contributions remains uncertain or unverifiable. This tension highlights the complex relationship between authority, expertise, and mathematical certainty. Again, this connects back to broader questions of mathematical certainty. While the perception of mathematical knowledge is generally framed as objective, the empirical chapter revealed that this objectivity is treated as intrinsic and unquestioned. This reinforces the cultural status of mathematics as uniquely authoritative, where the appearance of neutrality and formal rigor obscures the social processes involved in knowledge production. Notably, this seems to be a property almost exclusive to mathematics.

These dynamics also raise important questions about science communication in mathematics. As the analysis showed, participants expressed a desire for mathematics to be better understood by the public, but the version of mathematical knowledge that should be communicated remains contested. This reflects the broader tension between internal epistemic diversity and external representations of the field.

In sum, while the empirical data on science communication is limited in my study, the interviews nonetheless point to the question about how mathematics is portrayed to the public. What image of the discipline is communicated and what version of mathematical knowledge is made visible within and beyond the academic community? These observations raise the question of how such properties influence the researchers themselves, their practices, perspectives, and sense of belonging. What became apparent in the analysis was that several epistemological beliefs are present in mathematics. However, mostly it is the researchers' approach to certain mathematical problems and not their identity that intersects with the resulting knowledge. As a result, mathematical knowledge continues to present itself as disembodied and detached from its social and historical contexts. This complicates attempts to critically observe knowledge production in mathematics, since the field's internal logic often resists the kinds of subject-positioning or reflexivity found in other disciplines.

In this discussion, I have focused on three key themes that emerged from the analysis: the persistence of weak objectivity, the epistemic duality and the role of standpoint, as well as the dynamics of authority and validation in peer review practices. These findings speak to core debates in the literature on objectivity and epistemic cultures (Haraway, 1988; Harding, 1996; Knorr-Cetina, 1999) and contribute to a deeper understanding of how mathematical knowledge is produced, legitimated, and communicated.

7.3 Limitations of my study

While I am confident that this research will offer valuable insights into the creation of mathematical knowledge, it is important to acknowledge several methodological limitations of the study.
First, as discussed in the state of the art, the field of situated mathematical research has already been well-explored, particularly in the context of teaching environments (Greene et al., 2016; Hodgen, 2011). This may limit the novelty of the findings. However, by focusing on non-teaching environments, such as research groups and academic research communities, this thesis aims to provide a perspective that is less frequently addressed in the existing literature. It seeks to explore how mathematical knowledge is produced and validated in these spaces, thereby offering a fresh angle on the issue of objectivity and inclusivity in mathematics.
Second, mathematics as a discipline does not present the same kind of public controversies as other sciences, which limits the applicability of certain analytical tools commonly used in controversy studies. As a result, some established sociology (STS) methodologies proved less effective for examining the more implicit ways in which mathematical knowledge is negotiated and legitimized.
Third, I encountered specific challenges when trying to analyze the concept of mathematical intuition. During my interviews, terms such as "mysterious" and "intuitive" came up several times. However,

these descriptions resist analysis using standard sociological methods, which rely on observable or articulable practices. Similar limitations have been noted in prior studies of mathematical cultures, particularly in the work of Heintz (2000, 2007), as discussed in the state of the art.
Finally, it is important to note that my findings are based on interviews with PhD students in mathematics at universities in Vienna. I do not claim that these results are generalizable to the entire mathematical community globally. Given the small sample size, limited to a specific group of mathematicians, this study cannot produce broad generalizations. Rather, it offers a situated perspective on how epistemological beliefs and practices operate within a particular institutional and cultural context.

Future analysis could complement this study by applying alternative methods, such as ethnographic observation, discourse analysis or peer review research to further analyze how mathematical knowledge is produced, communicated and institutionalized across different contexts. Through using different methods new ways of finding insights into the social dynamics and power structures that shape the discipline could be found.
In addition to different methodologies, future work could also refine the theoretical framing of epistemological beliefs in mathematics. For instance, while this study highlighted the coexistence of absolutist and fallibilist beliefs among PhD students in mathematics, a more open perspective might be helpful: one that does not see these beliefs as merely coexisting in tension but rather as potentially reconcilable within a broader framework that reflects the thought processes. This might offer new explanations for why mathematical knowledge often appears disembodied from its producers, a recurring theme in both interviews and broader discourses around mathematics.

In summary, this discussion has examined three key aspects of the findings: the persistence of weak objectivity in mathematical discourse, the epistemic duality and standpoint-based tensions within the field, and the dynamics of authority and validation in peer review practices. These themes engage directly with the broader literature on objectivity and epistemic cultures (Haraway, 1988; Harding, 1996; Knorr-Cetina, 1999), and highlight the situated, contested nature of mathematical knowledge production. The findings suggest that while mathematics continues to uphold an ideal of universality and objectivity, the lived practices of mathematicians reveal a more complex and socially embedded epistemic landscape. As such, this thesis contributes to ongoing debates in feminist STS and the philosophy of mathematics, while also pointing toward the need for further reflexive engagement with the processes through which mathematical authority and legitimacy are constructed. The following conclusion will reflect on the broader implications of these findings and suggest directions for future research.

8. Conclusion

This thesis set out to explore how mathematical knowledge is defined, validated, and shaped by epistemological beliefs and academic cultures. I tried to understand how PhD students in mathematics navigate questions of objectivity, epistemic authority, and inclusivity within their field. While the research questions could not be fully answered in all dimensions, partly due to the inherent challenges of empirically capturing such deeply embedded epistemic processes, the study nonetheless provides valuable insights into the multiple and often contradictory ways in which mathematical knowledge is understood and enacted.

One of the key findings is the coexistence of multiple epistemological beliefs within academic mathematical communities. Both absolutist and fallibilist perspectives were present in the discourse of interview participants, often even within the statements of a single individual. This epistemic duality reflects broader tensions in the field between the ideal of universal objectivity and the lived experience of doing mathematics as a situated, social practice. Furthermore, while diversity and inclusivity were valued at a social level, these concerns were rarely linked to the epistemic core of mathematical knowledge, suggesting an ongoing separation between the "social" and the "epistemological" in how mathematics is imagined.

The analysis also highlighted the important role of authority and peer-review practices in shaping what is recognized as legitimate knowledge. Authority was often conferred through experience, institutional status, and community recognition, rather than solely through the intrinsic qualities of the mathematical results themselves. In this sense, even in a discipline that is often perceived as the most objective and neutral of all, knowledge validation remains deeply embedded in social structures and cultural practices.

Conducting this research also prompted a critical reflection on my own assumptions. Initially, I approached the project with a strong focus on uncovering subjectivity in mathematics and its potential consequences for equity in the field. However, I soon recognized that this was itself a situated perspective. Maintaining openness during the interviews and throughout the analysis allowed me to engage more genuinely with the interviewees' views, even when they did not align with my initial expectations. This reflexive stance was particularly important during the coding process, where I had to continuously adapt my categories and acknowledge where early assumptions had shaped my analytical lens. The flexibility of the methodological framework proved crucial in supporting this iterative, reflective process.

Finally, it is important to note that this study focused on a specific group, PhD students in mathematics at universities in Vienna, and does not claim to speak for the entire mathematical community. The interviewees' perspectives are naturally shaped by their status as early-career researchers, which may limit their outlook compared to those of more senior mathematicians with more professional experience. Different participant groups might have brought up different insights or emphasized other aspects of epistemological beliefs and knowledge production. Nonetheless, it offers a situated perspective on how epistemological beliefs, authority, and validation practices operate within this context, and contributes to broader debates in feminist STS and the philosophy of mathematics.

In closing, what this study suggests is that the production of mathematical knowledge is far from a purely abstract or disembodied process. It is a deeply human activity, shaped by history, culture, and community, and one that remains open to further critical reflection and transformation.

Appendix

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II Interview Questionnaire

Introduction and context

- Purpose of my research is my master thesis
- Consent; ask for permission to record the interview
- Warm-up questions: How did you end up studying mathematics?
  - Can you tell me about your academic background and what led you to your current position in mathematics?
  - What drew you to pursue research in this field?

Core research themes

Theme 1: Epistemological beliefs and mathematical objectivity

- How would you describe your view of mathematics? (Do you see it as an objective, neutral field, or influenced by social and cultural factors?)
- Do you think there are multiple ways to define and validate mathematical knowledge, depending on one's epistemological beliefs? (Do you know what those are?)
- Do you consider mathematical knowledge to be objective?
- Is there an objective way of defining what good mathematical knowledge is?
- What makes you think that? What makes something objective for you?
- In your view, how do different mathematical traditions or schools of thought coexist within academic mathematics?

Probes:

- Can you give an example where personal or cultural background seemed to influence the way a problem was approached?
- How do you feel about the idea that mathematics is a socially constructed discipline?

Theme 2: Authority and validation in mathematical knowledge

- Who do you think holds the authority to define and validate mathematical knowledge within academic settings?
- Do you feel that PhD students and post-docs have a voice in shaping what counts as valid research or knowledge in mathematics? Why or why not?
- How do you see the balance of power between senior academics and early-career researchers in terms of decision-making in your field?

Probes:

- Can you recall a time when your ideas or research were questioned? How did that experience influence your views on authority in mathematics?
- What role do you think academic structures play in either reinforcing or challenging traditional views of mathematical authority?

Theme 3: Situatedness and inclusivity in mathematics

- How do you perceive the inclusivity and diversity within your department or the field at large?
- Do you feel that certain voices or perspectives are more dominant in defining what counts as valuable mathematical knowledge? Why?
- How do social factors such as gender, race, or socio-economic background play a role in shaping access to mathematical authority or recognition?
- How does your experience as a PhD student or post-doc intersect with your identity (e.g., gender, class, race, cultural background) in shaping your journey through academia?

Probes:

- Have you encountered moments where your own identity influenced your experience in academic mathematics, either positively or negatively?
- What do you think could be done to make mathematics more inclusive?
- Do you think critical approaches like feminist theory or intersectionality can contribute to the way mathematics is taught, learned, and researched? If yes, how?
- What role do you think critical theories could play in redefining the culture of mathematics?
- Have you seen any initiatives or examples where diversity or inclusivity efforts were integrated into mathematical practices?

Closing questions

- What changes would you like to see in how mathematical knowledge is defined and who gets to contribute to its creation?
- Is there anything else you'd like to share about your experience or views on the objectivity of mathematics?

Conclusion

- Thank the interviewee for their participation.
- Reiterate how the data will be used and offer the possibility of sharing the results.

III Codes

code/ theme	memo	derived from	example(s)
modesty	two overlapping dimensions expressed by interviewees: (1) personal modesty, or the tendency to downplay one's own achievements or competence in mathematics; and (2) epistemic modesty, the view of mathematics as an ever-expanding, partially unknowable domain that resists total mastery	emergent	(1) "my mathematical knowledge is very bad compared to a lot of people that I know." (2) "I think it's like a huge field and I feel like, I think, I feel I know like a super, super small part of it and everything. And the more, the more I study it and the more I understand like that I actually don't know anything about it."
intuition	refers to how interviewees describe mathematical understanding as something that becomes "natural," internalized, or felt rather than explicitly reasoned through	in vivo	"I think also in the most areas, in the end axioms don't really, don't really matter that much. It's much more about intuition than axioms"
mathematical certainty	about the nature of truth, proof, and validation in mathematical research, about how certainty is constructed (often through formal proof) and how this relates to broader epistemological assumptions about what counts as true or valid also: whether participants make distinctions between good/bad mathematics versus true/false mathematics	literature	"if you start with these assumptions and these rules, then this holds in, always, in every case."; "I think in the end it can only be true or false."
idea of a math genius/ perception of math from the outside	about the cultural myth of the male mathematical "genius," often imagined as a young, isolated prodigy whose insights stem from innate brilliance rather than collaboration or effort; raises the question of what makes someone a mathematician, and how such perceptions shape who feels they belong in the field	emergent	"acting as if […] mathematics is just something which a few select people can do."

code/ theme	**memo**	**derived from**	**example(s)**
AI and proof assistance	explores how AI tools and proof assistants are used in research and how they influence the process of validation and certainty in mathematics		“for analysis it’s useless”; “they are usually used for verifying proofs”
the social vs. the epistemological	this code captures statements that connect the broader social context in which mathematics is practiced with underlying epistemological beliefs; used to explore tensions between how interviewees separate (or blend) social identity and mathematical knowledge	literature	“most of the things that I study or even that are there in pure mathematics don't really have applications and, yeah, not so much, not so many real world applications, but they can change a little bit the way you think about, you think about things.”
science communication	two dimensions of science communication: (1) the way mathematical knowledge is communicated to the broader public; also statements about the way mathematics is (assumed to be) perceived by the public; and (2) the way mathematical knowledge is communicated within the discipline between the different subfields	emergent	(1) “I think what we need is more people understanding what mathematics is, and mathematical thinking”; “it is not very well known what mathematicians do or what they think about, or what being a researcher in mathematics means” (2) “I also find it necessary to be able to, you know, communicate what comes out of your research in the end. So, yeah. I wouldn’t say there is very good communication between different areas because of that, but it’s also very hard.”
personal experience in research (changes/ wishes)	to capture personal narratives (reflect positionality) and meaning-making aspects in mathematical identities; can help link structural dynamics to lived experience; may support concepts of situated knowledge	literature	“I feel like the university is a place, or at least like my university environment, is where you can decide a lot about yourself, how involved you wanna be. And how not involved you wanna be. So for me it was important to be like part of the female network, part of the VSM. So just that I feel like I belong here.”

code/ theme	**memo**	**derived from**	**example(s)**
schools of thought/ individualism	this code captures different schools of thought; used to explore tensions between specific cities/ groups/ communities that have a bigger influence than others; also: puts it into a relation to individualism	in vivo	“I know this is some historical notion that, you know, there were schools of thought, there were certain, you know, schools in different places, almost literally, you know, where people would do certain kinds of mathematics. I don’t see it quite as much right now, at least I feel myself not belonging to any particular school.”; “I don’t think so. I think everybody has, even individually, has a quite unique way to think about mathematics.”
black box of mathematics	about the way they talk about mathematics feels like they refer to this process which is out of their control, not understandable, mysterious	emergent	“of course things that nobody understands and they're mysterious and they're still there”
subfield specific beliefs	this code explores statements that interviewees mention that are specifically connected to their region, their field of mathematics; and could only be valid for their field and not the entire discipline	emergent	“And they have like a complete different way of talking about things, so that's how I would differentiate between like a philosophy, logic, and mathematical logic, like the methods that are used and the way that people talk about it.”
(mathematical) science community	about broader statements about the mathematical community, the way not only (smaller) research groups think but more generally; this code is linked to diversity in mathematics	emergent	“mathematics does not develop from a single person it develops from a small community”; “a big community of people decides it's interesting then they will like cite the paper, they will work on a topic, they will do conferences on it and then it will become more valuable through that. But it’s just, it's quite arbitrary.”
absolutist perspective	“[…] assume mathematical knowledge to be absolutely secure, fixed, and objective. They believe that mathematical objects are real and exist outside the human mind.” (p. 147); contrast two epistemological beliefs (Greene et al., 2016)	literature	“one of the things that drove me somehow to mathematics that is very, so, again, objective in the sense that, I mean, the theorem I will study and will either understand it or not, yes, but the theorem is there, it’s true, and if I prove something, it’s, it’s, again, it’s true independently of, of me, somehow.”

code/ theme	memo	derived from	example(s)
objectivity (definition)	about how different interviewees define objectivity specifically in regard to mathematics	literature	“I think that maths has this claim to objectivity like it wants to distance itself as much as it can from people and it wants to be objective”
objectivity (context)	this code captures the tension between the interviewees and their identity with objectivity; used to find differences between the conceptual and situated definition	literature	“I think this term objectivity is not quite as prominent anymore in research mathematics because somehow it is assumed that everyone has this common basis, this common ground on we all more or less use the same mathematical framework and then it's just kind of the question of which path do you go afterwards.”
fallibilist perspective	“mathematics as the outcome of social processes, […] seen as fallible and open to revision. […] focus on doing mathematics - within the social conventions in a particular context - and its human side.” (p. 147); contrast two epistemological beliefs (Greene et al., 2016)	literature	“I can't imagine. Reading a proof and seeing, yeah, this is definitely written by a woman or whatever. I don’t feel that would be possible. Just again, because you can’t you, you don’t write a long text or whatever.”
academic failure/ mistakes	asks the question in what sense does academic failure (or research mistakes) influence the way authority and the validation of knowledge is changed? also, is this connected to the identity in a stronger sense, not the way that people generally deal with mistakes better/ worse	emergent	“generally there should not be a mistake at all. what happens, again, is there’s an impreciseness”; “you cannot make mistakes”
research in general	about descriptions of research in general; experiences of being in academia	emergent	“you have the university, where you have very interesting problems, and very challenging problems, but you don't get a lot of money”
value of knowledge	this code came up a lot in the context of good/ bad mathematical knowledge; maybe good to highlight in comparison to validation of knowledge as this code is more about personal value (or for the	emergent	“If you do something and you understand it, but nobody else understands it, then it has value to one person, you know, and nobody else.”

code/ theme	memo	derived from	example(s)
	community) rather than monetary value		
validation of knowledge	this code captures ways in which knowledge is being validated concerning authority and how this shapes the way knowledge is being defined	literature	“knowledge always has to be somewhat validated by also the people around you”
research authority	this code is used to capture how epistemic authority is created specifically when it comes to mathematical knowledge (field-specific)	literature	“certainly authority in some cases, but also just experience”, “there certainly are voices that have a lot more power”
publishing and peer review process	about mechanisms by which disciplines control standards and access, link to authority in mathematical knowledge production; also in what sense do these practices of evaluation influence the way research is being done	emergent	“some of these things are really complicated and some papers are really badly written so […] not that many people can actually follow them enough to check them, […] some things aren’t necessarily all reviewed”
access to resources in academia	asks about access to resources in academia; to investigate structural inequalities in access to funding, mentorship, or institutional support and how these shape epistemic authority; also: in opposition to gatekeeping practices	literature	“in Europe […] you have […] easier access to some journals.”; “for the mathematics that I’m doing you just need books and pen and paper, you don’t need a lot of resources that could gatekeep certain people but still of course, it's done in universities.”
diversity in mathematics	for studying inclusion, perspective variation, or disciplinary norms, how is diversity understood and acted out in the mathematical academic sphere, this includes intersectionality (gender, race, class, etc.)	literature	“mathematics isn’t, isn’t a super diverse field if you, in terms of, in terms of identity”; “it’s very inclusive mathematics as an environment”

code/ theme	memo	derived from	example(s)
contextual influences	this code captures how broader institutional, historical or cultural factors shape mathematical knowledge production	literature	“if you’re a good mathematician people still like value you for the maths, um and I don’t think they care so much where you're from or whatever but I do think in social situations [it is] a little bit of a problem”

IV Abstract

Mathematics is often perceived as an entirely objective discipline, grounded in solid and unquestionable calculations. However, this perception overlooks the significant influence of social and cultural contexts on mathematical practices and understandings. This thesis explores the concept of objectivity within mathematics, examining how epistemological beliefs shape distinct mathematical realities for individuals and research groups. It particularly focuses on how different kinds of mathematical knowledge and epistemological beliefs shape the situatedness, inclusivity, and diversity within the field of mathematics. My research seeks to explore the differences and similarities these beliefs foster, asking how mathematical knowledge is defined and validated within different epistemological frameworks, what is included in the definition, and who holds the authority to make these decisions.

Drawing on feminist epistemological beliefs and standpoint theory, particularly Donna Haraway's concept of 'situated knowledges', as well as social constructivist and fallibilist perspectives in mathematics, and theories of (gender) performativity, I investigate how mathematical knowledge is shaped. To this end, I employ semi-structured interviews with PhD students primarily based in Vienna, Austria. This approach provides a deeper understanding of how contexts shape mathematical knowledge production within academic settings.

V German Abstract

Die Mathematik wird oft als eine völlig objektive Disziplin wahrgenommen, die auf soliden und unanfechtbaren Berechnungen beruht. Diese Wahrnehmung übersieht jedoch den bedeutenden Einfluss sozialer und kultureller Kontexte auf mathematische Praktiken und Verständnisse. Diese Arbeit befasst sich mit dem Konzept der Objektivität in der Mathematik und untersucht, wie epistemologische Überzeugungen die unterschiedlichen mathematischen Realitäten von Einzelpersonen und Forschungsgruppen prägen. Der Schwerpunkt liegt dabei auf der Frage, wie unterschiedliche Arten von mathematischem Wissen und epistemologischen Überzeugungen die Situiertheit, Inklusivität und Vielfalt im Bereich der Mathematik prägen. Meine Arbeit versucht, die Unterschiede und Gemeinsamkeiten zu erforschen, die diese Überzeugungen fördern, und untersucht, wie mathematisches Wissen innerhalb verschiedener epistemologischer Rahmen definiert und validiert wird, was in die Definitionen einfließt und wer die Autorität besitzt, diese Entscheidungen zu treffen.

Unter Verwendung von feministischen epistemologischen Überzeugungen und Standpunkttheorie, insbesondere Donna Haraways Konzept des „situierten Wissens“, sowie sozialkonstruktivistische und fallibilistische Perspektiven in der Mathematik und Theorien der (Gender-) Performativität untersuche ich, wie mathematisches Wissen geformt wird. Zu diesem Zweck führe ich halbstrukturierte Interviews mit Doktorand:innen durch, die hauptsächlich in Wien, Österreich, leben. Dieser Ansatz ermöglicht ein tieferes Verständnis dafür, wie Kontexte die mathematische Wissensproduktion im akademischen Umfeld beeinflussen.