English for Mathematics in the University Context: A Needs Analysis

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Abstract:

The paper presents the results of the *Needs Analysis* project focusing on the process of acquiring and using specialized mathematical language. The project was motivated by the need to create a meaningful English for Specific Purposes (ESP) course and related testing for students of the Faculty of Mathematics and Physics, Charles University. In conducting the project, the methodology of triangulation combining quantitative and qualitative methods and including an anonymous online questionnaire distributed to students and semi-structured interviews with professional mathematicians was followed. The methodology was established by the original study performed at ENS Paris-Saclay in France.

Key words: ESP, English for mathematics, Needs Analysis, university education, specialised test

1 Introduction

This present paper presents a step forward in improving the teaching of English for mathematics for students at university level. We bring insight into what English skills students should acquire to become competent mathematicians. The conclusions follow from a needs analysis combining a student questionnaire and interviews with professional mathematicians. The chosen methodology follows that of Bouyé et al. (2024), who mapped the English language needs in the field of mathematics at the French university ENS Paris-Saclay. This enables a comparison of the two analyses leading to more widely applicable results. As will become clear from later in this section, Bouyé et al. (2024) present the only study in this area immediately relevant to our context. The present research is therefore essential in designing quality courses at the Faculty of Mathematics and Physics at Charles University (MFF UK).

Faculty of Mathematics and Physics at Charles University offers English courses at all degrees of study. To guarantee that all students reach an upper-intermediate to advanced level of English by the end of the bachelor's degree, all students pass an obligatory English exam. The exam reflects the specifics of the faculty in that it consists not only of general English but also of specialised English, more specifically English for mathematics. Therefore, mathematical English forms a vital part of the preparatory courses for bachelor students. In addition to the bachelor courses, the language department offers courses in English for Specific Purposes

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(ESP), in here relevantly the course of English for mathematicians, designed for students of mathematics in their master's or PhD studies.

The challenges of creating a meaningful ESP course derive from its central characteristics. First, it is a multidisciplinary approach, which requires the instructor to straddle two professional domains. Secondly, ESP is in essence a learner-centred approach, placing the focus on how the particular course helps the learners meet their current and/or future 'non-linguistic' target needs (Anthony, 2018, p. 16). To design such a course, it is vital that ESP instructors make use of the available research in the target domain, e.g. mathematics, and use insights of the target specialists (ibid.).

Despite the flourishing field of research into ESP and disciplinary discourses mathematics is still an under-researched discipline. Existing research focuses mainly on rhetorical and organizational macro-structure rather than on lexico-grammatical features (Burton & Morgan, 2000; Graves et al., 2013, 2014; Kuteeva & McGrath, 2015; Lin & Evans, 2012; Anthony & Bowen, 2013, Moghaddasi & Graves, 2017; Moghaddasi et al., 2019; Onder-Ozdemir and Ozdemir, 2019). There are three exceptions, namely McGrath and Kuteeva's (2012) investigation of stance and engagement in pure mathematics research articles, which applies Hyland's framework (2005), Swales et al. (1998) with their study of the use of imperatives across disciplines, and two studies by Petit (1991, 1993), which are concerned with syntactic patterns associated with proper nouns and abbreviations. Furthermore, three studies focus on the phraseology of mathematical discourse, specifically on mathematical research articles. Cunningham (2017) identifies key phrase frames, i.e. strings of words of a given length with a single variable slot, and characterises them with respect to their function, such as logical cohesion, discourse organisers, and establishing assumptions. In a master's thesis, Bouyé (2014) investigates the phraseology of mathematical genres of differing formality, comparing research papers with weblogs and TED talks. The most extensive overview of mathematical phraseology specific to research papers was given by Steidlová (2022), who identifies and describes the key constructions or building blocks of mathematical research papers across three specializations.

In the field of needs analysis, mathematics seems to be even more neglected. To our best of knowledge, there exist only three needs analyses regarding this discipline. Apsari et al. (2020) combine the analysis of written production of second year university students with interviews with both students and EfM lecturers. The target group of the study, represented by a sample of 27 students, are prospective mathematics teachers in Indonesia. The findings revealed that their courses should put more emphasis on mathematical terminology and the ability to read mathematical symbols and equations. In a similar context, Nurpahmi et al. (2020) map the English for mathematics situation in Indonesia through a ques-

tionnaire and interviews on the population of 64 students, 10 graduates, and 2 lecturers. The goal is to establish what English language students of mathematics need to acquire to complete their degree successfully. The study concludes that students would benefit from more instruction in reading, grammar, and vocabulary specific to their specialisation. Finally, Bouyé et al. (2024) seek to determine the needs of university students of mathematics at the bachelor and master levels at the university ENS Paris-Saclay in France with the aim of preparing them for their future career as professional mathematicians. We discuss their findings in relation to the present analysis in section 4.4 of the results.

2 Methodology

In conducting this needs analysis, we closely followed the methodology established by the original study performed at ENS Paris-Saclay in France (Bouyé et al., 2024), with slight adaptations to fit the context of the Faculty of Mathematics and Physics, Charles University, Czech Republic. This section outlines the specific methodological steps taken to analyse the specialized English language education needs of non-English-speaking students of mathematics. The overall design of the study utilizes the method of "triangulation" of sources and methods (Long, 2005), i.e. comparing the perceived needs from the perspective of two different groups and combining quantitative and qualitative methods. More specifically, these included an anonymous online questionnaire distributed to students and semi-structured interviews with professional mathematicians.

2.1 Participants and data collection

The study involved two key groups of participants: students of mathematics and professional mathematicians.

A. Mathematics students: An anonymous online questionnaire was distributed via the Study Department of the Faculty of Mathematics and Physics to 366 students at various stages of their academic progression in mathematics. Specifically, the contacted participants were as follows:

- Third-year undergraduate students (Bachelor's level): 135 students
- Graduate students (Master's level): 171 students
- Postgraduate students (PhD candidates): 60 students.

The questionnaire was available from April 18, 2024, to May 26, 2024, with a reminder sent on May 20, 2024. Participation was voluntary, and anonymity was guaranteed to encourage honest and thoughtful responses. The online format allowed us to reach a large number of students efficiently, although the potential for participant bias is acknowledged.

B. Professional mathematicians: For the qualitative part of the study, we invited 24 professional mathematicians to participate in personal interviews. These professionals were selected from professors, associate professors, and senior assistant professors across all the five mathematical departments at the faculty. Both men and women were included in the sample. A total of 10 mathematicians agreed to participate, representing the departments in the following way:

- Department of Algebra: 1 professor, 1 associate professor
- Department of Mathematical Analysis: 1 professor, 1 associate professor, 2 senior assistant professors
- Department of Numerical Mathematics: 1 associate professor
- Department of Probability and Mathematical Statistics: 2 senior assistant professors
- Mathematical Institute of Charles University: 1 senior assistant professor

All participants were proficient in both mathematics and English, ensuring their responses reflected a clear understanding of the language needs within the mathematical community. Prior to the interviews, all participants signed written consent forms agreeing to the recording and transcription of the interviews.

2.2 Online questionnaire

The anonymous online questionnaire sent to students consisted of two main sections (see Attachment 1). The first section collected demographic data, including academic level, specific area of focus within mathematics, and prior experience with English language instruction. Participants were also asked about their career plans and interest in working abroad.

The second section aimed to evaluate students' perceptions of the importance of various English language skills. Participants ranked the significance of different language competencies using a Likert scale with five options: "I don't know," followed by a scale from "not important" to "very important."

The assessed competencies covered both the area of English for general purposes and English for mathematics, with an emphasis on the latter. The questions cover all traditional language skills, i.e. speaking, listening, writing, and reading. Moreover, we explored internship-related skills, e.g. handling applications and performing in job interviews, and conference/seminar skills, such as listening to presentations and delivering short talks. The set of target skills and sub-skills was created for the purposes of the original study (Bouyé et al., 2024) by the researchers, i.e. ESP lecturers, in cooperation with informants from among professional mathematicians.

2.3 Personal interviews

Along with the student questionnaire, we conducted semi-structured interviews with the sample of 10 professional mathematicians. The main objective of these interviews was to obtain in-depth, context-specific insights into the use of English in their professional practices. The interviews covered competencies overlapping with those in the student questionnaire. Once again, the set of discussed skills was compiled for the purposes of the original study (Bouyé et al., 2024) by the researchers, i.e. ESP lecturers, in cooperation with professional mathematicians. In addition to this, we used the opportunity to gather feedback on the relevance of the current specialised test (ESP test) given to students as part of their obligatory English exam.

The interviews were structured into three parts:

A. Frequency of language use: The first part of the interview focused on how frequently participants engaged in tasks requiring English language skills (speaking, reading, writing, listening, and interaction). To ensure consistency with the methodology of the prior French study, we used flashcards listing detailed situations for each task. Participants rated the frequency of each task on a Likert scale with five options: "constantly," "very often," "often," "occasionally," and "never," along with an "I don't know" option.
Participants could also mention other relevant situations not included on the flashcards. This approach helped us assess the integration of English into their professional activities.

B. Perceived importance of language skills: The second part of the interview asked participants to rate the importance of English language skills in their professional work using a similar Likert scale, which ranged from "unimportant" to "important," with an "I don't know" option.
Similarly to the questionnaire, the skills encompass both English for general purposes and English for mathematics contexts. Participants could add other relevant situations or language skills not explicitly mentioned.

C. Feedback on the ESP test: As part of the interviews, we also sought feedback from professional mathematicians on the existing ESP test that is currently given to undergraduate students. The test assesses students' proficiency in mathematical English. The interviewed mathematicians reviewed the test content and provided suggestions for improvement, particularly regarding its relevance to real-world mathematical tasks. A Likert scale of importance was used to evaluate the individual skills assessed by the test, with a range from "unimportant" to "important" and an "I don't know" option.

2.4 Data analysis

Both the quantitative data from the questionnaires and the quantitative and qualitative data from the interviews were analysed to identify common trends and significant differences between the two participant groups. Descriptive statistics were used to summarize the perceived importance of various language skills among students. This data was compared with the responses given in expert interviews. In the quantitative data from the interviews we faced the problem of intermediate answers, e.g. '2–3'. We decided to take the approach of making the answers more decisive, meaning that we recorded the lower value for indecisive answers between degrees 1 to 3 and the higher value for degrees 3 to 5.

For the qualitative interview data, we conducted thematic analysis to identify recurring themes and patterns in mathematicians' responses. We paid particular attention to whether their feedback aligned with, or diverged from the needs expressed by students, and the recommendations they made regarding the current ESP test.

2.5 Methodological considerations and limitations

Several methodological considerations should be noted. First, the use of an online questionnaire enabled us to reach a large number of students, but it also introduced the possibility of participant bias. Students particularly interested in English language skills may have been more likely to participate, which could distort the results towards a higher perceived importance of English language education.

Second, we recognise the limitations of the semi-structured interviews. Interviewing the sample of 10 professional mathematicians provided valuable qualitative data, but the findings may not be fully representative of the broader population of mathematicians. The semi-structured interviews provided flexibility, allowing for diverse and detailed responses. However, this also introduced variability, as the depth and quality of responses varied significantly among participants. Finally, while the study aimed to assess both the frequency and perceived importance of language skills, these two aspects may not always correspond in practice. Recognizing this potential discrepancy is essential for interpreting the results accurately.

Despite these limitations, we believe that the methodology provides a strong framework for analysing the English language needs of non-English-speaking mathematicians in the Czech Republic. By combining quantitative and qualitative approaches and triangulating between two groups of informants, the study offers a comprehensive understanding of the language skills valued by both students and professionals in this field.

3 Results: students' point of view

The questionnaire aimed at establishing the perceived needs of the students of mathematics was answered by 63 respondents, amounting to approximately 17 per cent of the contacted students. Among the respondents 30 were bachelor's students, 31 master's students, and 2 doctoral students.

The personal information gathered about the respondents corresponds with the university cultural context. The native language of the great majority is Czech, followed by Slovak. Only three students listed another language, i.e. Ukrainian, Serbo-Croatian, and Hungarian. Since mathematical English is part of the fundamental courses of English at the faculty, 87 per cent of the respondents had had some experience with such training. The perceived language competence of the respondents was rather high, with 59 per cent claiming an advanced level (C1/C2), 30 per cent upper-intermediate (B2), and 11 per cent intermediate (B1).

With respect to their future careers, the respondents preferred the field of applied mathematics (51 per cent) to that of theoretical mathematics (30 per cent). More specifically, most respondents intended to pursue a career in research (41 per cent) or data science (41 per cent), followed by teaching (20 per cent), finance (17 per cent), and business (17 per cent)[1]. It is somewhat surprising that a strong majority of respondents (59 per cent) did not intend to work abroad.

In what follows we report on the findings form the questionnaire in the order the questions were presented to the respondents.

3.1 English for general purposes

Figure 1 shows the respondent's preferences with respect to English for general purposes (EGP). The graph is organised in such a way that the skills with the strongest positive response, i.e. the highest sum of the answers 'important' and 'very important', are listed at the top.

There is a clear tendency for the students to attach more importance to receptive skills, i.e. reading and listening, than to productive skills, i.e. speaking and writing, let alone interactional or cultural skills. This seems to reflect their current stage of their career, where they predominantly receive information and instruction rather than being themselves asked to produce something.

[1] The other options in the questionnaire were Civil service (3 per cent), "I don't know" (24 per cent), and "other", where one student wrote 'Cybersecurity'.

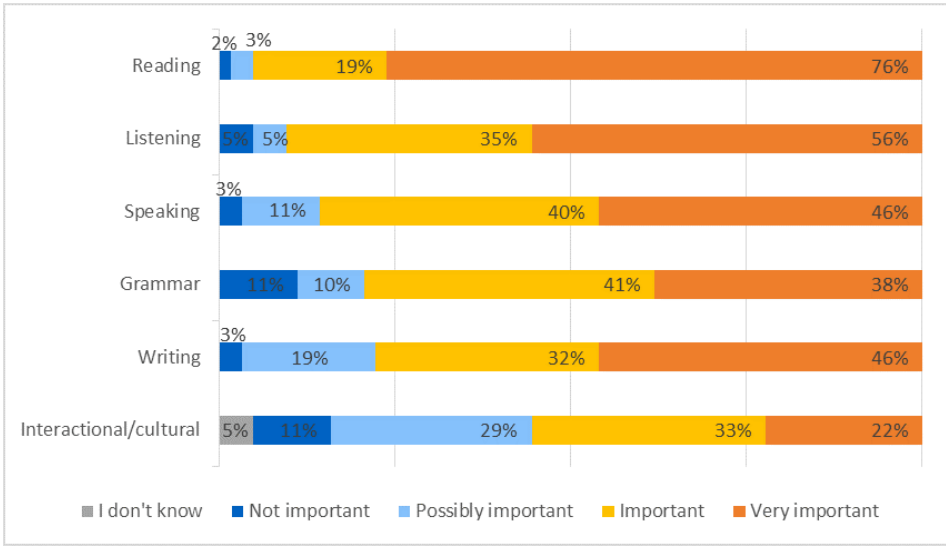

Fig. 1: *The perceived needs related to English for general purposes*

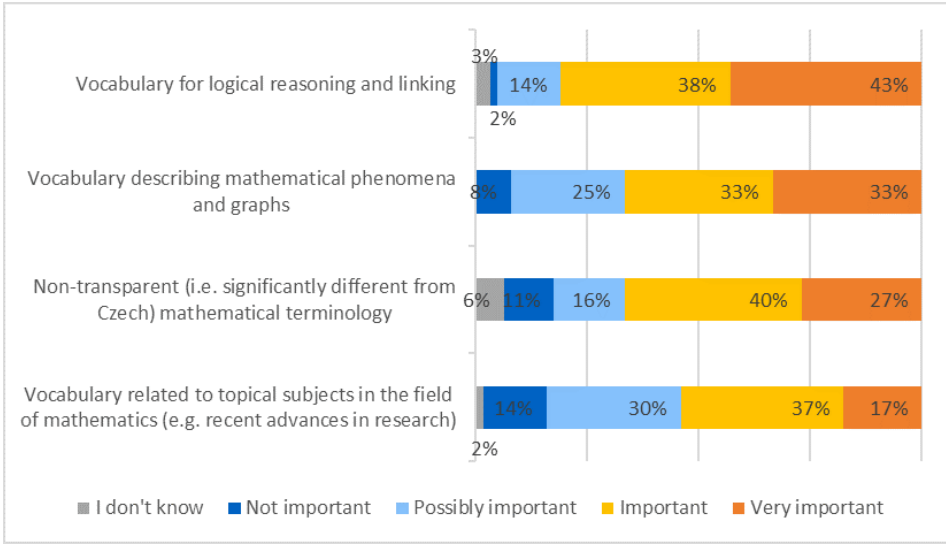

Fig. 2: *The perceived needs related to English for mathematics: vocabulary*

3.2 Competences in English for mathematics

In this section of the questionnaire students rated the importance of skills related specifically to English for mathematics, organised into areas of vocabulary, speaking, reading, writing, and listening.

The first set of skills represents needs in the vocabulary domain. The students' responses, visualised in Figure 2, indicate a somewhat divided view of the need of studying this area. We believe this to reflect the view that discipline specific vocabulary can be acquired naturally in the process of one's studies and therefore does not require focused instruction (see also the professionals' view on this in section 4). At the same time, the use of isolated terminology tends to be perceived as easier compared to phraseology or textual organisation. The vocabulary for logical reasoning and linking clearly stands out in this domain, showing that this skill is understood by the students to lie at the very heart of the discipline, a position independently confirmed by the professionals (see section 4).

The second question related to speaking skills. In general, this set of skills was attached the least importance of all needs in English for mathematics. The number of respondents who used 'not important' or 'possibly important' to evaluate reading out mathematical symbols including numbers, reading out equations, and avoiding pronunciation mistakes reaches 50 per cent (Fig. 3). It is only the mathematical demonstration before audience, once again a central enterprise of a mathematician, which was perceived as important by an overwhelming majority of 75 per cent. This is a score even higher than expected, given that only 40 per cent of the respondents visualise a career in research, which would entail such demonstrations. Apparently, students have a need for this skill as part of their studies.

The rather surprisingly low need for other speaking skills could be explained by the passive role the students play in the educational process, where they typically receive information by reading and listening rather than actively engage in speaking in class. Added to this is a tendency to underestimate the pronunciation. However, the professionals confirmed the students' feelings on the relevance of pronunciation, as they say the conferences they attend, as well as their team collaborations, are international and there are often no native speakers present. There seems to be a need to be understood, which can be achieved even with an imperfect pronunciation and in case of symbols and equations by means of writing them down, if need be.

The next set of skills, related to reading, is in stark contrast to speaking skills. It is the overall most positively perceived area, with both listed skills rated as 'very important' by more than a half of the respondents (see Fig. 4).

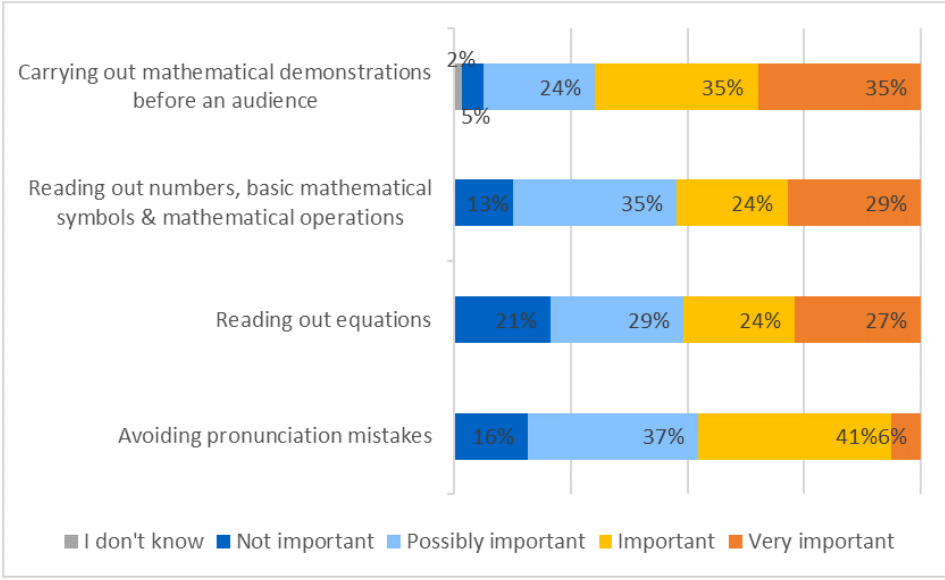

Fig. 3: *The perceived needs related to English for mathematics: speaking*

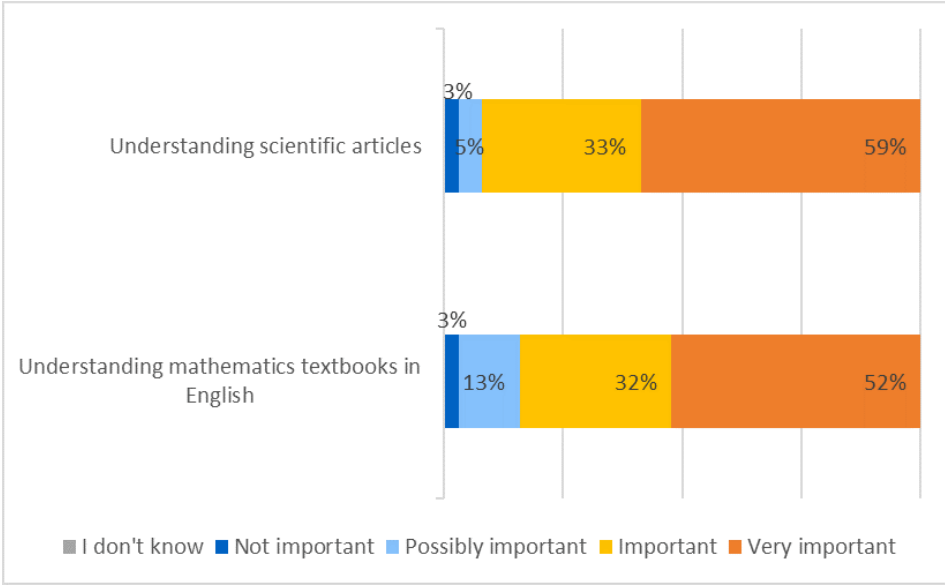

Fig. 4: *The perceived needs related to English for mathematics: reading*

This finding is in line with the students' preference for reading among the English skills for general purposes. It is clear that reading is the core activity of mathematical students, who see it as important apparently regardless of their future career choice. There is little difference between the importance of reading scientific articles and mathematical textbooks.

The fifth part asked students' views on the importance of writing skills. It is noteworthy that students attribute higher importance to writing a research paper than to writing an abstract (see Fig. 5). This is despite the fact that all students are asked to provide an English abstract to their thesis, even when it is otherwise written in Czech. Furthermore, in the professional mathematical environment, papers for both conferences and journals are judged by the abstracts, making it of the utmost importance. Therefore, we have to assume that this practice is so far unknown to the students and that they dismiss the English abstract to their thesis as a peripheral enterprise.

The least valued writing skill was writing a cover letter for a journal, where only a minority of 43 per cent of the respondents saw it as either 'important' or 'very important'. On the one hand, this could show a lack of experience, or a lack of interest due to a foreseen career outside of academia. On the other hand, this low importance seems justified by the comments of the interviewed professionals, who inform us that such communication is currently being eliminated altogether by the use of automatic submission systems.

The last set of skills in this section of the questionnaire are those connected to listening. Similarly to the rating of needs linked to English for general purposes, there is an overall positive response to listening. The students feel the need to understand lectures and conference talks (86 per cent rate this as 'important' or 'very important', where a majority chose the latter). Videos and tutorials are of almost equal importance (Fig. 6). This suggests that students do not rely solely on the university lectures and seminars as a source of information and rather actively search for more instruction online. This creates the need to understand such videos in English not to be limited to the Czech internet environment.

One interesting observation arises from the comparison of the students' answers and the professional's interviews. While students were less convinced about the importance of informal conversations, this skill was repeatedly mentioned as extremely important by the professional mathematicians. According to them, it is the informal interactions that are the basis of successful cooperation and the means of networking (see also section 4 on this).

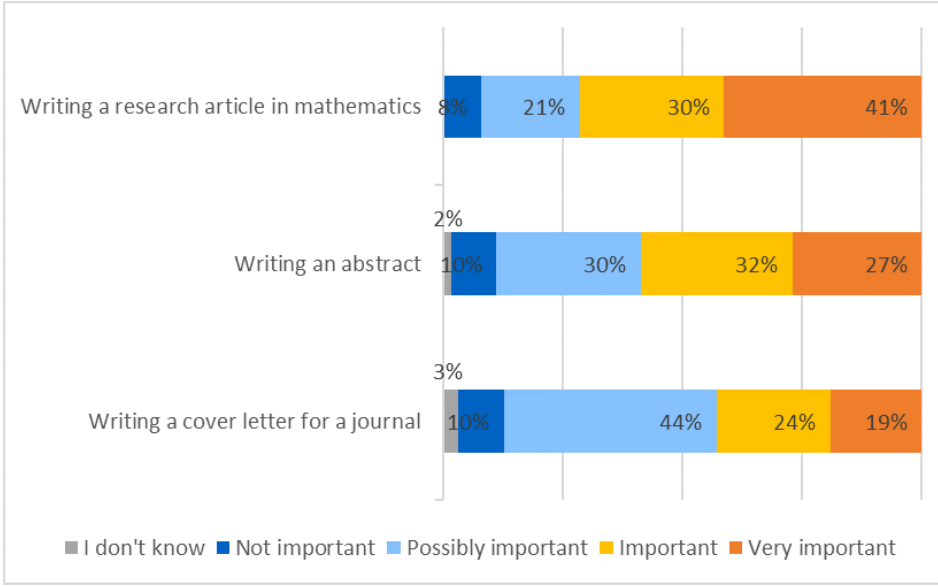

Fig. 5: *The perceived needs related to English for mathematics: writing*

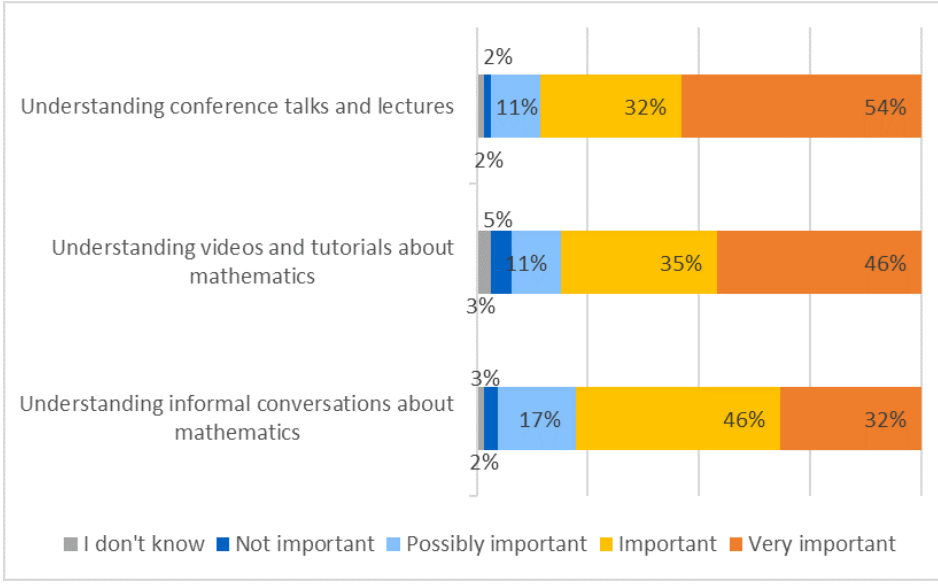

Fig. 6: *The perceived needs related to English for mathematics: listening*

3.3 Needs connected to internships, conferences, and seminars

The last two questions of the questionnaire related to more specific professional situations students and mathematicians in general can encounter, i.e. research internships and conferences or seminars. The results in this section are characterised by the raised percentage of the answer 'I don't know', for a number of skills amounting to 11 per cent (see Fig. 7 and 8), compared to the mostly 2 per cent share in the previous sections. Furthermore, the opinions tend to be less radical, most students preferring to rate these skills as 'possibly important' or 'important' rather than using the extreme values of the rating scale. This indicates that these professional skills are more distant to the students, who so far lack much experience with any of the presented contexts. Nevertheless, it should be noted that despite this somewhat weaker response every skill was still rated as 'important' or 'very important' by the majority of the respondents (see Fig. 7 and 8 for the exact numbers).

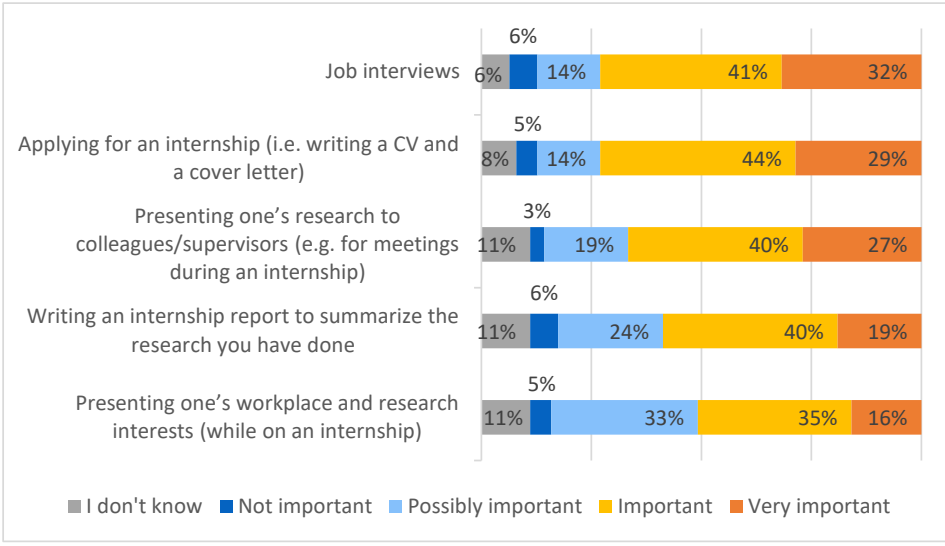

Fig. 7: *The perceived needs related to research internship*

In the context of research internship students consider important especially those skills that lead to getting a job, i.e. job interviews and internship applications. These skills represent the most immediate experience to students.

The respondents' experience with seminars was at this stage of their career mostly limited to the university context, specifically internal seminars. This seems to be reflected in their stronger perceived need to be able to listen to a presentation and take notes, as well as to give a short talk on their own.

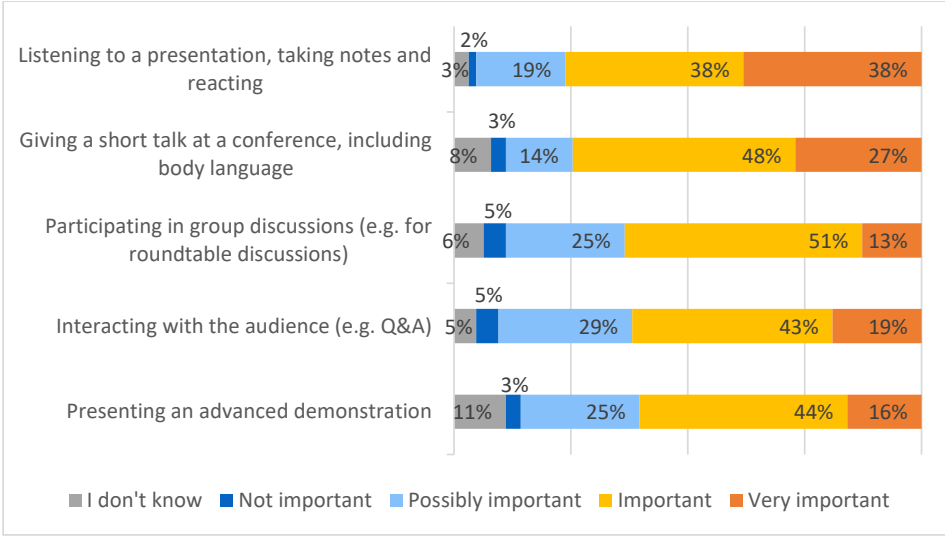

Fig. 8: *The perceived needs related to conferences and seminars*

4 Results: professionals' point of view

The second pillar of the present needs analysis are interviews with professional mathematicians associated with the university. We have carried out 10 interviews with mathematicians across the individual departments of the mathematical section of the Faculty of Mathematics and Physics with the aim at establishing a common ground between the specialisations. The interviewees included both male and female scientists, with varied degree of experience.

The aim was to shed light on the everyday practices of a mathematician with respect to their use of English. We tried to establish in what contexts and how often English is used and which language skills are seen as important to the mathematicians in their professional lives. On the one hand, the answers were quantified as explained in the methodology (Section 2). On the other hand, we encouraged the interviewees to express their opinions broadly. This section reports on both the quantitative and qualitative findings.

4.1 Frequency of use

The first part of the interview contained five questions which grouped together activities according to language skills and asked about the frequency with which

the interviewee performed the given activity in English[2]. Tables 1 through 5 summarise the given answers ordered for each item from the least common (number 5) to the most common (1). The activities within the group are ordered from top to bottom by the mode, i.e. the most commonly given answer. The activities listed on the top are therefore generally more commonly performed.

The listed speaking activities were rated predominantly as quite common (Tab. 1)[3]. What stands out are both reading out equations, and numbers and other mathematical symbols. The interviewees did not see a difference between these items and reported both mostly as integral part of their profession, happening 'constantly' or 'very often'. It was mentioned that this occurs mostly while teaching which, as can be seen, is to some degree done by all the interviewed mathematicians. Other contexts involved discussions with foreign colleagues and marginally a talk at a conference.

Tab. 1: *Activities involving speaking*

Activities	**Mode**	**Individual answers**									
Reading out equations	1	4	4	3	2	2	2	1	1	1	1
Reading out numbers, basic mathematical symbols & mathematical operations	1	5	4	3	2	2	2	1	1	1	1
Carrying out mathematical demonstrations in front of an audience	2	4	4	3	3	2	2	2	2	2	1
Presenting research interests to colleagues	2	4	4	4	3	3	2	2	2	2	1
Presenting research progress and results to colleagues and supervisors	2, 3	5	4	4	3	3	3	2	2	2	1
Teaching mathematics in English	2, 4	4	4	4	4	3	2	2	2	2	1

Carrying out mathematical demonstrations was mostly perceived as a vital activity for a mathematician, both in interactions with students and other mathematicians. As expressed by one of the respondents, 'mathematical demonstrations in front

[2] The reader should bear in mind that some of the activities rated as uncommon are in fact commonly carried out in Czech, e.g. presenting research progress to one's supervisors, or answering questions from the public.

[3] The tables are colour-coded for more immediate understanding. The answers indicating higher frequency, i.e. 1 and 2, are in green, while answers indicating low frequency, i.e. 4, 5, are in red. The answer in the middle of the scale, i.e. 3, is white. The predominance of one colour over the other then reveals the overall frequency of the given group of activities.

of an audience, well that's simply the basics'[4]. The differences in frequency here are mostly due to differences in the specialisation, number of conferences per year, and number of classes taught in English. Apart from the listed activities one respondent mentioned that asking for financing is also sometimes done in spoken form.

The second set of activities related to interaction. As can be clearly seen from Table 2, this is not a central endeavour of a professional mathematician. Out of the individual activities only informal discussions were generally rated as happening 'very often'. Moreover, it was pointed out by four respondents that these are of great importance. They are the means of establishing and maintaining cooperation, and of getting valuable insight and results otherwise not present in the official conference talks.

Tab. 2: *Activities involving interaction*

Activities	**Mode**	**Individual answers**									
Informal discussion on mathematical topics	2	4	4	2	2	2	2	2	2	2	2
Conducting and participation in interviews	3	5	5	5	4	4	4	3	3	3	3
Responding to questions from the public	5	5	5	5	5	5	5	4	2	2	1
Round table discussions	5	5	5	5	5	5	5	5	4	4	2

There do not seem to be other common forms of interaction in English among mathematicians. Round table discussions are virtually non-existent in this disciplinary context and while some questions from the public are asked, it is hardly ever in English. In addition to the given list, half of the respondents mentioned interaction in the university teaching context, specifically one-on-one consultations with their students and examinations.

Table 3 shows the frequency of reading activities, as given by the respondents. It is obvious that this is the core activity of a professional mathematician. Respondents claimed to read scientific papers 'all day long' and noted it is 'part of the everyday work'. The answers were given quickly and decisively. They clearly indicate that at this stage of the professional career, scientific papers are of more importance than mathematical textbooks. However, respondents admitted studying these even for their personal needs, not only for the purposes of teaching. Only three respondents mentioned reading other texts related to mathematics, namely biographies of mathematicians, mathematical popularisations, and blogs.

[4] Excerpts from the interviews have been translated from Czech by Steidlová.

Tab. 3: *Activities involving reading*

Activities	**Mode**	**Individual answers**									
Reading scientific papers, dissertations, etc.	1	2	2	1	1	1	1	1	1	1	1
Studying mathematical textbooks	2	5	3	3	2	2	2	2	2	1	1

The most common context in which mathematicians activate listening comprehension are conferences and other seminars or lectures. A great majority of the respondents rated this activity as happening 'often', 'very often', or 'constantly' (see Table 4). The specific frequency then depends on the number of such events the mathematician attends. It appears from the interviews that this is linked to the current financing options rather than differences between specialisations.

Tab. 4: *Activities involving listening*

Activities	Mode	Individual answers									
Listening to a presentation, taking notes	2, 3	4	4	3	3	3	2	2	2	1	1
Understanding informal conversations about mathematics	3, 4	4	4	4	3	3	3	2	2	1	1
Understanding videos and tutorials about mathematics	4	5	5	4	4	4	4	4	4	3	3

Two respondents listed additional listening activities, i.e. listening to popularisation podcasts about mathematics, and online communication with colleagues. In general, the interviewees viewed listening skills as somewhat unimportant. It was mentioned that if you do not understand the presentation exactly, you can always resort to reading the paper afterwards.

The last question mapped the writing practices of the interviewed mathematicians. The respondents explained that research papers in their specialisations are written and published solely in English. For a great majority this is a central activity of their professional lives and so was rated as being carried out 'constantly'. Writing an abstract was reported as a little less common (see Tab. 5) simply because it is shorter and does not take as much time to write.

In the Czech university environment emails to colleagues are written both in Czech and English. None of the respondents have any cooperation with a firm and they reported it as quite rare in their disciplinary (and cultural) context. The fourth skill in Table 5 was rated with a fair degree of variability. The answers with higher frequency reflect writing either CVs for the purposes of internal job evaluation and letters of recommendation. Reportedly, not all respondents are

Tab. 5: *Activities involving writing*

Activities	Mode	Individual answers									
Writing a research article in mathematics	1	4	3	3	1	1	1	1	1	1	1
Writing an abstract	1	4	4	3	3	2	2	1	1	1	1
Writing emails to colleagues or partners from collaborating firms	2	4	3	2	2	2	2	2	1	1	1
Writing a CV, cover letter and/or letter of recommendation	4	4	4	4	4	3	3	2	2	1	1
Writing an email/letter to the editor or publisher	4	5	4	4	4	4	3	2	2	1	1
Writing a (grant) report or funding application	4	4	4	4	4	4	4	4	3	1	1

often asked to do this. The frequency of writing an email or letter to the editor or publisher was reported to dependent on the journals one publishes in. Respondents commented that most journals use solely automatic submission systems thus eliminating this email altogether. One's seniority in the research team can also have impact as writing such emails is a task often left to the more junior members. While all respondents write grant reports and funding applications in English, it is required only a couple of times a year. Three respondents added the skill of writing review of research papers or dissertations to the list as relevant, but written only 'often' or 'occasionally'.

4.2 Perceived importance of language skills

The second part of the interview asked participants to rate the importance of English language skills in their professional work. Mirroring the student questionnaire, we focused separately on English for mathematics (Tab. 6) and English for general purposes (Tab. 7).

Among the skills specific to English for mathematics, the most positive and unanimous response was provoked by 'logical reasoning and linking'. As put by one of the respondents, 'this here is basic math skills... without it, the math is lost'. Interestingly, two respondents specifically mentioned that this skill is not limited to English but needs to be built even in the native language. The two following items, related to vocabulary, were attached a varied degree of importance. In selecting their answers, the interviewees were influenced by the fact that the discipline specific vocabulary, while essential, is acquired naturally through exposure. It was therefore judged important to master such vocabulary but at the same time not important to focus on it in language instruction. Finally, describing graphs and

Tab. 6: *Skills specific to English for mathematics*

Skills	Mode	Individual answers									
Logical reasoning and linking	1	1	1	1	1	1	1	1	1	1	1
Understanding non-transparent mathematical terminology	1	5	4	3	2	1	1	1	1	1	1
Understanding vocabulary related to topical subjects in the field of mathematics	1	4	3	3	3	2	2	1	1	1	1
Describing mathematical phenomena, figures and graphs	1	5	5	4	4	3	2	2	1	1	1

figures was found to be specialisation specific, e.g. does not occur in algebra, but was said to be very important in statistics.

Tab. 7: *Skills in English for general purposes*

Skills	Mode	Individual answers									
Reading	1	1	1	1	1	1	1	1	1	1	1
Writing	1	1	1	1	1	1	1	1	1	1	1
Speaking	1	2	2	2	1	1	1	1	1	1	1
Interactional skills	1, 2	2	2	2	2	2	1	1	1	1	1
Listening	2	2	2	2	2	2	2	1	1	1	1
Cultural competences	2, 3	4	3	3	3	3	2	2	2	2	1

When asked to judge the importance of the skills in English for general purposes, our respondents' first reaction was that they are all important. Only on more reflection were some of them able to distinguish between what they called perhaps essential skills and a little less essential ones. As can be seen from Table 7, of most importance are without question reading and writing. This also corresponds to the frequency section of the interviews, where we found that reading and writing were overall most commonly carried out activities.

The lowest importance was attached to cultural competences. The respondents commented that while the mathematical community is international with people from various cultural backgrounds, it is the disciplinary interest which binds them together and any possible cultural misunderstandings are therefore tolerable.

4.3 ESP test at MFF UK

The last part of the questionnaire was concerned with the specialised test taken by undergraduate students at MFF UK. The respondents were presented a set of skills tested in the test and were asked how relevant these are for the future career of a mathematician.

The respondents' evaluation of the importance of the individual skills mirrors their answers in the previous two parts of the questionnaire. The mathematicians unanimously agreed that reading comprehension is very important (see Table 8)[5]. This is closely followed by the importance of phraseology of logical reasoning, deduction, notation and definitions. Testing the knowledge of basic vocabulary from specific areas of mathematics was overall positive, although individual respondents added various comments to this, the prevailing one was a suggestion to reduce the amount of geometry related vocabulary. The ability to read out equations and mathematical expressions produced even more divided views, with three mathematicians rating it as either 'neither important, nor unimportant' or 'rather unimportant'. Two of them commented that this skill is not necessary or useful for students at the bachelor level and can be acquired later, an observation made also by several respondents claiming this skill to be 'possibly important'. The third one believed it is trivial for the students and does not need to be studied in courses.

Tab. 8: *The composition of the ESP test at MFF UK*

Skills	Mode	Individual answers									
Local comprehension of a mathematical textbook (i.e. at sentence, paragraph level)	1	N	1	1	1	1	1	1	1	1	1
Basic phraseology of logical reasoning, deduction, giving notation and definitions	1	N	2	1	1	1	1	1	1	1	1
Knowledge of basic mathematical terminology from specific areas of mathematics (arithmetic, logic, linear algebra, analysis, geometry)	2	N	3	3	2	2	2	2	1	1	1
Reading out equations and other mathematical expressions	2	N	4	4	3	2	2	2	2	1	1
Ability to correct language errors in a mathematical text	1, 2, 3	N	N	5	4	3	3	2	2	1	1

[5] One mathematician refused to evaluate the skills by importance because they claimed the whole test is 'artificial' and the tasks have little to do with real life endeavours of a mathematician. Hence the column of 'N'.

The respondents mostly hesitated when attaching the importance to the ability to correct language errors in a mathematical text. They commented that students will be able to have their writing checked on the one hand by available software tools for grammar correction and on the other hand by co-authors.

Finally, we asked for any suggestions for improvement of the test. The majority of eight mathematicians would suggest putting more emphasis on students' active independent use of the language, especially in the form of a writing exercise. Five of these suggested writing an academic mathematical text. Two more emphasized the skill of logical reasoning and argumentation and proposed writing a simple mathematical proof. One respondent preferred writing a summary of a given text. Apart from the writing assignments, three respondents suggested including a listening in the test.

4.4 Comparison with France

One impulse for the present needs analysis was a study of this kind conducted at ENS Paris-Saclay (Bouyé et al., 2024). We followed the same methodology to acquire comparable results. The original study did not apply scales in the interviews with professionals. Moreover, it included only six participants. Therefore, we are unable to report on the comparison of the interview findings with any reasonably degree of precision and we will limit ourselves to the questionnaire, i.e. the perceived needs of the students. As we are not at liberty to publish the precise results of the previous study, we focus on the overview of the main trends in the data.

To begin with, the sample of students completing the questionnaire at ENS Paris-Saclay matched ours both in size (61 compared to our 63) and composition (bachelor and master students). The reported level of English was similarly 60 per cent of advanced speakers. The foreseen future career paths correspond to our findings, with a slightly higher preference of research and teaching over data science.

The first question of the questionnaire focused on English for general purposes. Generally, Czech students attached higher importance to their knowledge of EGP than French students, especially in the areas of grammar (32 per cent more) and reading (24 per cent more).

The trends in the perceived importance of the competences in English for mathematics correspond between the two groups in the areas of vocabulary, speaking, reading, and writing. The only discrepancy between the two groups was in the listening skills. Here French students rated informal conversations higher in importance than understanding videos and tutorials (60 per cent 'important' or 'very important' compared to 48), while the order was reversed for Czech students. One

possible explanation could be the wider choice of mathematical video tutorials in the students' native language.

Among the needs connected to research internships, French student attached more importance to writing a report to summarize the research one has done (by 7 per cent). Czech students rate higher applying for an internship (by 10 per cent) and especially job interviews (73 compared to 53 per cent). These differences appear to be best explained by the different study contexts. All master students at ESN Paris-Saclay are required to participate in two research internships, at least one of them abroad, while no such condition is set at MFF UK. They therefore feel a greater need for reporting back on research, as this is what their evaluation depends on. The needs related to conferences and seminars were rated similarly in both groups of students.

Discussion and conclusions

Having presented the individual results in detail, we will now turn to the global tendencies emerging from the data. This section starts with the global picture of the students' perceived needs, then offers the mathematicians' point of view, and follows with a comparison of the two, leading to considerations for our future ESP courses and tests.

Students participating in the research overall prioritized the receptive skills. This was noticeable both in the area of English for general purposes and the individual skills within English for mathematics. Among these, reading was decisively judged to be the most important skill. It is interesting to note that there were only a few skills which were perceived as rather unimportant, i.e. the sum of the 'not important' and 'possibly important' labels reached 50 per cent. In accord with the general preference, these were among productive skills: writing a cover letter, reading out numbers, mathematical symbols and equations, and avoiding pronunciation mistakes.

Based on the interviews with professional mathematicians, it can be said that on the whole mathematicians devote most of their time to reading and writing. In contrast, the least time is spent on interaction and listening. The speaking activities vary in frequency and are typically closely linked to the frequency of attending conferences. The differences in frequency correspond to the perceived importance of the skills with relation to EGP.

Two global significant needs emerged from the interviews. First, the interviews confirmed the centrality of logical argumentation and deduction in mathematics, apparent in the attached importance in the area of vocabulary (phraseology), speaking (giving a demonstration), writing (writing a research paper), and also in reflecting on the ESP test at MFF. Second, interviewees reported the need to

express complex mathematical meanings informally, both in spoken and written form. This was repeatedly highlighted in answers to various questions, even those that did not target this skill directly, e.g. writing skills.

The applied method of triangulation, used to obtain as informative results as possible, allows for comparison of the perceived needs of the two sample groups, i.e. students and professional mathematicians. The comparison yields two interesting groups of needs, i.e. needs whose importance was judged differently for the two groups, and needs on whose importance the two groups agree. While the difference in opinion could suggest that the students do not have a well-formed idea of their needs, it also seems to reflect the different stages of the career of a mathematician. More specifically, as mentioned above, students give priority to receptive skills, while professional mathematicians prioritize written communication. Both of these reflect their respective daily experience. In the same way, while students use videos and tutorials as a valuable source of information in studying, this is no longer relevant to professional mathematicians. At the same time a mathematician who teaches a class in English is more probable to need to read aloud mathematical expressions than their students. In this respect it is interesting to note that the need to be able to explain complex ideas in simple informal language comes only later in the career.

Where the two groups agree that a certain skill is important, it can be supposed that the needs stem from the nature of the discipline and are more stable in time and therefore possibly more central. Among these the most notable were reading skills, logical argumentation and deduction (including giving a demonstration), and writing research articles. It is equally noteworthy when the two groups agree that a skill is not important. In this way it seems perhaps unnecessary to focus on formal group discussions or teaching precise pronunciation.

Both of the above groups of needs should be taken into account when re-designing our ESP courses. It is clear that the skills on which there is an agreement will form a central part of the new syllabus. As for the needs dependent on the position in the career, the question must be answered whether it is the immediate or the long-term needs that we want to fulfil. The creation of a new syllabus for the ESP courses and the design of a corresponding test is now in progress.

Finally, in comparison between the two needs analyses carried out at MFF UK and at ENS Paris-Saclay, there are in general only a few notable differences and, as was explained in the previous section, they seem to stem mostly from differing cultural and university contexts. One can therefore tentatively conclude that the detected trends might point to the needs of mathematical students in general, rather than the specific group under investigation. However, we are well aware of the limits of the comparison and sample sizes and would encourage further research in order to support this finding.

It can be concluded that the findings in this paper present a valuable insight into what English skills students of mathematics at university level should acquire to become professional mathematicians. Since this is to date a largely unexplored territory, we believe the findings will be of use to many an ESP lecturer and will inspire the design of relevant learner-centred courses.

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Attachment 1.

Questionnaire

Key teachable and certifiable skills in English for Mathematics

Part 1: Tell us about yourself

1. Which year of studies are you in?
   ◯ Bachelor – 3rd year
   ◯ Master – 1st year
   ◯ Master – 2nd year
   ◯ PhD
2. Please identify your mother tongue.
   ◯ Czech
   ◯ Slovak
   ◯ Other
3. How would you rate your level of proficiency in English?
   ◯ Beginner (A1)
   ◯ Beginner-intermediate (A2)
   ◯ Intermediate (B1)
   ◯ Intermediate-advanced (B2)
   ◯ Advanced (C1/C2)
4. In your opinion, which subject matter is more important, English for General Purposes (EGP) or English For Mathematics (EFM)?
   ◯ English for General Purposes (EGP)
   ◯ Applied Mathematics
   ◯ I don't know
5. Have you previously received training in English for mathematics?
   ☐ Yes – as part of the bachelor courses at the language department of MFF
   ☐ Yes – the course English for Mathematicians at MFF

☐ Yes – elsewhere
☐ No

6. In which field do you plan to specialize, Theoretical Mathematics or Applied Mathematics?
   ◯ Theoretical Mathematics
   ◯ Applied Mathematics
   ◯ I don't know
7. Which career path(s) do you plan on pursuing after graduating?
   ☐ Research
   ☐ Education
   ☐ Business
   ☐ Finance
   ☐ Civil service
   ☐ Data science
   ☐ I don't know
   ☐ Other
8. Do you plan to work abroad?
   ◯ Yes
   ◯ No

Part 2. A: Foundational skills related to English for General Purposes

Rate how important the following skills are to you as a student of mathematics.

9. Needs related to English for General Purposes (EGP)

	I don't know	Not important	Possibly important	Important	Very important
Grammar	◯	◯	◯	◯	◯
Listening	◯	◯	◯	◯	◯
Speaking	◯	◯	◯	◯	◯
Reading	◯	◯	◯	◯	◯
Interactional (e.g. conversation)/cultural	◯	◯	◯	◯	◯

Part 2. B: Foundational skills related to English for Mathematics (EfM)

Rate how important the following skills are to you as a student of mathematics.

The first four sets of skills are related to general English for Mathematics competencies: Speaking, Reading, Writing and Listening. The last two sets are related to more specific professional situations that you may encounter as a university student: internships and conferences/seminars.

10. General needs

	I don't know	Not important	Possibly important	Important	Very important
Non-transparent (i.e. significantly different from Czech) mathematical terminology	○	○	○	○	○
Vocabulary describing mathematical phenomena and graphs	○	○	○	○	○
Vocabulary for logical reasoning and linking	○	○	○	○	○
Vocabulary related to topical subjects in the field of mathematics (e.g. recent advances in research)	○	○	○	○	○

11. Are there any other related skills not mentioned here that you believe are important?
12. Speaking skills

	I don't know	Not important	Possibly important	Important	Very important
Reading out numbers, basic mathematical symbols & mathematical operations	○	○	○	○	○
Reading out equations	○	○	○	○	○
Avoiding pronunciation mistakes	○	○	○	○	○
Carrying out mathematical demonstrations before an audience	○	○	○	○	○

13. Are there any other speaking skills not mentioned here that you believe are important?
14. Reading skills

	I don't know	Not important	Possibly important	Important	Very important
Understanding scientific articles	○	○	○	○	○
Understanding mathematics textbooks in English	○	○	○	○	○

15. Are there any other reading skills not mentioned here that you believe are important?
16. Writing skills

	I don't know	Not important	Possibly important	Important	Very important
Writing an abstract	○	○	○	○	○
Writing a research article in mathematics	○	○	○	○	○
Writing a cover letter for a journal	○	○	○	○	○

17. Are there any other writing skills not mentioned here that you believe are important?

18. Listening skills

	I don't know	Not important	Possibly important	Important	Very important
Understanding videos and tutorials about mathematics	○	○	○	○	○
Understanding conference talks and lectures	○	○	○	○	○
Understanding informal conversations about mathematics	○	○	○	○	○

19. Are there any other listening skills not mentioned here that you believe are important?
20. Research internship-related skills

	I don't know	Not important	Possibly important	Important	Very important
Applying for an internship (i.e. writing a CV and a cover letter)	○	○	○	○	○
Job interviews	○	○	○	○	○
Presenting one's workplace and research interests (while on an internship)	○	○	○	○	○
Writing an internship report to summarize the research you have done	○	○	○	○	○
Presenting one's research to colleagues/supervisors (e.g. for meetings during an internship)	○	○	○	○	○

21. Are there any other skills related to internships not mentioned here that you believe are important?
22. Conference/seminar skills

	I don't know	Not important	Possibly important	Important	Very important
Listening to a presentation, taking notes and reacting	○	○	○	○	○
Giving a short talk at a conference, including body language	○	○	○	○	○
Interacting with the audience (e.g. Q&A)	○	○	○	○	○
Participating in group discussions (e.g. for roundtable discussions)	○	○	○	○	○
Presenting an advanced demonstration	○	○	○	○	○

23. Are there any other skills related to conferences not mentioned here that you believe are important?
24. Is there anything you would like to add?

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