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When communication tasks become tools to enhance learning

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Abstract

Effective communication in the classroom is a key element for learning, yet when and how future teachers should acquire such competence is not clear. In this article we explore students–prospective teachers’ written productions of a set of instructions in a learning situation. Through three emblematic cases we illustrate how a communication task focused on a partner selected by the student reveals not only the student’s domain-specific knowledge, but also a mental frame induced by an assumed paradigm, which is both constrained by the student’s knowledge level, and purpose oriented by the need of successful social interaction.

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1. Introduction

Investigating in-service and pre-service teachers’ strategies for task adaptation, Pelczer, Singer and Voica (2011) noticed that (future) teachers often provide rote procedures and skill-based practice problems in order to ensure their students’ short term success in a test (exam)-driven approach. However, students-prospective teachers who develop and implement small scale educational projects during their training manifest a reflective attitude towards teaching and learning (Voică & Singer, 2011). Starting from these research outcomes, we exposed students-prospective teachers to a communication-adaptation task in which they had to communicate effectively a set of instructions.

Mathematical activities build on the use of different semiotic representational systems and require the fluent switch between them (Duval, 2006). This switch is mediated by language and a profitable effect on learning can be obtained by valuing language and mathematics computational properties that our minds naturally share (Singer,

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In general, in communication, the shared context complements the communication with personal elements and references so to make sense of a certain statement. In order to facilitate students’ acquisition of the mathematical language, and to integrate it into the general linguistic ability, it might be relevant to create situations where a shared context is missing and the message has to be self-content in order to be understandable; in such a situation, the student is forced to use a commonly adopted, formal mathematical language and precise specifications. In the case of geometry, Duval (2005) argues that at least two different registers need to combine: a verbal register for describing the statements related to a figure, and a visualization register.

Our main interest lies in exploring the potential difficulties encountered by students when they switch registers in order to formulate clear instructions for a third person who does not share the teaching and learning context. We hypothesize that the way of writing the instructions and the changes students make on their first elaborated versions along their own experiment might give an indication on the students’ understanding of the topic and can be used as a lever to improve this understanding.

2. Theoretical framework


In iconic visualization the drawing is a compact element that is perceived as a whole. Non-iconic visualization is a sequence of operations that allows the recognition of a series of geometrical properties (Duval, 2005). This visualization requires three types of decomposition processes: instrumental (allowing the identification of elements such that the figure can be constructed with tools), heuristic (splitting the shape into parts that can be recombined into the original), and dimensional (breaking the figure into lower dimensional figural units). In addition, Duval (2006) argues that at the core of mathematical comprehension is the coordination of multiple registers and that the inability of such mediation is the source of difficulties for students.

Houdement and Kuzniak (2003) state the idea that elementary geometry can be seen as split into three kinds of geometry: Natural Geometry (G1), Natural Axiomatic Geometry (G2), and Formalist Axiomatic Geometry (G3). G1 concerns material objects and relies on experience and intuition as ways of reasoning. G2 is the study of ideal objects and the reasoning relies on a system of definitions, axiomatic constructions and the rules of logic accepted in the system. G3 cuts any relation to the real-world – it is based on a complete system of axioms that is independent of any real-world referent. The difficulties encountered by students and teachers in passing from G1 to G2 are more evident when the starting points in tasks are real-world objects, yet their exploration requires an abstract description.

3. Method

The data presented in this paper come from a group of students-prospective teachers in year two of their undergraduate studies at the Faculty of Mathematics and Informatics of Bucharest, who followed a Didactics of Mathematics course for one semester. The paper focuses the students’ activity and results for a communication task. More precisely, students were presented with the image of Figure 1a, and a “box” which could be obtained from it (Figure 1b). The assignment consisted of the following three steps.
First, as a step one, the students had to write a set of instructions on how the box can be built using as tools only straightedge and compass, explaining the procedures verbally, without any drawings, diagrams or pictures. Later, at step 2, the instructions had to be given to a resource person (who was not previously informed about the experiment goal), who had to follow the instructions. During this process, students were required to observe the person’s behavior without interfering with support or comments. Finally, as a step 3, students had to evaluate, based on observations, the person’s understanding of the instructions and if they have found that some instructions are unclear, to develop a revised version and to repeat the experiment with another person.

Students were given three weeks to solve this task. Because the assignment was considered complex, the teacher recommended pair-work, but this was not compulsory—some students preferred to work individually. By the end of the assignment time, the students submitted a file containing the versions of the instructions sets, a report on the experiment, and the records of observations (CDs or written comments). The data we analyze in this paper come from these documents.

We discuss here how three of the participating teams responded to this task: Adriana and Madalina (Team 1), Cristina and Rodica (Team 2), Michael and Georgeta (Team 3). We selected them from our database because they reveal three distinct approaches. In addition, although there was no condition for grouping, these were homogenous teams as referred to the students’ academic level. The six students represent the sample we use in this paper.

4. Results and discussion

We briefly present the content of the three teams’ first list of instructions.

Team 1 has made a sequence of 18 instructions, in which they used mathematical notations (“denote the intersections by B and D”), and they detailed on: how to position the drawing on the sheet of paper (“build it in the center of the sheet ...”), the sizes of some segments that appear in the construction (“build a circle with the radius of 4 cm”), or ways to highlight certain elements of the figure (“color the arch AB in red”). Besides these details used for ensuring the drawing precision, their list was designed to contain the minimum specifications needed to obtain the box.

Team 2 began with three preliminary instructions, in which they explained how to draw by only using straightedge and compass: the midpoint of a segment, the perpendicular from a point to a line, and the inscribed and circumscribed circles of a square. Their instruction list contains 11 items, in which cycles of repeating steps are included. Some instructions contain feedback or milestone elements (for example: “you should have two circles and, inside them, two “rhombus made of arches”).

Team 3 started with a required list of needed materials (cardboard, scissors, paste soldering, cutter, etc.) and continued with 11 instructions. The list ended with a technological approach (“make notches using the cutter - but not cut (!)the arches inside, so we can easily bend them”), which aimed to get the box done.

We further analyze the instruction lists from different perspectives. Duval’s semiotic approach helps us in identifying students’ ways of decomposing the initial figure, the translation of the identified elements into figural units constructible by tools, and the difficulties of using proper and precise language when moving between different registers. We consider Houdement and Kuzniak’s epistemological approach useful when looking at students’ positioning in relation to the task, and their arguments for the validity of their instructions in achieving a
physical product. Given that the specified task starts from a physical object (a box), and requires the instructions for constructing a new object of the same shape with the presented one, students have to switch between their positioning in G1 and G2. We were interested in identifying where and how the “pull and push” between the two geometric workspaces manifest in the written productions of the students.

4.1. Decomposition into “constructible” elements and positioning in the geometrical paradigm

Synthesizing the main ideas of each list, we found that each team has focused on some other elements of the original figure. We will show that these choices are influenced by the geometrical paradigm in which each team positioned itself.

Team 1 understood the given model through a network of congruent circles. Their instructions aim at this network construction: they identify (the network of) congruent circles – circles that appear in the original figure, as the components from which the configuration can be rebuilt. The basic element in the Team 1’s construction is a circle, as a figure that is most easy to construct with compass. For Team 1, rigorous constructions are important: the task is perceived as a G2-task. However, the instructions list includes references to the real-world by indications concerning positioning the compass on the paper and suggestions for appropriate dimensions. These inclusions are motivated by the need to obtain a physical box. Yet, they are mostly marginal as the students focus on the rigorousness of the geometrical constructions.

Team 2 used a tessellation with congruent squares and the circles inscribed in these squares as background for the construction. The basic element identified by Team 2 is a square. Team 2 starts with some basic definitions and then generates a list of instructions that contain ”subroutines” and cyclical repetition loops (“Repeat steps 2-6 for the new square”). This team also displays the G2 paradigm (in the sense of Houdement and Kuzniak).

Both teams 1 and 2 are mostly focused on the geometric constructability with straightedge and compass, and minimize indications of finalizing details (i.e. getting the real box). On the contrary, the Team 3’s instructions have lowered mathematical load (and value), as the language used is not rigorous (for example: “trace two parallel lines of the length of the square edge”), and some partial theoretical constructions are not explained. Instead, Team 3 is concentrated on the technological process: they start with a list of needed materials, they explain in detail the technology to get the real box and use warnings and “checkpoints” to prevail possible wrong approaches. Team 3 simplified the model. Here the students use only two adjacent squares and their circumscribed circles. Subsequently, new constructions are made of circles to complete the internal arches. The outgoing configuration consisted of two adjacent squares in which the circles were inscribed. All these show that Team 3 perceived the task as “something to do” and place it in the G1 paradigm.

At this point, we could explore the reasons for this positioning: did Team 3 just choose to work in G1, or their positioning is defined by their knowledge of geometry and experience? This question moved us to compare students’ approaches in solving this task with their academic results and performances.

4.2. The social dimension and students’ academic performance

Although positioned in a same geometric paradigm, the first two teams are distinguished by their different approaches in relation to the resource person who has to “put into practice ”the instructions list. Cristina and Rodica (Team 2) have good academic performances and are also active participants in the tutoring program held in the college. This previous tutoring work seems to be reflected in their ways to formulate the instructions: they start from a few basic elements (such as, for example, the construction of the midpoint of a segment with straightedge and compass), and simplifies as much as possible the instructions set using repetition and referring to the previously explained constructions. They give continuous feedback on what the reader should get (for example “you should have now the original square divided into four smaller squares”). This dual positioning (relative to the rigors of geometry, and to the reader) determines specific use of language as part of a didactical approach.

This approach –showing concern for the respondent’s previous knowledge and providing feedback –does not appear in Team 1’s solution. Madalina and Adriana (Team 1) are high-level academic performers. In their case, the use of “ideal” tools and a rigorous mathematical language appears to be a spontaneously accepted constraint for solving the task. Team 1 describes the construction by reference to the names of points and circles, previously

mentioned. At the same time, their sequence of instructions does not reveal where exactly the respondent is to arrive at, and there are no “milestones” where the control of the execution may take place. By contrast, Team 2 uses a “local” description, referring concretely, for example, to “these circles”, or “that point”, and tries to provide feedforward control; it is like the instructions are given in the presence of the resource person by someone who is nearby, and follows the construction progress.

Michael and Georgeta (Team 3) have rather poor academic performance. In their own learning, they seem to focus mainly on identifying "mainstreaming" schemes, which could lead to faster results. This observation (made in other learning situations) is validated by their list of instructions: Team 1 feels the need to include warnings (like: "Caution! We are interested in only the arches which are interior to the circle already drawn"), or instructions that can provide some control over the correctness of the construction (for example "count again the number of intersections and make sure they are 7 "). They seek to convey simplified algorithms, focused on results, without questioning the rigor of the approach, attitude that is totally opposite to the first analyzed group.

5. Conclusions

We started from an adaptive communication task the students prospective teachers had to perform within a Didactics of Mathematics course. This task proved to be multi-dimensional: it revealed students’ ability in manipulating specific concepts; it showed to be a rich learning task in the sense that it helped students to adjust their knowledge to a target audience that has to perform understanding; it stimulated metacognition by putting the students into the situation to revise own productions in order to better fit the audience; and finally, it forced the students to navigate between registers no matter their level of mathematical understanding.

Beyond the limitations of this study (given by the small number of students involved and by only partially processing all the data from the sample) some conclusions seem to clearly arise. First, the analyzed data show that students started solving this task through the lens of a paradigm– some perceived the task in a theoretical/abstract space, while others in a practical workspace. Once the students positioned in such a space, they directed the figure decomposition based on personal internal constraints (such as mathematical knowledge and skills), or the target audience (existing or imagined). Second, the students’ approaches seem to strongly correlate with their mathematical competence. Third, a previous tutoring experience dramatically influences the approach of such task that involves effective communication.

As mentioned above, the transposition in verbal register depends on two elements: the students’ academic competence and their positioning towards audience in communication, at the level of vocabulary, reasoning, and instructions formulation. Duval (2006) argues that at the core of mathematical comprehension is the coordination of multiple registers and that the inability of such mediation is the source of difficulties for students. But what might be the cause of this lack of coordination between multiple registers? What surprised us is that Team 2 would have written the instructions as Team 1, but they have chosen to do it differently because of their tutoring experience. This suggests that the relationships between the registers are mediated also by some experience of negotiating meaning in a learning process, that is, of teaching.

Through the three emblematic cases presented above we illustrated how a communication task focused on a partner selected by the student reveals not only the student’s domain-specific knowledge, but also a mental frame induced by an assumed paradigm, which is both constrained by the student’s knowledge level, and purpose oriented by the need of successful social interaction.

As a consequence of this study, as teaching is based (or should be) on effective communication (communication the outcome of which is the transformation of student’s learning behaviors), the teacher training programs should contain a variety of opportunities for direct tutoring, and role-playing experiences that use domain-specific (in our case mathematics) contexts. Future research in this direction could investigate in depth the connections between mathematics learning, social interactions and communicative competence, which have been revealed to be strong by this exploratory study.
References


