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First-year university students' mathematics capital and identities

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Abstract: Based on a survey of 150 respondents and 16 timeline interviews with first-year university mathematics students in Sweden, we explore how the material resources and conditions available to them —mathematics capital— connect to their mathematical identities. We found that mathematics capital has bearing on how early in life students start to consider doing mathematics. We also found individually different trajectories among students with low mathematics capital into university mathematics. The study expands both existing theoretical and methodological ways of researching the material bearings of identity and opens up for new ways of understanding and exploring the conditions that may facilitate access to participation and success in university mathematics. It contributes to understanding on the social and cultural resources that students bring with them to start mathematics, thus complementing the insights that Simon Goodchild's work had provided on the context of access to university mathematics.

Keywords: Mathematics capital, Mathematical identity, Materiality, University mathematics, In(ex)clusion.

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The problem of access to and in university mathematics

Research on higher education mathematics teaching and learning has increased in the last decades, providing insight into the characteristics of teaching practices and their impact on students' learning of different mathematical topics, the resources available, the professional development of university mathematics teachers, and the possibilities for change in those practices (e.g., Biza et al., 2016). The interest in improving the quality of teaching on the side of teachers and of learning on the side of students has been supported by the study of and intervention in the communities that sustain the everyday doings of all those involved in university mathematics. Simon Goodchild's work has been exemplary in understanding how communities of practice in higher education can be supported to offer increased opportunities for learning to students, since "the combination of students' personal characteristics and educational context puts students at risk and leads to poor performance" (Goodchild, 2023, p. 75). Such opportunities to learn, Goodchild argues, "emphasize students' meaning-making [… and adopting] effective learning strategies to support the development of understanding and fluency in concepts and procedures" (p. 85). Concerted effort in transforming the paradigms of teaching to provide learning opportunities beyond "accelerated remediation" (Goodchild, 2020, p. 88) is necessary; and ways of mobilizing such transformation need to be studied and acted upon.

The concern for learning opportunities in Goodchild's work may arguably be linked with the concerns in the literature on university mathematics education for increasing *accessibility* to the mathematics to be learned and to the development of students' mathematical thinking and understanding. In the literature, access and accessibility are connected to the dominant focus on the cognitive and epistemological challenges experienced by students that teachers would like to support addressing (Artigue, 2021). Furthermore, research has proposed that an important part of gaining access to mathematics also consists of dealing with the norms and behaviors that are part of the culture of university mathematics. As Burton's (2004, 2009) seminal work pointed out, being a mathematics student and becoming a mathematician happens as both students and teachers navigate back and forth between the *culture of mathematics* which refers to "those aspects of mathematics that are recognizably discipline-related (such as the particular attitudes towards beauty, rigour, structure, etc.)" (p. 159) and the *mathematical culture* which "is constituted through the socio-political attitudes, values and behaviours that dictate how mathematicians, and their students, experience mathematics in the settings of conferences, classrooms, tutorials, etc. [It] is the environment in which the mathematics is encountered and learned and inevitably influences the culture of mathematics." (p. 159).

In Burton's empirical study with mathematicians in universities in the UK, the mathematical culture was characterized by attitudes, behaviors and values such as hierarchy, competition, and isolation. She argued that there was a contradiction between the positive characteristics which mathematicians assigned to the culture of mathematics, and the not benign character of the mathematical culture that they described. For Burton, understanding the interplay of co-existing cultures was an important task for university mathematic education research, given its impact on how students come to succeed in —or give up— mathematics: "The sadness is that the open, questing, negotiated enquiry style that the mathematicians use when collaborating on their research represents the opposite of the closed, tired, dry ways in which they teach." (p. 170) Burton's sharp observation is at the core of the accessibility to mathematics and connects, in our view, to Goodchild's efforts to address the opportunities to learn and participate through bringing together the cognitive and epistemological components of university mathematic education, and its context and community dynamics.

Indeed, the issue of students' participation beyond the purely cognitive and epistemological aspects, and their belonging and thriving in university mathematics has been of increasing concern in recent research, that intends to bring the socio-political turn into higher mathematics education (Adiredja & Andrews-Larson, 2017). For such research, understanding and promoting access and accessibility are associated to the exploration and analysis of the ways in which mathematics education environments as important social, cultural, and political fields of practice inevitably reproduce larger dynamics of differentiation —on the grounds of, for example, gender, sexual orientation, race, ethnicity, and language (e.g., Leyva et al., 2022). It is in the articulation of the culture of mathematics and the mathematical culture that markers of differentiation in society come to operate to generate potential in(ex)clusions for different types of students. Besides identifying how such in(ex)clusions take place, the socio-political orientation is also concerned with proposing how university mathematics education may become a space for a wider and more productive belonging and mathematical identity formation (e.g., Lahdenperä & Nieminen, 2020). The present study intends to contribute to explore the socio-political constitution of university mathematics education by zooming in the connection between the material resources that students who enroll in mathematics programs have had access to, and the way they report to have built an identification with mathematics. That is, we address the overall question of which patterns can be traced between students' mathematics capital and their mathematical identities as they start to study mathematics in higher education.

Mathematical identities beyond discourse

The study of mathematical identities has been productive in understanding the interplay of students' individual characteristics, processes of participation, and in(ex)clusion in school mathematics education (Graven & Heyd-Metzuyanim, 2019). Research on mathematics students' identity building processes in university has been less frequent, but has been growing in recent years. Previous studies have shown that entering university mathematics often requires students to identify as being good or successful in mathematics (e.g., Rothrock & Gay, 2023), and these characteristics in turn are associated with the production of a selective "club" of mathematically competent students (Bartholomew et al., 2011). Furthermore, as students reach higher levels such as master's degree, identities are formed in a type of ascetic process that reinforces the sense of belonging to the selective club (Beccuti et al., 2024). Such results resonate with research that characterizes higher education mathematics as exclusive environments, where only few —with quite particular characteristics of both personal and cognitive type— feel at home and thrive (e.g., Nieminen et al., 2024; Rios, 2023). These studies, in various ways, confirm that the exploration of students' mathematical identities provides a window into how students learn to navigate the mathematical cultures as they acquire a taste for the characteristics of the culture of mathematics.

Furthermore, identity research in mathematics education has utilized a variety of theoretical foundations and methodologies. Narrative, discursive, and performative perspectives have provided lenses to examine the trajectories of individuals and their positions of (dis)advantage in the generation of relationships with mathematics (Darragh, 2016). Existing studies point to mathematical identity formation as multifaceted processes that dynamically mediate the participation of the individual in learning within a disciplinary culture while forming a mathematical sense of self (e.g., Lahdenperä & Nieminen, 2020). Such research has built on theoretical assumptions on the primacy of discourse for identity formation, since the socially and culturally construction of language —also the language available to talk about ourselves— is considered a central constituent of meaning in practice (e.g., Sfard, 2019). In contrast, the recent rise of new materialist scholarship in the social sciences (e.g., Lemke, 2021) has posed the challenge to recognize and study the role of materiality in processes of identity formation (e.g., de Freitas & Curinga, 2015). Theoretical stances that recognize the agentic force of materiality —the multiple forms of entangled matter, both non-human entities and also the biological and bodily potentialities in humans— offer new avenues to investigate students' becoming and belonging in the discipline (e.g., Sinclair & de Freitas, 2019). Thus, the challenge of bringing together the material and discursive components of practice, meaning-making, and identity formation in the context of university mathematics education becomes an interesting path to explore access and in(ex)clusion in university mathematics education.

In our project *IMMPACT* (In/exclusions and Materialities in Mathematics and Physics enACTments, see acknowledgements), we investigate the larger issue of students' access to university mathematics in terms of becoming and belonging. Broadly, we examine the trajectories of students from diverse backgrounds when entering university mathematics and physics, and how students engage in identification processes. We take on the challenge of studying the material configuration in which the trajectory into and the identification with mathematics take place. We also concretize the problem to the context of Sweden, for students who have finished high school, have chosen to enroll mathematics programs in higher education, and have started their first year of studies. Previous studies of similar type have been conducted in highly unequal contexts such as the USA and the UK (Archer & Mendick, 2024; Rios, 2023; Rothrock & Gay, 2023). The Swedish university context is interesting since, in comparison to other Western countries, the welfare-supported, democratic form of educational system provides a base of access to and opportunities for successful education for many. Education in school and at university are universally free of charge. The government also provides additional financial support, which helps students with a wide variety of socio-economic backgrounds to overcome possible economic barriers to enrolling in higher education. Notwithstanding, some areas in higher education such as mathematics and physics are documented to have a highly uneven recruitment in terms of gender and social class (e.g., Berge & Danielsson, 2022; Johansson et al., 2023). Therefore, the overall interest in our research is to identify and understand differences on who comes to enroll in mathematics and what are critical elements of the material-discursive configuration within which mathematical identities of belonging are formed in the first year of university mathematics.

In the first stage in our project, we examine the relationship between mathematical identity formation and its material-discursive configuration. We explore the significance of such configuration for engaging with mathematics in school and starting a mathematics program at university. The research question we address in this paper, based on our preliminary analysis, is: Which patterns can be identified between the material resources students have had access to —their mathematics capital— and their expressed relationships to mathematics —their mathematical identities— as they decide to start studying mathematics in higher education in Sweden?

Mathematical identity and mathematics capital

Discursive notions of identity in mathematics have allowed us to study the nature of identity narratives and how they connect to a large network of stories about students and their relationship to mathematics (Sfard, 2019). However, identity narratives and identification processes are not only rooted in discourse, but also on the arrangement of material resources and conditions that make the narratives possible. For example, parents' narrative that a child is good at school mathematics may have support in their own and/or extended family study (of mathematics) in higher education. It can also be accompanied with concrete materialized support in the form of booklets of mathematical puzzles, or a computer and internet connection to access YouTube mathematics videos, or bringing the child to a mathematics club after school. Materiality is also present in concrete enactments such as time spent in playing a mathematics-promoting games, or visiting public exhibitions related to mathematics. In other words, people narrate as they perform activities with things that facilitate children to connect with mathematics. The stories of identity have a clear material and materialized ground in activities and resources.

The materialization of different family, cultural and social resources that are (un)available to students while forming their relationship with mathematics, up to the point of entering a mathematics program at university, may have a differential impact on their sense of why and how they joined the study of mathematics. For the study of students' educational aspirations and potential enrollment in university science, Archer and collaborators (Archer et al., 2015; DeWitt et al., 2016) have proposed the concept of *science capital* "as a way of conceptually collating science-related forms of cultural and social capital, but particularly those forms which have the potential to influence a young person's science identity and prospective science participation" (DeWitt et al., 2016, p. 2433). They argue that the concept allows a close examination of the configurations of material resources —or capital— of social, cultural and economic type that may support or hinder developing identity narratives of relationship to science "between students who, otherwise, appear to share a similar social location." (p. 2433).

While existing studies in science education have shown the significance of science capital, few studies have gone deeper into this issue for mathematics. Black and Hernandez–Martinez (2016) concluded that the significance of students' science capital to enter a science program that is mathematics intensive was mediated by the type of identification that students built in their university mathematics courses. Godec et al. (2024) studied the relationship between science capital and STEM identity for university students choosing STEM and non-STEM areas. Since it was not found that high science capital was a strong predictor of choice for STEM areas, they point to the need to specify the connection between subject-specific capital and identity. Indeed, Archer and Mendick (2024) have recently shown, drawing on longitudinal data on three young men who chose to study mathematics at university, that the strong expression of their mathematical identities through the years was supported by the series of mathematics capital in the form of social and economic resources that their close family and acquaintances provided. More specifically, their choices on which types of mathematics programs to pursue —theoretical or more applied forms of mathematics— are connected to concrete perceptions of expectations and economic needs.

Following such line of work, we adopt the concept of *mathematics capital* to explore the material rooting of identity. Mathematics capital (e.g., Williams, 2012; Williams & Choudry, 2016) refers to the forms of social and cultural capital particularly connected to the value attributed to mathematical competence and achievement in society. Reasoning with Bourdieu's Marxist, historical-material based theory of social reproduction (e.g., Bourdieu & Passeron, 1990), Williams and collaborators document that perceived values of what mathematical competence can be used for —use value— and traded for —exchange value— "played a key mediating role in learners' and teachers' identity, in shaping choices and pedagogies, and above all in constraining institutional decisions and practices" (Williams, 2012, p. 59). In our work, we highlight the role that concrete configurations of matter and materials play in students' mathematics capital and how those configurations relate to meaning and discourse, forming students' mathematical identities.

Method

This study is part of the *IMMPACT* project, which draws upon two empirical datasets: a survey dataset and a longitudinal investigation incorporating timeline interviews and walking ethnographies. This article is based on a combination of survey data and selected timeline interviews to study the relationship between mathematics capital and students' identity at the moment they enter mathematics at university. The survey data provides insights into the configuration of mathematics capital that these students have had access to and allows us to identify patterns in the relationship of such capital and some important elements of student's mathematical identity. Additionally, the timeline interview data offers information on the dimensions of capital that some students have met and on how such dimensions connect to their trajectory into university mathematics. The study has ethical approval the Swedish Ethical Review Authority; and all participants in the interviews have been anonymized. Together, the data sets allow us to understand how identifiable quantitative patterns of relationship are instantiated in the particularities of the material-discursive practices of mathematics education that students have been participating.

Survey data

Our survey data was designed based on the validated instruments in the ASPIRES project (DeWitt et al. 2016), and recent recontextualization in the SCOPE-project (Pedersen et al., 2023) in Denmark and the Finsci-project (Kaakinen et al., 2023) in Finland. The selected questions were translated and adapted to the Swedish context and the intended target group. The process followed established guidelines for international survey translation, adaptation and piloting (Harkness et al., 2010). The final survey included items on demographic characteristics (e.g., gender, parental occupation, school background), reasons for choice of study, aspirations for the future, and items related to mathematical identity and mathematics capital. In contrast to the APIRES, SCOPE and Finsci projects, we did not include in our survey questions regarding what students think they know about mathematics/physics. The items about identity asked students to express the degree of agreement on statements about the perception of themselves or the perception of others about them regarding the relation to mathematics. Examples are: "Being a mathematician is an important part of who I currently am", "The main reason I enrolled is because I am good at mathematics", or "During my upbringing, a significant other thought I was good at mathematics". For mathematics capital, students were asked about individuals within their family or close social networks who work in the fields such as technology, medicine or mathematics; or the type of media or social contexts outside formal education where they receive information on or engage with mathematical activities; and the presence of significant others who have inspired them to pursue mathematics. The survey was distributed through e-mail to the full population of approximately 500 students entering either a Bachelor of Mathematics or Bachelor of Engineering Mathematics program in Sweden, offered at the 12 universities across Sweden. The survey was distributed four weeks after the study program started in the Fall of 2023, and reminders were sent each week for three weeks. Thus, the survey captures the students in the period between their start of studies and just before their first exams. We received 150 responses, which corresponds to a response rate of 30%, a modest but usual response rate for web-based surveys (Manzo & Burke, 2012).

For our explanatory construct, mathematics capital, we first selected the 20 survey items which intended to measure it. Based on the characteristics of the validated index of science capital (DeWitt et al., 2016), we generated an operational definition of mathematics capital in terms of three categories: who you know in mathematics, how you think about mathematics, and what you do out of school that is mathematics related and with which resources. Second, we ran a reliability analysis, and excluded two questions that showed to have low item-correlation. This left us with 18 items related to mathematics capital, with Chronbach’s alpha of 0.753, an acceptable level of reliability (George & Mallery, 2003). These 18 items were then used to calculate an index ranging between one and five, where one is assigned to those students whose responses to all questions indicate the absence of resources, and five is assigned to students whose responses indicate the presence of all resources. That is, the index allows to orders all students’ responses from low presence to strong presence of mathematics capital.

In contrast to the results of Godec et al. (2024) who explored the relationship between STEM capital and STEM identity through connecting an index of capital and an index of identity, we could not generate a satisfactory index for mathematics identity, probably due to the sample size or to the amount of identity items —seven in total— in our survey. Therefore, we conducted a series of cross-tabulations of the three levels of mathematics capital and the specific items that intended to measure mathematical identity. To further understand how mathematics capital is connected to the choice to study mathematics, we also investigated the distribution of mathematics capital with respect to the demographic characteristics of the sample, such as gender, age, country of birth or whether students grew up in an urban or rural area. Further details on the survey and the analysis can be provided by Lisa Österling upon request.

Timeline interview data

Additionally, we conducted individual timeline interviews (e.g., Johansson et al., 2023) with a sample of 16 mathematics students in five major Swedish universities. Students were recruited through e-mail and presentations in their mathematics classes just after they had completed the first examination, that is around two months into their study, during the Fall of 2023. The recruitment advertisement prompted students whose path into mathematics was "under-represented" to tell us about what had "brought them to mathematics" and how they "feel at home (or not) in the program during their first year". A timeline interview is a conversation between a student and a researcher on the student's pathways until enrolling in the current program, emphasizing important experiences with school and high school mathematics, the student's choice of study, and the different aspects of mathematics capital —who one knows, how one thinks about mathematics, and what one does outside of school that is mathematics related and with what — that have played a part in the students' entering into mathematics at university. During the conversation, the researcher asks the student to draw a timeline with some of the important moments and events in their trajectory. The conversations took around one hour. The interviews were audio-recorded and transcribed and have been read by the whole research team to summarize the important characteristics of each informant regarding the elements of mathematics capital that are part of their expressed trajectory and their expressed relationship to mathematics.

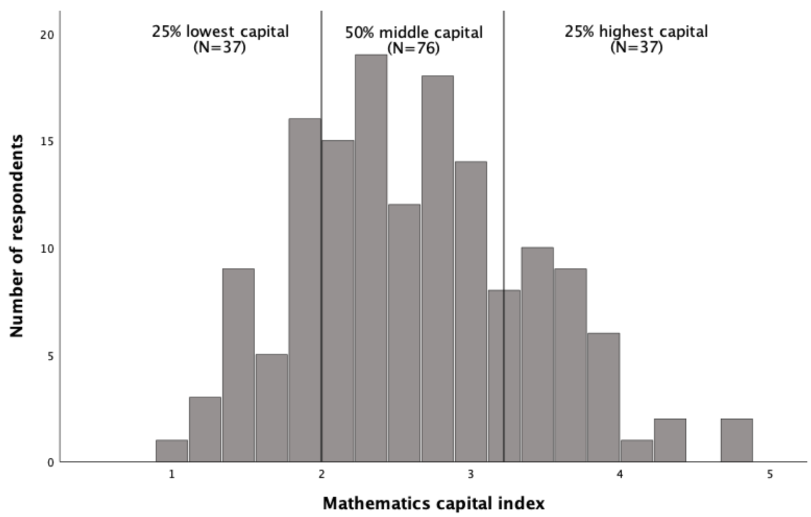
Results

We present here some of the preliminary results that come from our initial analysis of the two data sets. We construct these results first by presenting the three levels of mathematics capital that resulted from the index. Second, we explore the significant relationships between mathematics capital and demographic characteristics. Third, we attend to observable quantitative connections between mathematics capital and some of the items measuring mathematical identity, with particular emphasis on the students in the lowest and in the highest quartiles of the mathematics capital index. We combine the survey results with particularly illuminating cases from the timeline interviews, to exemplify and contextualize the connections.

We grouped respondents based on their level of mathematics capital to be able to examine the relationship between mathematics capital and identity in the sample. The first group consists of the 25% of respondents in the lowest level of capital (*N*= 37); the second group includes the 25% of respondents in the highest level of capital (*N*= 37), and the middle group comprises the remaining 50% of respondents (*N*= 76). The distribution of the index had a narrow spread, with a standard deviation of 0.776 around a mean of 2.62. Figure 1 shows a histogram with the distribution of the number of respondents (*y*-axis) across the range of the mathematics capital index (*x*-axis).

Figure 1

Distribution of respondents' level of mathematics capital in the sample



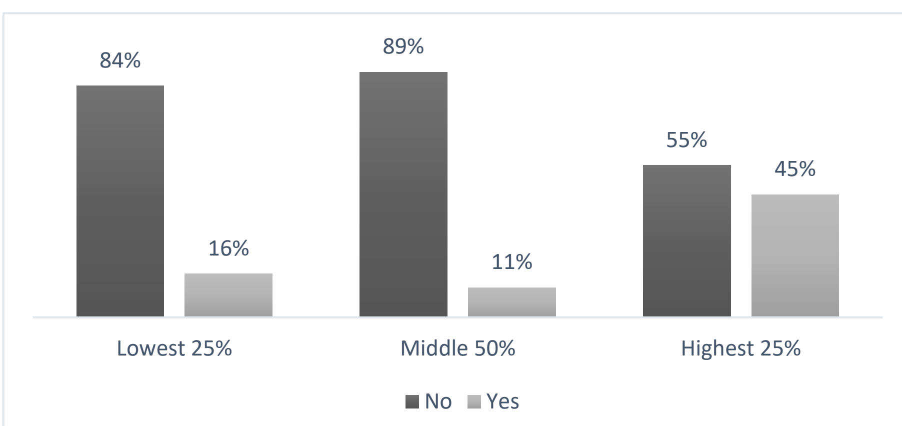
Concerning the connections between capital and demographics, our analysis revealed no significant differences in levels of mathematics capital with respect to students' gender, place of birth (urban or rural areas), or country of origin. However, students' age showed to be a marker of difference in the sample. The vast majority of participants (91.33%) were 24 years old or younger. Within this age group, 26.3% were in the highest level of mathematics capital, while 21.2% were in the lowest. In contrast, among the 13 students (8.57%) who were 25 years or older, only two were in the top 25% of mathematics capital, whereas nine were among those in the lowest level. Notably, we found significant differences in the level of mathematics capital between students aged 25 and older, and those younger than 25 (X^2 (2, *N*= 150) = 14.71, p< .001). The tendency identified is that students in a low mathematics capital level are likely to start their mathematics studies later in life, after different experiences of education and work.

In the timeline interview data, Bertil exemplifies students with a long and winding trajectory to university, who enter mathematics at a mature age. In his timeline-interview, he describes a rough childhood, with difficult parents and school environments. In school, he was usually told that for people like him, there was no future. His desire to get away from home took him through primary and secondary school, and he managed to get a professional college education to work in the transportation industry. He enrolled in mathematics because he "likes it", he "loves it", particularly problem solving, even if he thinks he is not so smart at it. Studying takes time for him but he is dedicated and spends significant time doing it. As an adult, with a wife and children, he uses his previous training in navigation to make sense of mathematics. Thanks to savings from him and his wife for earlier work, he now has the economic resources to go to university to study. In adult life he has learned to mobilize acquired —not family-given— resources such as the encouragement of some teachers and conversations with friends to follow his desire to study mathematics. As a first-year mathematics student, he uses media (e.g., YouTube) to study at his own pace and follow the classes. He had to figure out himself how to pursue his love for mathematics despite it requiring a lot of effort.

Regarding the cross-tabulation of mathematics capital and mathematical identity, only three items —of out seven— differed significantly. To the question of what best describes their path into mathematics, the choice "I knew from a young age that mathematics was for me" showed significant differences among the three goups. See Figure 2 below.

Figure 2

Distribution of responses to "I knew from a young age that mathematics was for me" and levels of mathematics capital. Significant difference (X^2 (2, N= 150) = 18.36, p< .001)

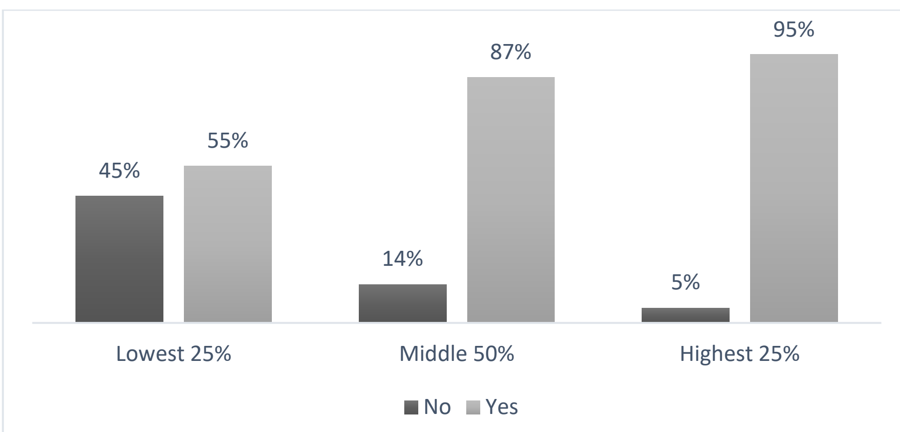


Most of the students in all groups did not know that mathematics was for them at a young age. However, for the students in the highest level of mathematics capital, the relative frequency of those who did not know (55%) was similar to those who knew (45%). Having a sense from a young age that mathematics is something for them differs sharply between the former and those students in the middle capital level (11%) and those in the lowest capital level (16%). The relative frequency of responses for the two latter groups is similar.

To the question of what significant others (e.g., parent, friend or teacher) have expressed a respondent about mathematics during upbringing (ages 5–18), the alternative "thought I was good at mathematics" also showed significant differences among groups. The majority of students in all groups have heard from significant others that they were good at mathematics; however, the relative frequency of such a statement of recognition and support from significant others increases as levels of capital increase. The answer for this item for students in the lowest level of capital is almost equally divided (45 % for a negative answer and 55% for a positive answer), whereas the percentage of a positive answer is significantly higher for the middle group (87%) and for the group in the highest level of capital (95%). See Figure 3 below.

Figure 3

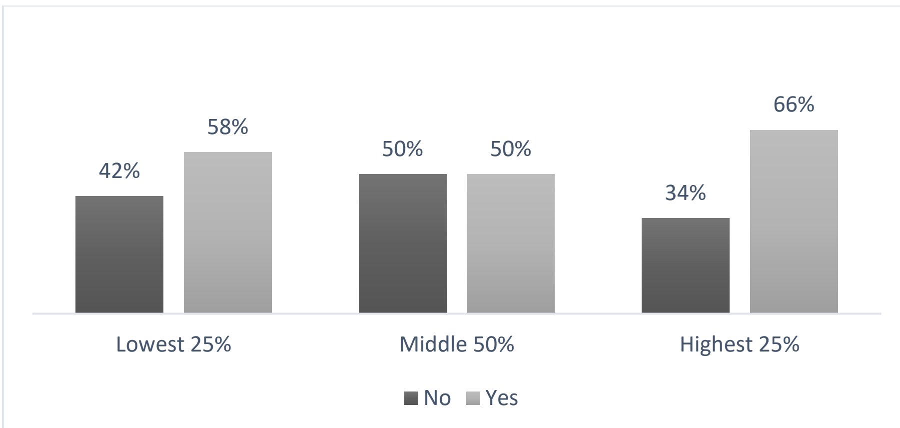
Distribution of responses to "During my upbringing, a significant other thought I was good at mathematics" and levels of mathematics capital. Significant difference (X^2 (2, N= 150) = 22.16, p< .001)



We contrast the distribution of answers in Figure 3 with responses to another related item on identity. When asked about the main reasons to enroll in mathematics, the distribution of answers to "because I am good at mathematics" did not show statistically significant differences among groups. Nevertheless, the percentages of positive answers in all groups are interesting to consider. In all three groups, more than half of the students responded that being good at mathematics is a reason for having enrolled in mathematics, with a slightly higher frequency for those in the group with low level of capital (58%) and for those in the high level (66%), being the latter the highest percentage for all groups. See Figure 4 below.

Figure 4

Distribution of responses to "The main reason I enrolled is because is because I'm good at mathematics" and levels of mathematics capital. No significant difference (X^2 (2, N= 150) = 2.61, p= .271).



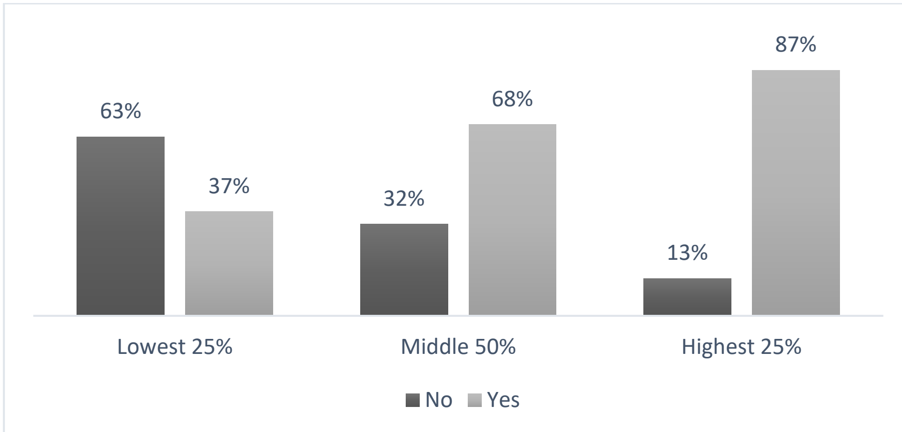
It is interesting to notice that the distribution of responses in Figure 3 and Figure 4 for students in the lowest group of mathematics capital is quite similar. That is, the percentage of respondents receiving acknowledgement from significant others (55%) is similar to the percentage of students who find that being good at mathematics is a reason to enroll in the subject (58%). However, this is not the case for those in the middle and highest groups. More students in the middle group have heard others acknowledging being good at mathematics (87%), while their own reason to engage due to being good at mathematics is much lower (50%). Students in the highest level of capital not only receive more recognition for being good at mathematics from significant others (95%). They also recognize themselves as being good in mathematics and having this as a reason to enroll in the program (66%). As previously mentioned, differences between the items in Figure 3 and Figure 4 seem to relate, but we cannot draw a solid conclusion. Tentatively, we could say that, across the three groups, being good at mathematics is a shared expression of mathematical identity that motivates enrolling in the program. Notwithstanding, the students in the lower mathematics capital group have received less confirmation from significant others.

In the timeline interview data, Ling exemplifies these connections. Ling moved with her mother from an Asian country and arrived in Sweden as a child. After having dealt with the challenges of starting school in a new culture and in an unknown language, Ling thinks she did well in school. She did not especially like mathematics neither thinks that she was good at it. Yet, mathematics was her best subject all the way until high school, when it became difficult to understand, probably because of Swedish being the language of instruction. Despite the struggle, she completed a science high school program after which she felt "school tired". She started working in all types of jobs to earn money and make a living. Her mother and step-father do not have an education or job connected to mathematics; but her partner is a system developer. Listening to him and his colleagues talk about work, she realized that data analysis could be something for her. She is fascinated by seeing connections and patterns of data; and mathematics helps her seeing structures. Until recently, she knew that one could study engineering, but she did not know at all that there were university programs in mathematics. Conversations with friends and movies have been important sources of inspiration. To finalize a degree in mathematics and get a job that allows her a stable income and flexibility to have time for a balanced life is a driver to choose and want to finalize mathematics.

A last item of identity showed significant differences among groups. Figure 5 shows another nuance in what the different groups of respondents consider important for the decision to enroll in the program.

Figure 5

Distribution of responses to "The main reason I enrolled is because I want to do something I love and am interested in" and levels of mathematics capital. Significat difference (X^2 (2, N= 150) = 21.33, p< .001)



According to Figure 5 above, 37% of respondents in the lowest mathematics capital level chose the alternative "because I want to do something I love and am interested in"; while the majority in this group (63%) does not consider this to be a main reason. For these students being good at mathematics is a stronger reason (58%) (see Figure 4 above). The answer of love for and interest in what one does as reasons to enroll in mathematics was 68% for those in the middle level of capital, and 86% for those in the highest level. It seems that "what one loves to do and is interested in" is an important element in all students' mathematical identity, a motive to begin studying mathematics at university. However, the higher the level of capital, the higher love and interest can be strong reasons to enroll in mathematics. For students in the lower level of capital, other factors may be at stake. For example, we interpret Ling's desire to have a stable job and income to have a good life as an expression of what students in low capital groups may consider their reasons to study mathematics.

From the above, we see the tendency that a high mathematics capital connects to a mathematical identity formation that happens at a younger age. The sense of being good at the subject because one has been told so —and to a smaller extent because one thinks so—, and the love and interest for it are more central for respondents in the high mathematics capital level. The presence and extent of mathematics capital seems to contribute to a mathematical identity that supports a trajectory into the study of mathematics at university.

In our timeline interview informants seem to confirm that this is a plausible connection. Emma, 19 years-old, exemplifies the straight and almost "natural" connection of high mathematics capital and strong mathematical identity. Emma finished high school one year prior to starting the Bachelor program in mathematics. She has always heard from teachers that she was "extremely good" at mathematics and got encouragement and extra tasks to solve. For her "mathematics was easy and cool". Her mother comes from a European country and works as a health professional in Sweden. She supported her during school up to high school with different games and activities where Emma could do logical thinking and calculations. Emma has also played a musical instrument in an orchestra and practiced a sport at a high level of competition. In school, she considered herself to have been "a type of big nerd". People thought that she studied a lot, but in her experience "math just came easy". This was a shared experience with her friends, most of whom study technical programs at a large university. To pursue a university degree was a given for her. She considered studying a foreign language which she likes because "grammar is logical, just like mathematics". But she selected mathematics because there was a good program where she lives, and because she just likes it. So far, she thinks her first semester is going fine because she can recognize some of the more advanced topics that she had already studied in high school: "it is much easier than what I thought it would be". As for the future, she has started talking with some people about different career paths in mathematics.

Discussion and conclusions

The survey shows that the sample of respondents has had differential access to several forms of resources which make part of mathematics capital. Concrete material resources such as printed or electronic materials, mathematics related activities, and access to people who have contact with or appreciate mathematics are part of the broad network of cultural, social and economic resources and materials that constitute mathematical capital. Hence it seems that for this sample of students who enroll in mathematics programs in Sweden, their middle or high mathematics capital is likely to establish the selective "club" of mathematics that Bartholomew et al. (2011) and Becutti et al. (2024) have previously described. In resonance with Archer and Mendick (2024), a good level of mathematics capital is needed to support strong mathematical identities that lead students into university mathematics.

In contrast, low mathematics capital poses challenges for students enrolling in mathematics almost “against the odds”. Yet, these students have a sense of wanting to do something that they themselves and others recognize they are good at, and that they love and are interested in. With little access to the material and cultural resources forming mathematics capital, other easily available resources —such as media or social networks of friends and new acquaintances related to mathematics— are mobilized to compensate for earlier lack of access to such material resources in their families. We see in both the survey and the timeline interviews that students who report low levels of mathematics capital tend to develop their mathematical identity later in life. This means that even if there is limited access to the material configuration of resources that support identity, it may be possible for some students to sustain their like for mathematics. This may also point to the fact that, at least for this sample and for students in the Swedish context, neither mathematics capital nor their mathematical identity are fixed entities. They can be supported and expanded.

The preliminary analysis that we present in this paper is a first attempt to move toward the invitation of a more materialist perspective to explore the configurations of matter and materials entangled with meaning and discourse. By adopting the notion of mathematics capital —which others have previously proposed (e.g., Williams & Choudry, 2016)— we were able to take a first approximation to the socially and culturally distributed base of resources that matter for students’ trajectories in education. The connection with identities both in the survey and interview data allows us to point to the nuances of experience that unfold in students’ educational path in mathematics. We expect to keep on delving into these connections as we explore in more detailed ways the students’ first year of studies at the university.

These results do not go against the grain of what is well-known for mathematics education: that different forms of social, economic, and cultural resources are highly connected with in(ex)clusion and success in mathematics, also when we are located in the spaces of university mathematics education (Leyva et al., 2022; Nieminen et al., 2024; Rios, 2023). Our results show that this holds also for a country such as Sweden where there is a broader and more democratic access to (higher) education. Yet, the study of the material basis of identity offers important nuances into how materiality and discourse entangle in producing in(ex)clusions in university mathematics education.

This is indeed an important complement to the burgeoning research in the area of the socio-political studies of mathematics in universities. We find important to understand that identified differences in first-year university students' previous knowledge, beliefs, attitudes, affect, identity, self-efficacy, and mathematical capacities that have been documented (e.g., Rothrock & Gay, 2023) are not just a function of students' own individual capacities. They connect to the characteristics of the society that they are a part of. Although our study has not directly shown the connection between students' mathematical capital and their family's socio-economic status, it is clear that the levels of mathematics capital are rooted in socio-economic differences as they play out in Sweden. Students carry all those narratives and resources with them as they start university mathematics. We argue that part of understanding how "context" is significant for the students being at risk of low performance —and eventually failing and being excluded— involves grasping the social and political dynamics on which students come to navigate university mathematics. Such awareness is a contribution to advance the legacy of dear colleagues such as Simon Goodchild.

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