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Interpretation of Mathematical Tasks Misunderstanding in the Context of Disciplinary Literacy of University Students

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Abstract

In the article, we focus on the investigation of the disciplinary literacy of technical university students with an emphasis on understanding the mathematical language and symbolism in the tasks assignment. As part of the pedagogical research, we were looking for an answer to the research question "How do students interpret the misunderstanding of the assignment?". In the first phase of the research, the students solved a test that contained four pairs of mathematical tasks: a standard task and its equivalent, which required the mastery of mathematical symbolic language at a higher level. In the second phase of the research, students filled out a questionnaire that contained possible causes of failure in solving tasks in the test. Based on the research findings, we can state that the teachers and students agreed on only one item of the questionnaire, namely that the primary cause of the students' failure was a misunderstanding of the assignment. Teachers and students differed statistically significantly in their responses to the other items of the questionnaire. Based on the students' statements, we conclude that their understanding of the assignment of the task corresponds with the ability to assign the learned calculation procedure to the task, that is, with procedural knowledge. Teachers attributed the causes of student failure in the test to insufficient knowledge of the mathematical language.

Keywords: disciplinary literacy, disciplinary reading, student, language of mathematics.

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1. Introduction

As part of the university study of mathematical disciplines, students are expected also to conduct self-study. For this, it is necessary they have adequate support in the form of quality study material and also support from the teacher (Kolodner et al., 2003). According to Martin et al. (2019) it is necessary to find a symbiosis between various sources of support, especially between support from the teacher and material resources. A common element of student support is explanations of concepts and problem-solving procedures. Explanations form the basis of teaching and learning, but concrete explanations do not always lead to successful learning (Wittwer Renkl, 2008), despite the fact that teachers use explanations on a daily basis. One of the reasons why explanations do not always lead to successful learning may be the lack of connection between the advanced skills of teachers of mathematics subjects and the skills of students in mathematics (Gee, 2012). One of the significant barriers that prevents the creation of the necessary connection (synergy) between teacher and student is the language of mathematics. The language of mathematics, unlike language as a means of communication, does not contain elements of time and emotional elements. However, it has its own grammar, syntax and sentence structure (Moursund, 2005). According to Adams (2003), students should be able to read mathematical sentences, symbols and diagrams in order to be successful in mathematics. Several researches (e.g., Bergqvist et al., 2018; Andanik Fitrianawati, 2018; Ünal et al., 2021) confirmed the correlation between the ability to read mathematical texts with comprehension and success in mathematics. From the mentioned research, it is necessary for mathematics teachers to know the extent to which students can understand the language of mathematics and to adapt the language of explanation accordingly. The ability to read, write and explain clearly in a specific academic discipline, in our case mathematics, is the content of disciplinary literacy (Fang, Chapman, 2020). Disciplinary literacy was defined as "the use of reading, thinking, researching, speaking, and writing necessary to learn and form complex content knowledge appropriate to a specific discipline" (McConachie, Petrosky, 2010: 6).

The goal of teaching mathematics are mathematically literate people, i.e., j. people able to think mathematically and use mathematical knowledge in practical life, which is different from teaching mathematical content (Piatek-Jimenez et al., 2012). According to Hillman (2014), the foundation of mathematical literacy is discourse, which requires students to explain their reasoning and problem-solving procedures. According to Sfard (2007), mathematical discourse is characterized by four textual features: mathematical words, narratives, visual mediators, and routines (mathematical words, stories, visual mediators and routines.) By studying the transformations in these signs, several experts assume the discursive development of students (e.g., Sfard, 2007; Munson, 2019). To develop students in mathematical discourse, it is necessary that students are able to learn from available resources and that there is synergy between these resources (Tabak, 2004; Tropper et al., 2015; Hähkiöniemi et al., 2022). To create this necessary synergy, disciplinary literacy is required from teachers - the creators of teaching texts – in order to be able to communicate the knowledge of the given scientific discipline correctly (Shanahan Shanahan, 2012). At the same time, it is necessary to develop not only content, but also disciplinary literacy of students. The aim of our research was to find out how students interpret the misunderstanding of the assignment.

Reading in mathematics

Mathematics teachers, in an effort to support student learning, constantly produce teaching texts in which they explain the subject matter to their students. The explanations found in the study materials are of different quality (Chi et al., 2001; Lew et al., 2016), which may not be the only factor affecting the suitability of the given study material for students. According to Capraro et al. (2012), teachers assume that students can analyze and synthesize the main ideas of a mathematical text, learn unfamiliar vocabulary through context, draw and justify conclusions with evidence from the text, and monitor understanding of new knowledge. However, several research studies point to the fact that college students have significant reading comprehension problems in mathematics textbooks (Shepherd et al., 2012; Doerr Temple, 2016). The reason for these difficulties may be the language of mathematics used by the teacher when writing teaching texts. According to Azmi (2021), when creating teaching texts, it is necessary to consider the important fact that the teaching of mathematical content is connected with the teaching of mathematical language. According to Doerr and Temple (2016), it is already beneficial for students in secondary schools if contact with mathematical professional language that is in accordance with the norms of the discipline, part of learning mathematics. In this way, it is possible to build solid foundations of mathematical knowledge in students at a young age and build the prerequisites for using mathematics later in life (Cervetti, 2021; Grysko, Zygouris-Coe, 2020). The need to link the teaching of mathematical content and mathematical language is emphasized by mathematics researchers (e.g. Kulm et al., 2007; Purpura et al., 2017; Lin, 2021), who state that students' understanding of mathematical concepts depends largely on their mastery of the vocabulary used to define and explaining mathematical concepts and procedures and their ability to recognize the meaning of words in a given context. Text structure plays an equally key role in text comprehension (Piccolo et al., 2008).

The method of acquiring mathematical knowledge from the point of view of the cognitive process in mathematics is also related to this. In the process of forming mathematical knowledge, it is mainly a procedural or conceptual acquisition of knowledge (Dubinsky, 1991; Gray, Tall, 1994; Sfard, 1991). Procedural understanding is focused on processes – it requires knowledge of algorithms, techniques and methods by which we arrive at a result. Procedural understanding is preferred by students who prefer memorizing mathematics over actually understanding it (Shirvani, 2016). Hiebert, Lefevre (1986), distinguish two types of procedural knowledge. One is familiarity with the individual symbols of the system and the syntactic conventions that create acceptable configurations of symbols. Another type of procedural knowledge is rules or procedures for solving mathematical problems. Many of the procedures that students master seem to consist of a chain of instructions on how to manipulate symbols. Conceptual understanding expresses the interrelationships between basic elements within a larger structure that enable them to function together. Hiebert, Lefevre (1986) characterize conceptual knowledge as knowledge rich in relations, which we can think of as an interconnected web, a network in which relations are as important as separate information. Shirvani (2016) states that conceptual understanding helps to use acquired knowledge even in non-standard situations.

According to Sfard (1991), any mathematical concept is usually defined both conceptually and procedurally (e.g., when defining rational numbers procedurally, we speak of a rational number as the result of dividing two integers; in the conceptual definition of the concept of a rational number, we mean a pair of integers that is a member of a specially defined set of pairs). Research shows that the best results in mathematics are achieved by students who acquire both conceptual and procedural understanding of mathematical concepts.

Introducing disciplinary literacy practices into the teaching of mathematics allows students to approach the thinking, learning and speaking of scientists (Cervetti, 2021). This key approach requires students to move from reading comprehension of text content to disciplinary reading that promotes mathematical thinking and professional discussion skills (Shanahan, Shanahan, 2012). Since the 1990s, the field of mathematics education has demanded the creation of written texts that use language in a discipline-specific way (e.g., Chapman, 1997; Burton, Morgan, 2000; Sfard, 2007; Draper, Siebert, 2004). At the same time, teachers are encouraged to focus not only on content literacy, but also on disciplinary literacy when creating teaching texts (Moje, 2008). At the secondary school level, these requirements were met with resistance from teachers (Alvermann, Moore, 1991; O'Brien et al., 1995), who perceived the teaching of reading strategies as a matter of extracurricular pedagogy (Dillon et al., 2011; Draper et al., 2010). The implementation of disciplinary literacy promises to resolve this "dualism" of disciplinary and content literacy by replacing the teaching of general reading strategies with the teaching of discipline-specific strategies (Draper et al., 2005).

According to Shanahan Shanahan (2012), content literacy focuses on study skills that help students learn from subject-specific texts. Disciplinary literacy, on the other hand, emphasizes the abilities of those who create, communicate, and use knowledge within disciplines. The goal of disciplinary literacy is to identify differences in reading and writing between disciplines and to find ways to implement this knowledge into teaching disciplines so that students can read and communicate like experts in that discipline (Shanahan, Shanahan, 2012). The need to simultaneously develop both content and disciplinary literacy is justified because school teaching of subjects can be considered disciplinary discussions recontextualized for educational purposes (Fang, Coatoam, 2013). An integral part of disciplinary literacy, and thus students' academic success, is the proficiency in academic language (Johnson et al., 2011).

Each discipline has a unique language and according to Johnson et al. (2011), each language typically consists of a specialized vocabulary, sentence structure, and symbol system, creating specific features of disciplinary texts. Hyland (2020) considers each scientific discipline as a distinctive discourse community with its own way of structuring communication and knowledge. We conceptualize mathematical language as a mode of discourse that is focused on learning mathematics and contains an expressive (speaking and writing) and a receptive (reading and listening) component (Barton et al., 2002). The specifics of mathematical language have been described by several studies (e.g., Fang, 2012; Fang, Schleppegrell, 2010; O'Halloran, 2005; Schleppegrell, 2007), which point to the fact that mathematical vocabulary is highly specialized and cognitively demanding. Unknown words that carry a large part of the content of a mathematical text are little known from everyday life and have multiple meanings. Some words have a different meaning in mathematics than in everyday life (Capraro, Joffrion, 2006). Therefore, reading mathematical texts requires increased demands on the reader's critical reading skills (Gardner, 2007), which the reader needs to be able to understand the exact expression of the words used and the way to solve the problem. In order to implement disciplinary literacy in teaching, it is necessary to simultaneously identify the characteristic elements of professional texts (Neugebauer, Gilmour, 2020).

Mathematical professional texts have a multimodal character because they communicate information through linguistic, symbolic and visual representations. In addition, mathematical texts are also characterized by conceptual density, as they often contain more important concepts per line, sentence or paragraph than any other type of text, which is another factor causing problems for students when reading mathematical texts (Barton et al., 2002; Wiesner et al., 2020). On the basis of the mentioned research, it can be concluded that students entering the first year of the B.Sc. have problems reading professional mathematical texts. These problems are caused by the specifics of mathematical disciplinary language and the structure of mathematical texts. Both of these factors are the subject of disciplinary literacy, and therefore it is justified to look for ways to help students improve their reading of mathematical texts. According to Barton et al. (2002) helping students with mathematical texts does not mean teaching them to read. Rather, it is necessary to enrich them with special reading skills that they do not use in other scientific fields. For example, in addition to understanding text that is organized differently than in core subjects, students must be able to decode and correctly interpret mathematical symbols, tables, and graphs. Reading, like learning, is a constructive process in which students draw on prior knowledge and experience (Vacca, Vacca, 1999).

The more knowledge and skills the teacher puts into the text, the better the students will learn new knowledge from the read text. One of the ways in which teachers try to make it easier for students to read mathematical texts is the creation of teaching texts that explain mathematical concepts or calculation procedures in a "non-mathematical" way. They use real contexts, express mathematical principles in an informal way and use less technical language (Davis, 2012; Stylianides, 2009). Such a form of teaching mathematics texts is significantly different from disciplinary texts (Thompson et al., 2012) and contributes to students' difficulties in reading mathematics texts in future studies (Brantlinger, 2011). Instead of moving away from disciplinary mathematics texts, it is more appropriate to develop students' abilities to read disciplinary texts (Borasi, Siegel, 2000; Fang, Coatoam, 2013). Fang and Chapman (2020) emphasize that disciplined reading is one way that can help students improve their own mathematical competence. For disciplinary reading strategies to be effective in learning mathematics, they must be embedded in meaningful disciplinary experiences where students explore issues relevant to the discipline (Fang, Chapman, 2020). Understanding the way texts are read by experts in a given scientific field will enable educators to design appropriate strategies to support students' necessary ability to read professional texts. According to Fisher (2018), mathematicians use different strategies when reading scholarly texts than do historians or chemists. Some other scientific studies have also revealed that the ways of reading scientific texts by disciplinary experts are specific to the given discipline (Burton, Morgan, 2000; Shanahan Shanahan, 2008; Johnson, Watson, 2011; Mejia-Ramos, Weber, 2014; Melhuish et al., 2022).

For example, Weber (2008) states that when reading a mathematical proof, mathematicians first use a shrinking strategy (i.e., examine larger parts of the logical structure) before reading each line of the text in more detail (a zooming strategy). In contrast to Weber (2008), Inglis and Alcock (2012) report that research-active mathematicians used a zoom-in strategy and did not use a shrink-in strategy. When reading the text of a mathematical proof, mathematicians focused their attention first on the logical details of the argument and did not examine the overall logical structure of the proof text. Another study found that mathematicians use the structure of a text to support their comprehension and carefully compare new information with their prior knowledge as they read (Shanahan et al., 2011). In a study conducted by T. Shanahan Shanahan (2008), mathematicians reported that they use close reading and rereading as their dominant strategies when reading academic texts because every word counts when learning from a text. Close reading and re-reading of expressions that have precise meaning is part of mathematical literacy (Gritter, 2010; Shanahan, Shanahan, 2008). In their study, Hodds, Alcock, and Inglis (2014) found that rereading, monitoring, paraphrasing, and questioning are effective strategies that students can use when reading disciplinary mathematics texts. However, these strategies are also used by experts in other disciplines, such as literature and history (Chapman, 2015; Rainey, 2017)

The problem is that general reading practices are rarely taught in alignment with disciplinary goals (Dillon et al., 2011), leading mathematics teachers to view them as irrelevant to mathematics instruction (Shanahan, Shanahan, 2008). Likewise, Hillman (2014) in her review of the literature on disciplinary literacy in mathematics found that little attention has been paid to how teachers implement the demands of disciplinary literacy into their teaching. Disciplinary literacy provides the language through which mathematical literacy grows, is used, and is shared. When we equip every student to use a full range of communication strategies and tools – including those particular to the discipline of mathematics – we also enable them to identify themselves as knowers and doers of mathematics. With these strong mathematical identities, they can comfortably and ably apply mathematical thinking and tools in a wide variety of abstract and real-world situations, which may be the most practical outcome of being literate in mathematics.

According to Fountas Pinnell (2018), students with a developed ability to read disciplinary texts are able to think beyond the scope of the text they are reading because they are not focused only on the content of the text. This fact corresponds with the results of research by Lent (2017), who found that when mathematicians read, they look for patterns and relationships, try to decipher symbols and abstract ideas, ask questions and apply mathematical reasoning, which includes the use of previous knowledge. These are the strategies that gradually transform students into experts in the field of mathematics, which is one of the reasons for the implementation of disciplinary literacy in the teaching of mathematics (Shanahan, Shanahan, 2012). Mathematical disciplinary reading presupposes linguistic understanding and knowledge of the "language of mathematics" (Esty, 2011). Adams (2003) emphasizes that students should be able to read mathematical sentences, symbols and diagrams in order to be successful in mathematics. However, Wollman (1983) found in his research that university students are not able to adequately express their thoughts using standard mathematical symbols. According to Muth (1991), students' problems with problem solving do not lie in a lack of calculation skills, but in a lack of understanding of the assignment, which is caused by a lack of knowledge of the meaning of mathematical symbols used in mathematical texts (Hiebert, 1988; Adams, Lowery, 2007).

The analysis of scientific literature shows the importance of linking mathematical content with mathematical professional language, the specifics of which cause difficulties for students in learning it. Therefore, it is necessary to pay attention to disciplinary reading when teaching mathematics. The development of disciplinary reading must also be taken into account when creating teaching texts for students. Students capable of disciplinary reading can effectively use the acquired knowledge when solving various tasks. The lack of disciplinary reading ability manifests itself in a misunderstanding of the assignment of the solved task, so the student cannot use the acquired computing skills or uses them to a limited extent.

Research design

Based on the knowledge presented in the previous sections, we carried out pedagogical research in the academic year 2022/2023. Before the start of the research, we approached 183 randomly selected first-year bachelor's degree students at a technical college, who were familiar with the content of the research. Seventy-four 74 students between the ages of 19 and 21 voluntarily decided to participate in the research. All participants were assured of the anonymity of the research and agreed to participate. The research was conducted in two phases. As part of our research, we set the research question:

RQ: How do students interpret the misunderstanding of the assignment?

We used feedback from students to find the answer. According to several experts, the student plays a leading role in the creation of feedback (Carless, Winstone, 2020, Tai et al., 2018, Winstone et al., 2017). It is known that a suitable form of feedback for university students is self-evaluation, which includes reflection on one's own products (Harris, Brown, 2013). Since the accuracy of self-assessment can be determined by comparing a student's self-assessment with the judgments of qualified evaluators, such as teachers or classmates, or with test performance (Panadero, Lipnevich, 2022), we also included six teachers in our research. The research was conducted in two phases. In the first phase, students completed a math test that included four standard tasks and four tasks that required students to master mathematical symbolic language at a higher level. Tasks that required proficiency in higher-level mathematical symbolism were intentionally set to be equivalent to tasks that were set as standard math tasks. So, the test contained four pairs of tasks. If the student has solved the standard task, he should also solve its equivalent, provided he can correctly read the mathematical symbolic language.

Let us give an example. As a standard task, we classified e.g., task:

Construct the graph of the function $y = 3x - 1$.

Its equivalent, a task with higher demands for controlling (mastering) mathematical symbolic language, was the given task:

Represent the set: $A = \{(x, y): x = y + 1; x, y \in R\}$.

After passing the test, we asked six teachers to evaluate together the developed tests of the students. The second phase of the research took place approximately one hour after the end of the test. First, the students were informed about the results they achieved in the test by being told which task they solved correctly and which one incorrectly. Subsequently, we asked the students to fill out a questionnaire. The questionnaire contained seven items that contained possible reasons for the student's failure to solve the tasks in the test. The students commented on the individual items of the questionnaire using a Likert scale from 1 to 4 (1 – weak belief; 2 – mild belief; 3 – strong belief; 4 – strong belief) and thereby expressed their opinion (feedback) about the cause of their failure when solving tasks in the test.

Subsequently, we asked the teachers who evaluated the students' test results to also fill out a (modified) questionnaire and thus express their opinion on the causes of the students' test failures. We analyzed the results obtained by the experiment using statistical methods of qualitative features.

2. Data analysis

For the analysis of the results obtained by the questionnaire method, we used the χ^2- test of independence for the $k \times m$ type contingency table. We tested the null hypothesis H_0 characters A, B are independent against the alternative hypothesis H_1: characters A, B are dependent. While character A represents the teachers' answers to the questions listed in the questionnaire and character B represents the students' answers to the questions listed in the same questionnaire. As a test criterion, we used the χ^2 statistic, which is given by the relation

$$\chi^2 = \sum_{i=1}^{k} \sum_{j=1}^{m} \frac{(f_{ij} - o_{ij})^2}{o_{ij}},$$

where f_{ij} are empirical abundances and o_{ij} are expected abundances. The test statistic χ^2 has the validity of the tested hypothesis H_0 χ^2 – distribution with the number of degrees of freedom $r = (k-1)(m-1)$.

We reject the tested hypothesis H_0 at the significance level α if the value of the test criterion χ^2 exceeds the critical value $\chi^2_\alpha(r)$. The critical value $\chi^2_\alpha(r)$. can be found in the table of critical values of the χ^2- distribution. As part of our research, we used the χ^2-test of independence for the $k \times m$ contingency table to verify whether there is a significant difference in the answers of students and teachers to each question (or the cause of failure) in the questionnaire. We implemented the test in the STATISTICA program. After entering the data, we received in the output report of the computer a contingency table, the value of the test criterion of the χ^2-test and the p-value, which is the probability of the error we make when we reject the tested hypothesis. We can also evaluate the test based on the calculated p values. If the calculated value p is sufficiently small ($p < 0.05$ or $p < 0.01$), we reject the tested hypothesis H_0 about the independence of the observed features A, B (at the significance level of 0.05 or 0.01). Otherwise, we cannot reject the hypothesis H_0, i.e., the observed differences are not statistically significant.

We assessed the degree of statistical dependence between qualitative features A, B using the *contingency coefficient*, which is defined by the following formula.

$$C = \sqrt{\frac{\chi^2}{n+\chi^2}}, \qquad \text{where } \chi^2 = \sum_{i=1}^{k}\sum_{j=1}^{m}\frac{\left(f_{ij}-\frac{f_i^A f_j^B}{n}\right)^2}{\frac{f_i^A f_j^B}{n}}.$$

The contingency coefficient C takes values from the interval $\langle 0,1 \rangle$. If $C = 0$, characters A, B are independent. Values close to zero indicate weak dependence and vice versa, values close to one indicate strong dependence. The interpretation of other values of the contingency coefficient is the same as the interpretation of the values of the correlation coefficient. In the case of a statistically significant difference between the answers of students and teachers, we also calculated the contingency coefficient.

In our case, when testing the statistical relationship between the answers of students and teachers, we used the χ^2-test of independence for the $k \times m$ contingency table to verify whether the students' answers to each question are related to the teachers' answers to the given question.

Results of the χ^2-test and the contingency coefficient are shown in Table 1.

Table 1. Results of the χ^2-test and values of the contingency coefficient

	χ^2	p	C
Item 1	4.368	0.224	-
Item 2	42.397	0.000*	0.588
Item 3	16.717	0.000*	0.460
Item 4	10.929	0.016*	0.453
Item 5	18.498	0.000*	0.539
Item 6	40.083	0.000*	0.628
Item 7	78.000	0.000*	0.707

* Statistically significant values

From Table 1, we can see that the p-value is in all cases, except for question 1, smaller than the chosen level of significance $\alpha = 0.05$, i.e., we reject the hypothesis H_0 at the level of significance $\alpha = 0.05$ and accept the alternative hypothesis H_1. This means that belonging to a group (student or teacher) has a statistically significant effect on the selection from the offered scale for each of the items 2 to 7.

The only reason for failure for which no statistically significant difference was found between the statements of students and teachers was I did not sufficiently understand the assignment (item 1). The statistical test proved ($\chi^2 = 4.368, p = 0.224$), that the statement on item 1 does not depend significantly (or statistically significantly) on whether the student or the teacher comments on the given item. The situation is illustrated in Figure 1.

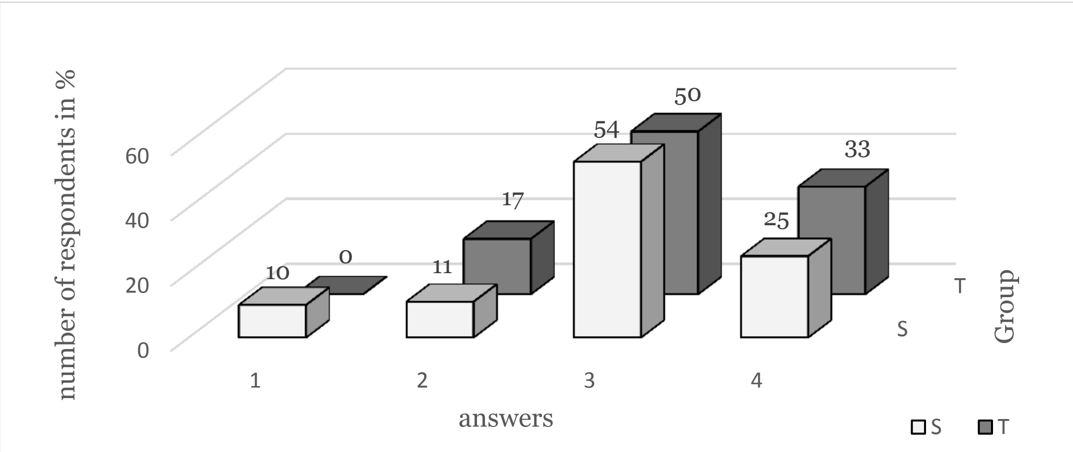

Fig. 1. Distribution of the frequency of student and teacher statements regarding item 1

From Figure 1, we can see that the students and the teachers were strongly and even very strongly convinced that the reason for the students' failure in solving the tasks was a lack of understanding of the assignment.

In the comments on item 2 (I chose the wrong solution procedure), item 3 (I did not remember the entire solution procedure) and item 4 (I did not encounter this type of task), students expressed a strong to very strong belief that their failure in the test was caused by stated reasons. On the other hand, the teachers expressed the opinion that they are weak to moderately convinced that the mentioned reasons were the reason for the students' failure in the test. The most significant difference between the opinions of teachers and students in these three items was for item 2. Figure 2 illustrates this difference of opinion.

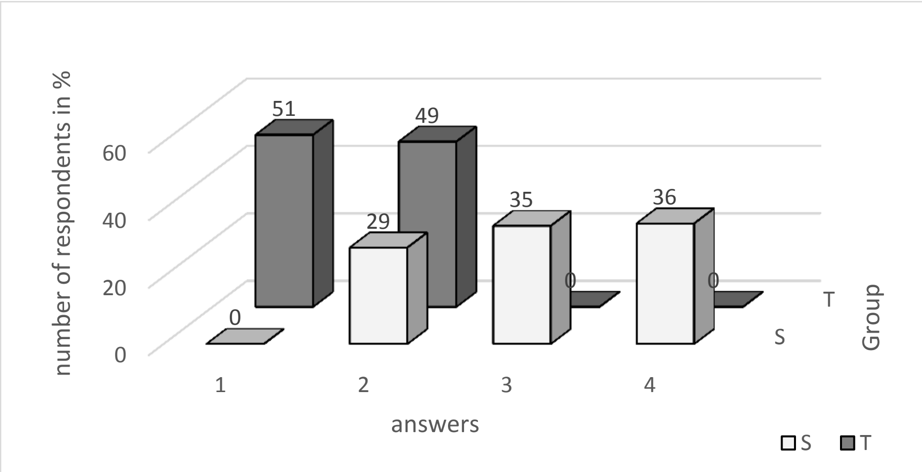

Fig. 2. Distribution of the frequency of student and teacher statements regarding item 2

In Figure 2, we can see that on the item whether the cause of students' failure in solving mathematical problems is the fact "I chose the wrong procedure", all teachers have a weak or only moderate belief, but more than 70 % of students marked "choosing the wrong procedure" as "strong conviction", or is students are mostly strongly convinced that they have chosen the wrong course of action. Based on the calculated value of the contingency coefficient ($C = 0.588$), we can conclude that there is a significant degree of connection between the group (student and teacher) and the choice of response to item from the scale. This means that the choice of expression for item from the scale are statistically significantly dependent on whether the teacher or student commented on the given item.

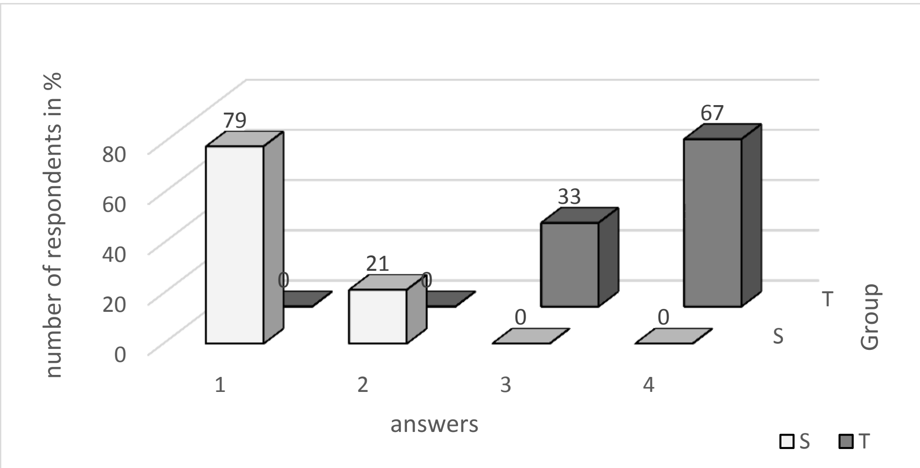

Fig. 3. Distribution of the frequency of statements of students and teachers regarding item 7

In the responses to item 5 (I did not consider the meaning of mathematical symbols), item 6 (I interpreted the mathematical symbols incorrectly) and item 7 (I did not realize the additional meaning of some mathematical symbols in the assignment) we noted the opposite trend in the responses to the previous three items. Students expressed a weak to moderate belief that the listed factors caused them to fail the test. On the other hand, the teachers expressed the opinion that they strongly or very strongly believe that the mentioned factors were the cause of the students' failure in the test. The most significant difference between the opinions of teachers and students in these three items was for item 7 ($C = 0.707$). Figure 3 illustrates this difference of opinion.

From Figure 3, we can see that 67 % of the teachers expressed a strong belief that not realizing the multiple meanings of some mathematical symbols in the assignment was the cause of the students' failure in the test. On the other hand, up to 79 % of students only weakly agreed that the mentioned fact would be the cause of their failure in the test.

3. Discussion

Mathematical disciplinary reading presupposes knowledge of mathematical language. As part of the first phase of our research, we found that students had a significantly lower success rate in tasks that required a higher level of understanding of mathematical symbolic language. In the questionnaire, the students themselves identified a lack of understanding of the assignment (item 1) as the reason for their failure to solve the assigned tasks in the test. Other reasons for their failure in solving tasks were considered to be an incorrectly chosen solution procedure (item 2) and failure to remember the entire procedure (item 3). These statements of theirs indicate their focus on learning calculation procedures as instructions for solving a certain set of tasks. On the other hand, students did not agree or only weakly agreed that the cause of their failure in the tasks was insufficient proficiency in mathematical symbolism (items 5-7). Based on the statements of the students, which we obtained through the implementation of the experiment, we conclude that their understanding of the assignment of the task corresponds to the ability to assign the learned calculation procedure to the task.

And they associate their potential success or failure in solving tasks with the ability to remember how to calculate a given type of task. These findings showed that the acquisition of calculation procedures is still a priority for students in learning mathematics (Rittle-Johnson et al., 2012), mainly in the form of calculation templates (Lithner, 2017). It is often enough for students to know the rule (instructions) how to find solutions to the assigned task (Legesse et al., 2020) and after reading the assignment, they try to assign some learned procedure to it. According to some research, this approach of students to learning mathematics is also supported by the way mathematics is taught, where the transfer of ready-made calculation procedures prevails (e.g., Leung, 2006; Boesen et al., 2014).

Based on the results of the experiment, we can state that the teachers and students agreed that the primary cause of student failure in tasks requiring higher reading of mathematical symbols was a misunderstanding of the assignment (item 1). Teachers and students differed statistically significantly in their responses to the other items of the questionnaire. The teachers identified as the cause of the students' failure the failure to think about the mathematical symbols in the assignment (item 4). During the interview, the teachers said that they came to this opinion primarily on the basis of the test task: simplify: 2:6·3:4·1:9. It turned out that in this example, only 31 % of students changed the symbol ":" to a fraction line, that is, they rewrote the ratio of two numbers to a fraction. Other causes of failure according to teachers were incorrect interpretation of mathematical symbols (item 5) and failure to consider multiple meanings of a mathematical symbol (item 7). Based on these answers, it can be concluded that the teachers associate the misunderstanding of the assignment with the problems of the students to correctly read and interpret the mathematical symbolic language. Our findings reveal students' beliefs that their failure in mathematics is due to a lack of ability to "count". In contrast, the teachers in our research and experts such as Duru, Koklu, 2011 see the cause in the lack of ability to read a mathematical text with understanding (Duru, Koklu, 2011).

Based on this finding, we would like to suggest that more space be devoted to the development of conceptual understanding of mathematical symbolic language in the teaching of mathematics (Capraro, Joffrion, 2006). The ability to read a mathematical text leads to the discovery of relationships between the data in the assignment of the task, which is a prerequisite for finding one's own solution to the task and allows the student to connect the calculation procedure with the task, or to adapt the calculation procedure to a new task (Rittle-Johnson, Schneider, 2015). Another space where it is possible to convey to students the need to learn to read mathematical texts is feedback (Panadero et al., 2019), which forms an integral part of communication between teacher and student (Small, Lin, 2018). According to several studies, teachers tend to focus mainly on procedural skills in feedback (Casey et al., 2018; Runnalls, Hong, 2019), but properly targeted feedback focusing on the development of conceptual knowledge pupils has an enormous influence on the progress of students in mathematics (Stovner, 2021).

We consider another important finding of our research to be the finding that is connected with the students' comments on item 4 – I have not encountered this type of task. Up to 65 % of students identified this phenomenon as the cause of their failure in the test. As we have already mentioned, however, the tasks in the test were deliberately designed so that for each standard assigned task, an equivalent task was assigned, but its assignment was predominantly in mathematical symbolic language. While the students' success in the first one was 100 %, only 28 % of them got the second one right, which confirms the fact that the students had a problem reading the symbolic assignment of the task with understanding. Unlike students, teachers did not consider the fact that students did not encounter a given type of task as the cause of student failure. It is in these different expressions of teachers and students that the importance of teaching mathematical symbolic language can be revealed. The teachers' reactions to item 4 expressed their belief that the students' failure in the test was largely caused by their insufficient knowledge of the mathematical language. Therefore, we think that it would be appropriate if the teachers draw attention to this important fact as part of the students' feedback. Appropriately targeted feedback can make it clear to students that their reliance on learned procedures (Boesen et al., 2014) is not a sufficient guarantee of success in mathematics. Inadequate proficiency in the mathematical language can cause students to be unable to solve a problem that is assigned "non-standardly", although it belongs to a set of problems whose calculation procedure is known to the students.

4. Conclusion

Following on from our research question: "How do students interpret the misunderstanding of the assignment?" we can state that their view of their own failure is subjective and based on their mathematical knowledge. Compared to the teachers' view of students' failure to solve tasks with non-standard assignments with an emphasis on the use of mathematical symbolism, we can say that only in one item of the questionnaire did the views of students and teachers differ significantly, namely in insufficient understanding of the assignment of the task. While the students largely attributed their failure to this cause alone, the teachers saw more behind it. With their professional and pedagogical experience, they were able to analyze the causes of student failure more critically and deeply. Since students did not understand or know the meaning of mathematical symbols well enough, they were not able to critically evaluate and attribute their failure to this factor as well, which is logical. At the same time, our findings indicate that students prefer formal knowledge, focusing on learning rather than understanding mathematics. Therefore, they prefer tasks whose solution algorithm is known to them or at least similar to other tasks they know, and even a slight change in the learned procedures can lead to failure. Formalism in the teaching of mathematics is a long-term phenomenon that significantly slows down or stops the development of important intellectual abilities, such as: analyzing a problem situation, arguing, hierarchizing knowledge, sorting knowledge. In order to reveal formal knowledge, the interaction of the teacher and the student through feedback on the subject matter is necessary.

Here we have to agree with studies (Casey et al., 2018; Runnalls, Hong, 2019) that in the framework of feedback, teachers often slip into asking questions focused on procedural knowledge and do not try to reveal the causes of deficiencies in students' conceptual understanding. Often times, the reason is a lack of time in regular teaching, but also the inexperience of the teacher, which is related to the disciplinary literacy of teachers and students. In school education, we often focus on the student's performance towards various national and international tests, therefore the teacher is looking for a way to teach students to solve the expected test tasks as quickly and efficiently as possible, thus supporting their focus on processes and not on concepts in mathematical knowledge. As part of our research, we must point out one more factor that could have influenced its results. The research sample consisted of university students with a technical focus, not students of mathematics as a field or teaching. Within the study of technical fields at high schools and universities, mathematics is primarily a tool for the application of the mathematical apparatus in solving various complex tasks and problems in professional subjects according to the focus of the field of study. However, it is precisely in these subjects of a technical focus that knowledge of various principles, signs and symbols is required, which also includes mathematical terminology and symbolism, which can lead students to failure in professional, not only mathematical, subjects. So, we come to the important connection of mathematical, professional and disciplinary literacy of students and teachers. Inadequate mathematical and disciplinary literacy can be the cause of failure of students in their university studies of a chosen "non-mathematical" field of study, who fail in the first year precisely for the reasons mentioned, which leads to the disappointment of students who attribute it to mathematics. This opens up space for further research in the field of disciplinary literacy of students of various fields of study, be it technical, natural science or mathematics.

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