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# Written test with oral explanation during the pandemic

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*In Hungary, assessment in school mathematics has always relied heavily on students' written work. Ensuring that only the student's own knowledge is manifested during the exam is a real challenge in distance learning. We combined the written test with verbal explanation by students. After writing down the solutions and sending them to the teacher, students also recorded short audio of each task. In this paper, we analyze students' oral explanations based on their written work, looking for additional information about students' thinking processes, furthermore, examine the quality of verbal communication.*

*Keywords: Curriculum based assessment, metacognition, online education, mathematical problem solving.*

## Introduction

During the pandemic, teachers experienced the differences between face-to-face and online instruction (Doucet et al., 2020). They realized worldwide that online schooling requires collecting and reviewing old teaching methods adaptable to the new situation or even searching for new approaches. It is true for the ways of assessment of students learning as well. In Hungary, assessment in school mathematics has always relied heavily on students' written work. Written responses to mathematical tasks are often the basis of summative and formative assessments. However, ensuring that only the student's own knowledge is manifested during the exam is a real challenge in distance learning. The written examination was not appropriate anymore, while the oral was too time-consuming and unusual for senior high school students. It was our starting point when we combined the written test with verbal explanation by students. After writing down the solutions and sending them to the teacher, students also recorded short audio of each task.

Taking not only aspects of teaching and learning but also researching into consideration, the so-called “loud test” seems to be a valuable tool to detect students' metacognitive activities as well. After the solution of the task is written down, the loud explanation forces the learner to deal with the looking back phase in problem-solving (Polya, 1945), which is the most neglected phase, as much research shows (Cai & Brook, 2006).

In this paper, we analyse students' oral explanations based on their written solution, looking for additional information about students' thinking process, furthermore, examine the quality of verbal communication. Qualitative analysis is done on a per-pupil basis. We formulated the following research questions:

1. Does the oral explanation contain more information about the learner's knowledge and thinking process than can be read from the written solution?

2. What types of metacognitive activities can be observed in the verbal explanations?
3. What characterizes senior high school students' professional language communication?

## **Theoretical background**

In the educational process, we can distinguish three types of assessments: (1) assessment before instruction (diagnostic), (2) assessment during instruction (formative), and (3) assessment after instruction (summative). Formative and summative assessments are often characterized as assessments for learning and assessment of learning (Chigonga, 2020). It's clear that there is a significant overlap between assessment for and of learning. We designed summative assessment tasks to measure students' expected standards; however, we also aimed to get information about students' thoughts and possible misconceptions. It means that the assessment process was summative and formative at the same time.

The challenges to written assessments, especially that of problem-solving, are several. Most test situations require students to produce an extended written account explaining their problem-solving process and proposed solution. It is problematic because considerable skill is needed to make a clear and comprehensive description of the problem-solving process, a skill that students may or may not have (Monaghan et al., 2009). From this aspect, it seems that an oral explanation of the problem-solving process may be easier for students, as they do not have to transform their thoughts into a mathematically correct written form. Morgan and Watson (2002) argued that all mathematics assessment is interpretive in nature, so it also shows subjective features. Regarding the assessment of students' problem-solving ability, Teledahl concluded that "The fact that there are different ways to interpret what the students have written further strengthens the conclusion that using this writing, to assess other mathematical abilities, may be problematic." (2017, p. 3602)

Huxham et al. (2012) note five main advantages to oral assessments: they (1) develop oral communication skills; (2) are authentic; (3) can be seen to be more inclusive; (4) can be a powerful way of evaluating understanding and (5) are more difficult to cheat in. Furthermore, in an oral exam, a small knowledge gap can be bridged with the teacher's help so that the student can solve a task that he/she would not be able to do in writing. Our "loud test" is similar to the oral exam in more aspects (see (1), (4), (5)), but the students have no opportunity to receive ongoing confirmation or help from the teacher. However, oral exams have not only advantages but also disadvantages. Anxiety and fairness are the most common concern (Iannone & Simpson, 2012). Since our "loud test" was not a typical face-to-face oral exam, we believe that anxiety did not significantly affect the results. As the evaluation did not coincide with the oral presentation, the teacher had the opportunity for a thoughtful assessment, so there was little harm to fairness.

Professional language communication is an essential element of both written and oral exams. The professional language of mathematics comprises technical terms (like geometric sequences or logarithms) and specific, often very concise, sentence structures. "In mathematics classes, we face the challenge of developing individual language use from orality towards literacy, in the direction of learning to speak and write mathematically." (Marei, 2019, p. 1657)

Asking students to think aloud is naturally connected to metacognition because the situation itself contributes to rethinking the problem-solving process. According to Flavell et al. (2002),

metacognition refers to people's knowledge of their own information processing skills, knowledge about the nature of cognitive tasks, and strategies for coping with such tasks. Moreover, it also includes executive skills related to monitoring, self-regulation, and evaluating one's own cognitive activities. Metacognition happens when students analyze tasks, set goals, implement strategies and reflect on their own learning (Spencer, 2018). Metacognitive experiences refer to a person's awareness and feelings elicited in a problem-solving situation (Schneider & Artelt, 2010). Libet's (2002) research suggests that roughly half-second time units can be associated with conscious decisions. From a pedagogical point of view, this means that if we make a decision during learning, it becomes conscious only a little bit later. It also follows that the speed of procedural metacognitive processes may prevent the individual from reporting them orally simultaneously as the process. However, the possibility of later conscious access and verbal reporting remains (Csíkós, 2017). According to our research setting, the oral explanation of the students took place later in time than the description of their thoughts.

## **Methodology**

The target class consists of 29 high school students (Grade 12), 27 of whom participated in the research. They have four lessons per week taught by one of the authors of this article. The research was done in the school year of 2020/2021 autumn in a small town in Hungary. The schools were open from September 1 to November 11 of 2020, then online education started. The summative assessment fell on November 16, so most of the material was taught face-to-face. The topic of the assessment was geometric series. The first task was considered a routine task. Two terms of a geometric series were given, the first term, the quotient, and the sum of the first ten terms had to be calculated. The answer was two different geometric series. The second and third tasks were real-world problems, and the second was similar to the third but simpler. In this paper, the third task is highlighted:

*The number of wild koalas in Australia is getting smaller and smaller. Surveys show that the number of koalas is decreasing by 9 % every year. In 2009, 43000 wild koalas were counted on the continent. Considering the same decrease, find the number of years after which the number of koalas in Australia falls under 60% of the 2009 data.*

Because of the school closure, the students responded to the written test at home. They also made audio recordings explaining how the tasks were solved (“Summarize and explain your proposed solution orally in 1-2 minutes.”). The time limit was 45 minutes to solve three tasks, scan the papers, record the oral explanations with mobile phones, and send them to the teacher. The students got scores for the written solution and the recording.

The recordings were investigated in the same way:

1. We identified the coding units; namely, we found those parts of the recordings which contain extra information, i.e., not just repeating or summarizing what is on the paper. (A recording may include more than one such unit.)
2. Using the content analysis method, these units were coded first according to three criteria: The extra information refers to A) one step of the solution, B) the entire solving process, C) the interpretation of the result obtained. For example, we coded the unit as A, if the student justifies one of the steps in the solution, B, if he/she explains the chosen strategy or model, or C if he/she notes

that his/her result is consistent with the problem situation or modifies it accordingly. These codes are closely related to the following metacognitive activities: A) monitoring, self-regulation, B) strategy, C) reflection, evaluation. (Not all extra information counts as metacognitive activity, but it creates the possibility of it.)

For each unit, a second code evaluates the quality of the oral explanation in terms of the mathematical language register: 1) Correct; 2) Sloppy (everyday language, but the mathematical content is clear); 3) Incorrect+ (incorrect terminology, but the mathematical content is recognizable); 4) Incorrect- (incorrect terminology, no recognizable mathematical content); 5) No (There is no mathematical content in the unit).

The recordings were analyzed independently by the two authors. In case of disagreement, the authors' consensus fixed the units and their codes. Figure 1 illustrates our coding system.

Handwritten solution for a problem involving interest rates and total value. The student uses the formula  $T_n = a \cdot (1 - \frac{p}{100})^n$  and calculates  $n$  using logarithms. The final answer is  $n = 5$ .

$$p = 9\%$$

$$T_n = 43.000$$

$$n = ?$$

$$T_n = ?$$

$$25.800 = 43.000 \cdot (1 - \frac{9}{100})^n$$

$$0,6 = 0,91^n$$

$$\lg 0,6 = \lg 0,91^n$$

$$\lg 0,6 = n \cdot \lg 0,91 \quad /: \lg 0,91$$

$$\frac{\lg 0,6}{\lg 0,91} = n$$

$$n \approx 5,42$$

$$n = 5$$

5 év után esik 60% alá a kezdeti száma Ausztráliában

**Figure 1: The written solution of Student S13**

The associated sound recording with the codes, where the numbered units are written in italics:

*"In the 3<sup>rd</sup> task, we only know the rate of interest, the percentage, and the total value. (S13-Unit 1, B, "Sloppy") and from these items, I calculated the value of  $T_n$  with percentage calculating. Then I got the result which I immediately substituted into the formula. And here, in the parenthesis, there is a minus because there is a decrease. (S13-U2, B, "Sloppy") I got the result 0,6 by dividing 25800 with 43000. The  $0,91^n$  is the task in the parenthesis. We brought in the base 10 logarithm because, with the use of it, we can get the result of  $n$ . (S13-U3, A, "Sloppy") Then I arranged the things and calculated. I would rather say that I arranged the equation so that I could get the value of  $n$ . I got a result of 5.42. Although the digit after the decimal point is less than 5, we have to lower the result because the task also includes a decrease. (S13-U4, C, "Incorrect+") I also answered in a whole sentence because it was a word problem."* (Student S13)

## Findings and discussion

27 students wrote the test; each consisted of 3 tasks. Out of a total of 81 written solutions, 3 were not accompanied by audio recordings so that we could examine 78 audio recordings. There were 40 recordings, which contained extra information. These belonged to 19 students out of the 27. In their

audio recordings, 4, 9, and 6 students provided additional information to one, two, and three tasks, respectively. The number of coded units associated with the first task is the lowest, 18 units, while for Task 2 and 3, these numbers are 30 and 31. This result confirms that Task 1 was indeed a routine task for our students, in which the way to solve it was conventional, so the students did not feel the need to explain their answers in more detail. Task 2 and Task 3 were real word problems in which finding and matching a model was part of the solution strategy. Obviously, these problems required more thinking, and they provided more opportunities to express background information in the recordings. The coding results for the types of extra information (Table 1) are also related to this idea. In the routine task, the students did not interpret the answer at all, while in the case of world problems, the number of units where students tried to explain their way of thinking or interpret the result obtained is higher.

**Table 1: The number of units according to what the extra information refers to**

	A	B	C	Total
Task 1	10	8	0	18
Task 2	3	18	9	30
Task 3	10	13	8	31

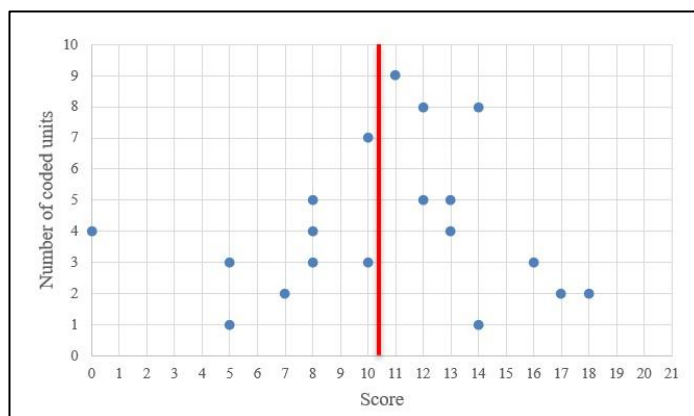
The coded units were also examined according to the types of extra information and the number of students. Analysis of the audio recordings supports our hypothesis that students also perform metacognitive activities during the oral explanations. Table 2 shows some examples of this in connection with Task 3.

**Table 2: The types of extra information and the number of students**

Codes	Number of Ss	Examples in connection with Task 3
A: explanation of a certain step of the solution	14	“I brought in the logarithm because n was known. Because we can write the unknown n in front of the logarithm.” (S9) (self-regulation) “Then I got an exponential equation, but I don't have the same base, so I brought in the base 10 logarithm. This way, I got that $\lg 1075 = n \cdot \lg 1,09$ .” (S4) (self-regulation, monitoring)
B: explanation regarding the entire solving process	16	“In Task 3, I also calculated with geometric sequence.” (S27) (strategy) “The value of q is 0,91 because 9% can be replaced by 0,91.” (S25) (strategy)
C: the interpretation of the result obtained	11	“The answer is 6 years because I got 5,41641 and it is more than 5 years, so 5 years are not enough, that's why the result is 6 years.” (S25) (evaluation)

We can say that almost half of the class reached the goal of the recordings. Justifying certain steps, explaining the key elements of the solution process, and interpreting the result provides a great opportunity for some metacognitive activities.

Figure 2 presents the students' distribution regarding their scores on the written test and the number of coded units. The total score was 21; the red line in the figure shows the class average of 10.4. The blue points indicate the 19 students. The average score of the students who add extra information is 10.6 (deviation: 4.4), while the average score of the rest of the students is 9.9 (deviation: 5.0).



**Figure 2: The scores and the number of coded units by students**

The willingness to explain in detail does not appear to be closely related to the points achieved. The students whose points were close to the average provided the most extra information. Students with higher scores typically did not supplement their written solution with additional oral information, even if it was quite sketchy. We also found a lot of interesting and instructive information in the recordings of the students with weaker performance. The example below shows how S3 realized that his solution was wrong. He tried to modify but also incorrectly.

$$\begin{aligned}
 25200 &= 43000 \cdot (1 - 0,09)^n \\
 25200 &= 43000 \cdot (0,91)^n \quad / : 43000 \\
 \log 0,6 &= n \cdot \log 0,91 \quad | : \log 0,91 \\
 -0,2216 &= n \cdot (-0,094) \\
 T_0 = 25200 & \quad 43000 = 25200 \cdot \left(1 + \frac{9}{100}\right)^n
 \end{aligned}$$

**Figure 3: The written solution of Student S3**

The explanation of S3: *“First, I did it with a minus, but it's sure didn't turn out well.”* (C - reflection)  
*Then I made it with a positive and came up with 6 years, which I don't know ... I don't think it is good either.”* (C - reflection)

The quality of the professional language of the examined coded units in all three tasks is summarized in Table 3. The verbal expression of the coded units was mainly mathematically correct; there were no "Incorrect–" performances. It probably means that the students only dared to say things they were sure about to a certain extent. It is important because, in this way, they are reinforcing and deepening their right ideas, not their wrong ones. The laxity of the students encourages the teacher to further corrections, and some "Incorrect +" units bring the mistakes and misconceptions to the surface. These things remain unknown in the written tests, but they are considered mistakes in the oral explanation.

**Table 3: The quality of the professional language**

	Correct	Sloppy	Incorrect+	Incorrect-	No	Total
Number of units	26	28	15	0	10	79

The first example highlights the inaccurate formulation of one of the identities of exponentiation. The other points out the incomplete knowledge regarding the concept of even root power and the term of absolute value:

- Student S4 refers to one of the exponential identities as “ $q^6/q^4=q^2$  because when dividing, we subtract the exponential value [instead of subtracting the exponents]”.
- Student S12 explained what he wrote ( $q^4 = |16|$ , then  $q = 2$  and  $q = -2$ ) as follows: “The value of  $q$  is 4 [instead of the exponent of  $q$  is 4], and it is an even root power, that's why we have two quotients. We had to use the absolute value of 16 [instead of the absolute value of 2], so we got 2 and -2.”

## Conclusion

We detected some positive impact of the “loud test”-method not only on learning but also on teaching. On the one hand, it was useful from the students’ point of view because students discovered errors in their written work during the recording that they modified, although not always correctly. On the other hand, at least half of the class prepared sound recordings that helped the teacher better understand their thought related to problem-solving and provided a more detailed error analysis, contributing to better future teaching (the effect of formative assessment). Furthermore, the “loud test” seemed to be a valuable tool to detect students' metacognitive activities. Loud explanations force learners to deal with the looking back phase in problem-solving, the most neglected step described by Polya (1945). However, the success was influenced by its quality and the student's content knowledge as well. The need to consciously apply the solution steps and use the appropriate professional language has also become apparent. In summary, we can state that the teacher gets a more detailed picture of students' current level of development, although the correction of students' works takes more time.

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