Perceived difficulty of mathematical tasks: The view of primary school teachers

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Abstract: Factors influencing the perceived difficulty of mathematical tasks have been analysed, considering secondary school teachers' and students' perspectives. This paper shows the results of qualitative research exploring and investigating the factors influencing primary school teachers' perceived difficulty after solving a mathematical task. We started with factors characterising perceived difficulty, which had been identified in previous studies about students and had also been considered suitable for high school teachers. We compared them to the primary school teachers' point of view, highlighting similarities and differences and discussing primary school teachers' beliefs regarding mathematics and perceived difficulty.

Keywords: macro-categories, mathematics education, perceived difficulty, primary, teachers

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1 Introduction

Research in mathematics education has recently started considering not only the objective difficulty of mathematical tasks but also the subjective aspects related to it, namely the perceived difficulty (Nicchiotti & Spagnolo, 2024a; Saccoletto & Spagnolo, 2022; Spagnolo & Saccoletto, 2023). While the concept of "perceived difficulty" is well-studied in other fields of research, such as metacognition research (see, for example, Efklides & Touroutoglou, 2010), it remains unclearly defined in mathematics education. The perceived difficulty of different mathematical tasks has been analysed to identify and describe the different factors influencing it, mainly through qualitative studies (Spagnolo & Saccoletto, 2023). In doing so, two different perspectives have been taken into account: the students' and the teachers', which have been analysed and then compared and contrasted in exploratory studies (Nicchiotti & Spagnolo, 2024b). The factors influencing students' and teachers' perceived difficulty of a mathematical task seem to fall into the same descriptive categories, meaning that the categories appear to include all the factors influencing the perceived difficulty for both students and teachers. The main difference, however, lies in the importance of the same factor for students and teachers; in other words, the factors are the same,

but the proportions among them are not (Nicchiotti & Spagnolo, 2024c).

Research shows that teachers sometimes are not able to understand the reasons behind students' mistakes (Arzarello & Ferretti, 2021). In addition to that, their experience does not always imply the ability to correctly predict students' outcomes, as experts might face difficulties understanding the challenges and obstacles faced by novices (Hinds, 1999). Studies about teachers' judgement, in which task-related judgement is included (cf. Ostermann et al., 2018; Urhahne & Wijnia, 2021 for a comprehensive review), state that the estimation of the difficulty of a mathematical task provided by teachers is not always precise. There are differences in the estimation between teachers at different school grades (Nathan & Koedinger, 2000).

Based on these premises, we believe it is important to delve deeper into teachers' perceived difficulty. This topic is significant, as demonstrated by the amount of research regarding teachers' task-related judgment, and it is part of the broader strand of research about teachers' beliefs regarding students' mathematical thinking (Philipp, 2007). This is crucial, considering that effective teaching and learning seem to happen when there is a correspondence between teachers' and students' beliefs (Kumaravadivelu, 1991). However, the factors that influence teachers' perceived difficulty have been considered and analysed only with small samples of secondary school teachers (Nicchiotti & Spagnolo, 2024c). The findings of the cited study suggest that teachers understand the factors determining students' perceived difficulty, but they sometimes underestimate them, and they do not seem to consider the emotional aspects linked to the perception of difficulty. However, there is still a need to investigate perceived difficulty from other school grade teachers' perspectives.

Hence, the aim of this paper is to explore, with a first qualitative study, the factors influencing primary school teachers' perceived difficulty regarding three mathematical tasks. In doing so, we are going to discuss primary school teachers' beliefs about perceived difficulty. In addition to that, in order to have a broader picture, we are going to compare their perceived difficulty to the actual difficulty experienced by the students who solved the tasks. Finally, we will compare primary school teachers' perceptions with secondary school teachers' to highlight possible differences between their perceived difficulties.

2 Theoretical background

The perceived difficulty of a mathematical task is commonly considered different from its objective difficulty. In fact, the latter is usually calculated after the administration of the task through the ratio between the number of students who solved it correctly and the total number of students to whom it had been proposed (Mehrens & Lehmann, 1991).

Moving on to the perceived difficulty, as previously said, the factors influencing it have been studied mainly referring to students' point of view (Saccoletto & Spagnolo, 2022), integrating it at a later stage with teachers' one (Nicchiotti & Spagnolo, 2024c). Thus, in this study, we adopted as a reference the descriptive and not mutually exclusive macro-categories of factors influencing perceived difficulty developed based on students' answers to questions focused on perceived difficulty (Saccoletto & Spagnolo, 2022; Spagnolo & Saccoletto, 2023b), which seem to be suitable for teachers as well (Nicchiotti & Spagnolo, 2024c).

The first macro-category, named *Resolution strategy,* includes answers that mention the strategy needed or used to solve the task, according to students' opinions. It also mentions necessary elements, such as calculus or reasoning, to reach a solution. The second macro-category, *Capabilities and experience*, is the broadest one, and it contains answers related to students' opinions about their competence and capabilities. Additionally, it includes elements such as their prior experience in solving similar problems and their familiarity with the task type. In general, answers which consider a problem easy due to similarity with something seen or done in the past fall into this category.

Furthermore, it addresses students' doubts about their answers and the obstacles they encounter during problem-solving, including time constraints. The third macro-category is *Emotions,* and it pertains to answers involving emotions and emotional states, both positive and negative. The authors state that this macro-category was not very present. The fourth macro-category is *Task formulation*, and it includes the answers considering the formulation of the task, ranging from the type of task to the textual aspect to the figures and graphs, if present. The fifth macro-category is *Personal consideration*, which contains students' personal considerations regarding their success in mathematics.

The aforementioned macro-categories form the reference used in our study to analyse teachers' open answers. To discuss our findings and analyse primary teachers' beliefs regarding perceived difficulty, we considered as a lens the theoretical construct

of the *diagnostic competence of teachers*, defined as an intersection between teachers' competence and educational assessment (Leuders et al., 2018). Meaning it in the broader sense, the model of diagnostic competence is a continuum which contains different elements (knowledge, beliefs, affect, etc.) and processes (perceive, interpret, decide, etc.) not connected by a sequential relationship (Leuders et al., 2018). Teachers' diagnostic judgement seems to be influenced by various factors, including social biases, knowledge of content and students, specificity and prior knowledge of the students they are referring to and intuitive decisions (Ostermann, 2018). This construct appears useful to frame teachers' ratings and discussion of perceived difficulty in our study, as it contextualises the different importance they give to each factor, depending on the task and the situation.

We also interpreted and discussed our results in the light of the concept of *expert blind spot* (Nathan & Koedinger, 2000; Nathan & Petrosino, 2003), an expression identifying teachers' lack of awareness of students' understanding and difficulties paired with excellent content knowledge. Deriving directly from expertise, the expert blind spot might not even be acknowledged by teachers who show it. The authors state that an expert blind spot may appear when pedagogical content knowledge and subject matter knowledge (Ball et al., 2008) are both owned by teachers, but when applying them, they come into conflict (Nathan & Petrosino, 2003).

3 Methodology

3.1 Overview of the study and sample description

We conducted an exploratory study based on the one described by Nicchiotti and Spagnolo (2024c). We used a volunteer sampling method, enrolling teachers during professional development courses. Teacher professional development courses were provided for teachers of a group of schools in northern Italy, including both primary and middle schools. The courses were based on discussion and debate, so teachers participating in them valued the possibility of expressing their point of view. In total, 27 teachers agreed to participate in the study. We excluded from the sample middle school teachers (2 out of 27) because we wanted to focus on primary school teachers, and we think that relevant differences might exist between the beliefs of the two groups; hence, our final sample was composed of 25 primary school teachers.

We administered an online questionnaire through Google Forms, which teachers filled out using their devices (smartphones, PC, tablets). The data collected was analysed qualitatively.

3.2 Questionnaire description

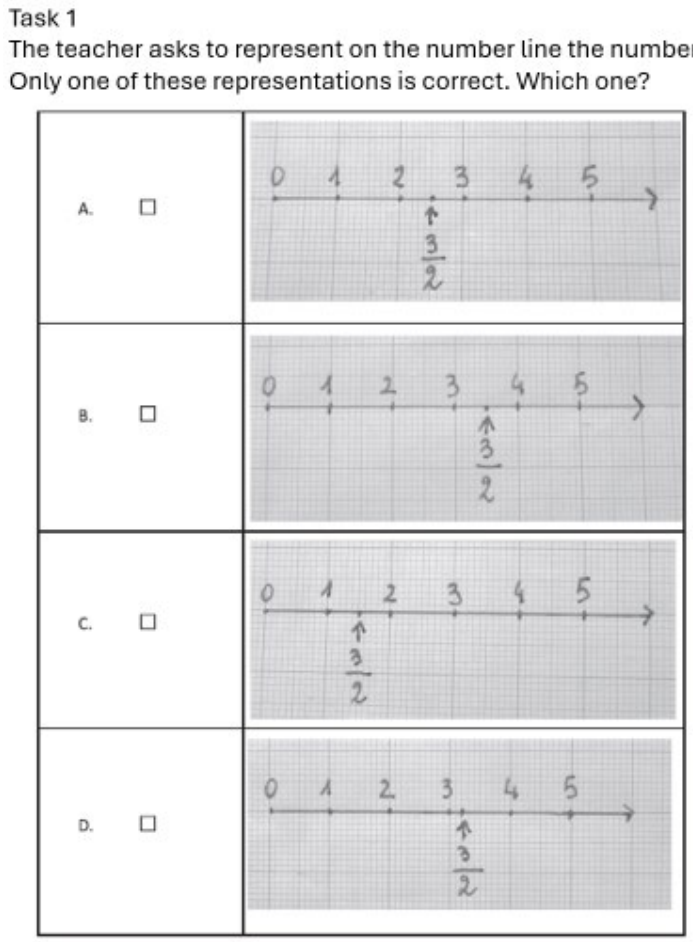
The questionnaire was designed following the one proposed to high school teachers by Nicchiotti & Spagnolo (2024c). It was structured into four sections: the first three contained a task to be solved, some specific questions regarding the perceived difficulty of the task solved, and a final section asked about the characteristics that make a mathematical task easy or difficult.

The three selected tasks are INVALSI tasks, administered in tests for national evaluation of Grade 5 students (last year of primary school in Italy) respectively in 2017, 2015 and 2022. INVALSI (Istituto Nazionale per la Valutazione del Sistema Educativo di Istruzione e di Formazione) is an Italian institution that assesses students' skills in different school subjects and many aspects of the Italian educational system. Since 2007-2008, it has been administering yearly tests to the students of selected grades. For each task, INVALSI releases the percentages of right, wrong and missing answers obtained from the national assessment.

The tasks were selected through a search on the online database Gestinv 3.0 (www.gestinv.it), an online interactive database of INVALSI tasks. For each task, it provides, among other information, text and figures of the task, keywords, and the percentages of right, wrong and missing answers, other than the analysis according to the item response theory. National assessments can be used to explore the strictness of teachers in grading students by comparing student grades to their scores on standardised tests (Doz, 2023). We chose the tasks according to the following criteria: they had to be grade 5 items, they had to be of different levels of difficulty, and they had to refer to different mathematical areas. We also considered it useful to include different types of tasks to diversify the selection as much as possible. This allowed us to propose tasks that included a wide range of elements of possible difficulty.

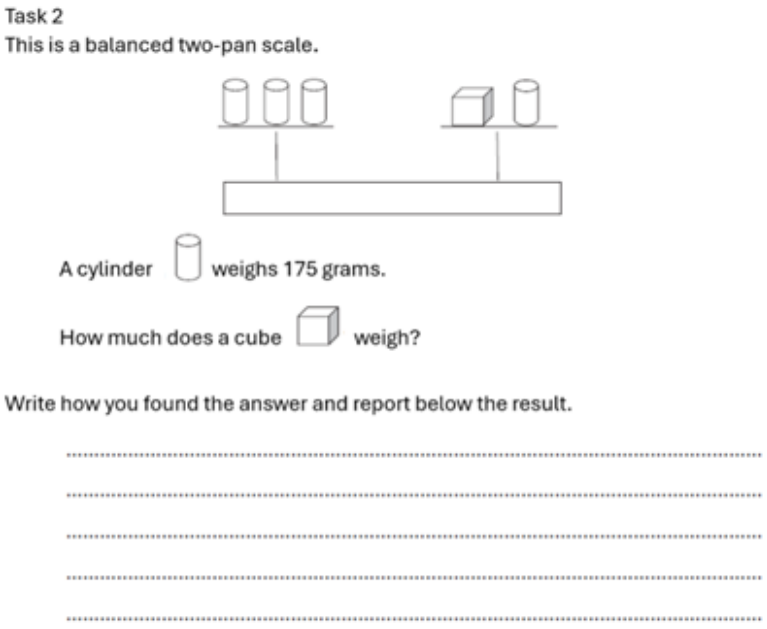
Task 1 is a multiple-choice task referring to the area of numbers. In particular, as shown in Figure 1, this task asks to choose, among the ones provided, the correct representation of a fraction on the line of numbers. In this case, the figure in the task collects the options of different representations. This task was particularly difficult for students, as from the national data, we saw that only 17.1% of the students solved it correctly.

Figure 1. Task 1 was administered to Grade 5 Italian students by INVALSI in 2017, www.gestinv.it



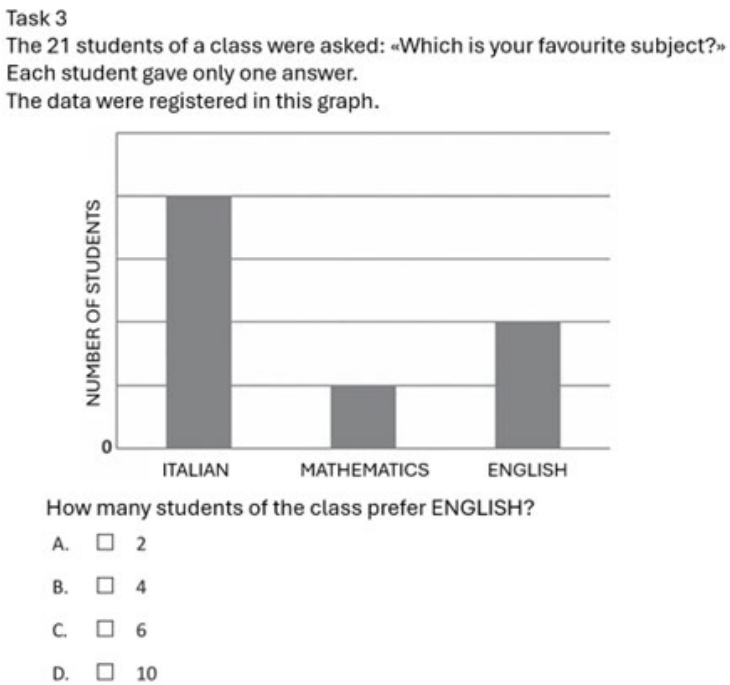
Task 2 is an open-ended question regarding the area of relations and functions, as shown in Figure 2. It asks to observe the figure included, which is a balanced two-pan scale, and, from it, deriving the weight of one of the elements on the scale. This task was the easiest among the ones we chose, even though it was not very simple; the national data show that 55.4% of the students solved it correctly.

Figure 2. Task 2 was administered to Grade 5 Italian students by INVALSI in 2015, www.gestinv.it



Task 3 is another multiple-choice task, but it falls into the area of data and predictions. As shown in Figure 3, this task is heavily based on the chart included, asking for interpretation and retrieval of information contained in it. This task was not very easy for students; in fact, only 40.1% of them solved it correctly; however, it is in the middle of the task selected for this research with respect to the difficulty.

Figure 3. Task 3 was administered to Grade 5 Italian students by INVALSI in 2022, www.gestinv.it



As previously explained, each task was followed by the questions below, which are connected to the task and its perceived difficulty:

(Q1) On a scale from 1 (very easy) to 10 (very difficult), how difficult was the task in your opinion?

(Q2) Why?

(Q3) Which aspects would you change to make the task easier?

(Q4) Which aspects would you change to make the task more difficult?

(Q5) What do you think is necessary to answer this task?

In the end, two general questions were asked. These last questions aimed to collect elements related to the perceived difficulty in general.

(Q6) According to you, which factors or aspects make a mathematical task difficult?

(Q7) According to you, which factors or aspects make a mathematical task easy?

4 Results and discussion

4.1 Rating of the tasks in terms of perceived difficulty

Analysing teachers' ratings of the three tasks regarding their perceived difficulty, we observed some evident differences between teachers' ratings of perceived difficulty and the actual difficulty evaluated by INVALSI through the national administration. Given the small sample size and the fact that teachers' ratings are not normally distributed, we will report the values of four descriptive statistics indexes (mean or average, median, standard deviation and interquartile range) for each task.

Task 1 resulted in the most difficult item for the students, with only 17.1% of correct answers; however, the average rating for this task for teachers is 4.3 on a scale from 1 (very easy) to 10 (very difficult) (standard deviation: 2.5; median: 5.0; interquartile range: 3.0). This means that teachers evaluated this task on average as almost medium difficulty, slightly easier than that. For this task, the difference between students' performance and teachers' perception appears very clear: teachers tend to underestimate the difficulty of such an item for various reasons described in the following paragraph.

On the other hand, Task 2 was, for the students, the easiest task among the selected ones; in fact, 55.4% of them gave a correct answer. In this case, teachers recognised that the task was easier than the first one, giving it an average rating equal to 3.4 on the same scale described before (standard deviation: 1.7; median: 3.0;

interquartile range: 2.5). However, teachers' ratings might make us define Task 2 as an easy task, which is not actually true, as students' percentages show only a little more than a student out of two answers correctly.

Finally, Task 3 was solved correctly by 40.8% of the students, resulting in just above the threshold value being defined as difficult (Mullis et al., 2021). For this task, teachers' rating of perceived difficulty was closer to the actual difficulty of the task, as the average teachers' rating is 5, identifying a medium difficulty task (standard deviation: 2.6; median: 5.0; interquartile range: 5.0). The data show that Task 3 was generally considered by the teachers the most difficult task among the three in the questionnaire, in contrast with the evidence resulting from students' large-scale assessment carried out by INVALSI. Moreover, our data show that primary school teachers also tend to underestimate the difficulty of mathematical tasks and that this underestimation sometimes is paired with a lack of understanding of what could be the students' difficulties. In fact, not only did teachers consider all the tasks easier than what emerged from actual students' results, but they also did not classify them in the actual order of difficulty with their ratings.

4.2 Analysis and discussion of teachers' answers

Teachers' answers expressing the reasons for their ratings were analysed qualitatively through text analysis, referring to the aforementioned macro-categories. In each open-ended answer, we highlighted the elements pertaining to different macro-categories, meaning that the same answer could be categorised into two or more macro-categories as they are not mutually exclusive. Both researchers coded the answers independently, and later, the coding choices were compared, discussing the few cases in which we disagreed with each other until an agreement was reached.

For Task 1, the macro-category containing the greatest number of references was *Resolution strategy*, in fact, to explain the perceived difficulty of the task, the majority of teachers referred to the process to follow to reach the solution or even described in detail the reasoning needed to answer correctly. Answers like "[Task 1 is of medium difficulty] because half of 3 is 1.5" are quite common but seem almost to be answering to the reason why the result is such and not to the reasons for the perceived difficulty; there are also answers referring to the fact that "it is necessary to do the division in mind. Easy for an adult, not always for a child" or to the fact that "students focus on the numerator of the fraction", which are more focused on parts of the solution that might be difficult for students. However, those teachers somehow identified the

difficulty of the task with the process needed to solve it, not mentioning any other element than that. This phenomenon might be explained through the *expert blind spot*, which did not allow them to see other possible factors influencing the perceived difficulty. The other macro-categories present in teachers' answers for Task 1 were *Capabilities and experience* and *Task formulation*, both with a very little number of references. In fact, occasionally, some teachers mentioned elements such as previous experiences with the topic ("I have already used this kind of representation with my students") or similar problems. Only minor remarks were made referring to the formulation and structure of the task. In particular, regarding this last macro-category, we could only find mentions of the figure presented as a facilitating element, like in the following example: "[Task 1 is very easy because] the numbers on the line make it easy to place the result of the division 3:2=1.5".

Table 1. Distribution of the references among the macro-categories for Task 1

Macro-category	**Number of references**	**Percentages**
Resolution strategy	15	60%
Capabilities and experience	7	28%
Emotions	0	0%
Task formulation	3	12%
Personal consideration	0	0%

Moving on to Task 2, we observed that the most present macro-categories were the same as those identified and discussed for Task 1: *Resolution strategy*, *Capabilities and experience*, and *Task formulation*. The main difference with the case previously described is that for this task, the macro-category containing the most references was *Task formulation*. In contrast, the other two contained almost the same number of references, slightly lower than the one of *Task formulation*. Hence, the elements contained in these three macro-categories seem to be of the same importance for teachers. Still, the relevant aspect is that for this task, the formulation (textual aspect, figure, etc.) was heavily considered. None of the teachers mentioned the type of question, meaning that they did not perceive the openness of the question as an additional element of difficulty. However, many teachers referred to the figure, saying that "[Task 2 is easy] because students are helped by the graphical representation" or "[Task 2 is easy] because just look at the picture". So, for this task,

the picture assumed a crucial role in the evaluation of the perceived difficulty, highlighting that the same element might have different importance depending on the task. Another aspect we noticed was the presence of a remark about personal consideration by one of the teachers, writing that "[Task 2 is of medium difficulty because] some children already have the competence and abilities, some others not yet"). For Task 2, hence, there is also the small presence of the macro-category *Personal consideration*.

Table 2. Distribution of the references among the macro-categories for Task 2

Macro-category	**Number of references**	**Percentages**
Resolution strategy	7	25%
Capabilities and experience	8	28.6%
Emotions	0	0%
Task formulation	12	42.9%
Personal consideration	1	3.6%

For Task 3 as well, the most important macro-categories resulted to be *Resolution strategy*, *Capabilities and experience* and *Task formulation* but in different proportions than before. In fact, in this case, there are fewer references to *Resolution strategy* and more to the other two macro-categories, which are almost equally divided among them. The references to the resolution strategy again explain the process of solving the task, not commenting on it ("One mark is worth 3" or "A lot of reflection is needed"). Instead, the answers belonging to *Capabilities and experience* and *Task formulation* are deeply intertwined because teachers consider the absence of the unit of measurement in the chart a concerning point, representing an obstacle in the resolution of the task. Answers like "[Task 3 is difficult] because the chart is missing a key" or "[Task 3 is difficult] because there is no unit of measurement in the chart" are highly representative and suggest that teachers, in this case, focused more on the elements of the task, believing that they could influence perceived difficulty. For this task as well, there is the presence of a few references to the macro-category of *Personal consideration*: it is the first time that teachers consider students' attitudes when approaching the task, and they recognise the impact that subjective factors might have on the perceived difficulty. We included in this macro-category answers

like "[Task 3 is difficult because] if you do not carefully read both the text and the graph, it is easy to make mistakes".

Table 3. Distribution of the references among the macro-categories for Task 3

Macro-category	**Number of references**	**Percentages**
Resolution strategy	8	23.5%
Capabilities and experience	10	29.4%
Emotions	0	0%
Task formulation	13	38.2%
Personal consideration	3	8.8%

We could identify evidence of the *expert blind spot* in many of the answers collected for each task; a very clear sign of it is the fact that the majority of the references fall into the macro-categories concerning mainly objective factors, while the ones regarding more subjective sides (*Emotions* and *Personal consideration*) are less considered. Teachers often referred to their students' abilities and difficulties in their answers. Still, they are always filtered through their viewpoint, and hence the statements might be influenced by their beliefs and not be as objective as they think. Moreover, in the broader perspective of the teachers' diagnostic competence, our results suggest that, like teachers from other school grades, primary school *teachers' diagnostic competence* when judging the perceived difficulty of tasks results not always accurate, focusing on elements that are objective and dismissing the subjective side.

Table 4. Comparison between the distributions of the references among the macro-categories for Task 1, 2 and 3

Macro-category	**Number of references**		
	Task 1	**Task 2**	**Task 3**
Resolution strategy	15	7	8
Capabilities and experience	7	8	10
Emotions	0	0	0
Task formulation	3	12	13
Personal consideration	0	1	3

The small sample size does not allow us to draw definitive conclusions; however, comparing the answers collected during this research with the answers from high school teachers analysed in other studies (Nicchiotti & Spagnolo, 2024c), we noticed that teachers, in general, tend to consider more important the objective factors, such as the formulation of the task, the strategy used, the obstacles faced, etcetera, when rating its perceived difficulty. Nevertheless, primary school teachers' data suggest that they are more inclined to evaluate subjective factors than secondary school teachers, and their rating of perceived difficulty seems slightly more accurate. In other words, from our first results, primary school teachers' perceived difficulty seems to be not always close to the actual difficulty of the tasks but more accurate in terms of the factors influencing it than the one expressed by high school teachers.

5 Conclusion

The study described in the paper explores the theme of teachers' perceived difficulty regarding mathematical tasks, deepening primary school teachers' perspective. Despite the small sample size, we could draw some conclusions that must be further studied to be confirmed. Extending the use of the macro-categories of factors influencing perceived difficulty (Spagnolo & Saccoletto, 2023b) to teachers from different school grades, we confirmed that also primary school teachers seem to be aware of some of the reasons behind students' mistakes, but they still tend to underestimate the difficulty of the tasks, which might be explained in terms of the *expert blind spot* (Nathan & Koedinger, 2000; Nathan & Petrosino, 2003). When considering factors influencing perceived difficulty, they are more focused on objective than subjective ones; nevertheless, some seem to consider them both, in contrast with what happened with secondary school teachers, which appeared to be focused only on the objective ones (Nicchiotti & Spagnolo, 2024c). When rating the perceived difficulty of tasks, primary school teachers often refer to their students. They support their statements with their everyday teaching experience rather than personal beliefs about mathematics, even though beliefs influence the interpretation of their experiences. Obviously, it is not possible to draw general conclusions regarding the comparison between primary school teachers and secondary school ones in terms of the factors influencing their perceived difficulty due to the limited number of teachers involved in the study; however, these first data suggest that primary and secondary school teachers might have similar perceived difficulties, with the difference that the former seem to consider also subjective factors when describing

it.

Further studies involving larger samples could allow us to explore the theme more thoroughly and confirm these initial findings.

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