FaSMEd

Raising Achievement through Formative Assessment in Science and Mathematics Education

The Archaeologist Giancarlo – Part 2

Subject:	Maths
Age of students:	9-12 years
Hardware:	Tablets, pc, IWB or data-projector
Software:	IDM-TClass
Functionalities:	Sending and displaying; Processing and Analysing
Time:	1-2 hours
FaSMEd partner:	University of Turin
Short Abstract:	This activity is framed within the context of **early algebra**. It is aimed at guiding students **to interpret** a **symbolic** representations of a given **relation** between two variables and, afterwards, **to construct** a **symbolic** expression that expresses another relation introduced within the activity.

Premises: theoretical tools

In presenting our methodology and the way of developing this activity we refer to two main theoretical tools.

The first theoretical tools are the Formative Assessment (FA) strategies proposed by Wiliam and Thompson (2007):

1) Clarifying/ Understanding/ Sharing learning intentions and criteria for success,
2) Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding,
3) Providing feedback that moves learners forward,
4) Activating students as instructional resources for one another,
5) Activating students as owners of their own learning.

The second theoretical tools are the Functionalities of Technology (FT) introduced within the FaSMEd Project (see the complete description on FaSMEd website https://microsites.ncl.ac.uk/fasmedtoolkit/theory-for-fa/the-fasmed-framework/):

(a) sending & displaying,
(b) processing & analysing,
(c) providing an interactive environment.

1. Content

The topic on which this activity is focused is early algebra. The Activity "The Archaeologist Giancarlo – part 1" (in particular worksheet 1) is propaedeutic to this one. The focus of this second part is on the introduction and construction of symbolic expressions to represent given relations. Students are, in fact, asked to interpret a symbolic expression that represents a relation introduced within the activity "Archaeologist Giancarlo – part 1" and, later, to construct another symbolic expression that represents another relation introduced within the same activity.

2. Activity

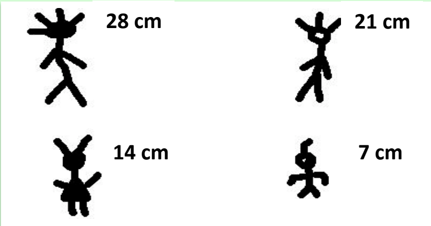
This activity - an adaptation from activities developed within the ArAl Project (Cusi, Malara and Navarra 2011) - can be developed referring to a set of *three worksheets*.

2.1 The worksheets: focus and aims

Worksheet 2 introduces a mediating figure, a foreign student (Martjin) that can communicate with the students involved in the activity only thanks to the use of symbols. Students are asked to interpret the symbolic expression that Martjin has written.

"The archaeologist Giancarlo"

On the ArAl mountain, in the middle of the desert, the archaeologist Giancarlo has found some graffiti engraved on the rock. He reproduced the incisions on his notebook, writing their heights. This is the page where Giancarlo reproduced the incisions:



Giancarlo's collaborators discuss a lot on the relation hidden in the graffiti.
Nicola says: "You can find the height of an incision only if you multiply 7 by the number of the tips on its head".
Battista concludes: "It is evident that , dividing the height of the incisions by 7, you can find the number of tips".
And Paolo: "What are you saying? The number of tips is the result of the division of the height by 7!".

(2) Martijn is a Dutch student involved in the FaSMEd project. He does not know Italian, so he was not able to read Nicola, Battista and Paolo's statements. However, looking at the incisions on Giancarlo's notebook, he wrote 7•n=k . What does he wants to say to us?

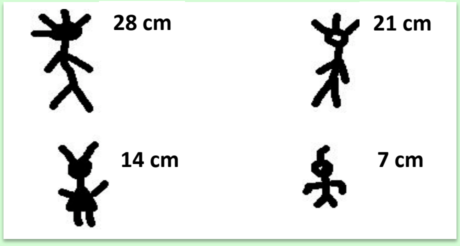
Fig. 1: Worksheet 2

The task introduced through *Worksheet 2* is focused on the interpretation of a symbolic expression: students have to operate a conversion from the symbolic to the verbal register (see Duval 2006 for an explanation of the concepts of "conversion" and "registers"). In particular, they have to recognise that the expression represents the relation introduced, within the text of the problem, by Nicola: the height of every incision can be obtained multiplying the number of tips on the head of the incision by 7.

Worksheet 3 has to be proposed after the collective discussion on worksheet 2. Students are now asked to construct a symbolic expression that represents the relation expressed, within the text by Battista.

"The archaeologist Giancarlo"

On the ArAl mountain, in the middle of the desert, the archaeologist Giancarlo has found some graffiti engraved on the rock. He reproduced the incisions on his notebook, writing their heights. This is the page where Giancarlo reproduced the incisions:



Giancarlo's collaborators discuss a lot on the relation hidden in the graffiti.
Nicola says: "You can find the height of an incision only if you multiply 7 by the number of the tips on its head".
Battista concludes: "It is evident that , dividing the height of the incisions by 7, you can find the number of tips".
And Paolo: "What are you saying? The number of tips is the result of the division of the height by 7!".

(3) We discovered that Martijn used symbols to share with us the same observation that Nicola proposed. Write a symbolic expression, which Martijn can understand, to share with him also Battista's observation.

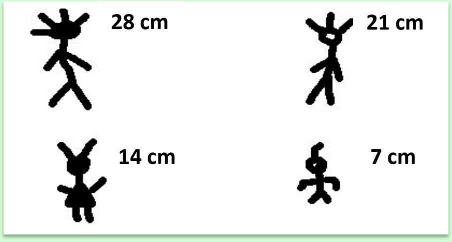
Fig. 2: Worksheet 3

Thanks to *Worksheet 3*, the focus is shifted: from a conversion from symbolic to verbal register (worksheet 2), to a conversion from verbal to symbolic.

Worksheet 3A constitutes an alternative to worksheet 3. It is a worksheet prompting a **poll**. Students are asked to choose, between two options, the symbolic expression that represents the relation introduced, within the text, by Battista.

"The archaeologist Giancarlo"

On the ArAl mountain, in the middle of the desert, the archaeologist Giancarlo has found some graffiti engraved on the rock. He reproduced the incisions on his notebook, writing their heights. This is the page where Giancarlo reproduced the incisions:



Giancarlo's collaborators discuss a lot on the relation hidden in the graffiti.
Nicola says: "You can find the height of an incision only if you multiply 7 by the number of the tips on its head".
Battista concludes: "It is evident that , dividing the height of the incisions by 7, you can find the number of tips".
And Paolo: "What are you saying? The number of tips is the result of the division of the height by 7!".

What symbolic expression correctly translates Battista's observation?

7 : h = p

k : 7 = n

Fig. 3: Worksheet 3A

Worksheet 3A could be displayed to prompt a poll in case the teacher thinks that her students could face too many difficulties in constructing a symbolic expression. For example, in some of the classes where we carried out our teaching experiments, especially at the primary level, the students were not used to representing relations through symbols, so the choice was to introduce the conversion from verbal to symbolic through a poll.

The option 7:h=p is introduced within the poll because it is a typical mistake that students can make if they construct the symbolic expression maintaining the order of the words in Battista's statement: "dividing by 7 the height" is therefore translated through the expression "7:h".

2.2 Methodology

Our hypothesis is that, in order to raise students' achievement, Formative Assessment (FA) has to focus not only on basic competences, but also on metacognitive factors (Schoenfeld, 1992). Accordingly, we planned and developed class activities with the aim of: (a) fostering students' development of ongoing reflections on the teaching-learning processes; (b) focusing on making thinking visible (Collins, Brown & Newmann, 1989), through the sharing of their ideas with the teacher and the classmates.

For this reason, we suggest that, during the activities, the teacher guides the students to focus on the analysis and comparison of not only their *products* but also the *processes* that led to these products. In particular, the class should be led to discuss, on one side, the written productions and, on the other side, the strategies developed to carry out the tasks.

As regards the collective analysis of the students' written productions and the developed strategies, in particular, we refer to *argumentation* as a possible FA tool in the interaction between teacher and students. Specifically, argumentation is promoted to support the development of effective class discussions, starting from questions such as: "Explain what you did", "Explain why your approach is effective", and to guide students in assessing the correctness, the clearness and the completeness of given explanations (their own or others).

The methodology adopted is in tune with these hypotheses. It will be clarified in section 2.4, after the introduction of the technology used (section 2.3).

2.3 Technology

In tune with the hypotheses presented in the previous section, we explored the use of a CCT, which connects the students' tablets with the teachers' laptop and allows the students to share their productions, and the teacher to easily collect the students' opinions and reflections during or at the end of an activity: IDM-TClass.

In the use of IDM-TClass to support FA processes, we in particular focused on the following three main functions of this software:

- the possibility of distributing documents to students and collecting documents from the students' tablets (related to the functionality *Sending and Displaying*);
- the possibility of creating instant polls and immediately showing their results to the whole class (related to the functionality *Processing and Analysing*);
- the possibility of displaying the students' written productions through the data projector or the interactive whiteboard (related to the functionality *Sending and Displaying*).

Each school was provided with tablets for the students and computers for the teachers, linked to IWB or data projector. In order to foster collaboration and sharing of ideas, students were asked to work in pairs or in small groups on the same tablet.

2.4 Structure of a typical lesson and aspects of Formative Assessment

In the following, we present the typical structure of a lesson developed during the teaching experiments carried out in Italy, in this case with specific reference to worksheets 2, 3, 3A.

Usually the activity starts with a worksheet focused on one or more questions (in this case **worksheet 2** and, later, **worksheet 3**), sent from the teacher's laptop to the students' tablets (functionality *Sending and Displaying*). Students work in pairs or small groups of three.

After facing the task and answering the questions, the pairs/groups send back their written productions (functionality *Sending and Displaying*) to the teacher. The teacher can decide to send helping worksheets (*FA strategy 3*, aimed at the activation of *FA strategy 5*) to some groups, or the groups can ask for them. In this case, no helping worksheets have been constructed because it is the first task that requires a conversion from symbolic to verbal register, so it is important to discuss the possible misinterpretations within a whole class discussion.

After all groups have sent back their answers, the teacher sets up a classroom discussion (*FA strategy 2*) in which the students' written productions are shown (functionality *Sending and Displaying*) and feedbacks are given by the teacher and by classmates (*FA strategies 3 and 4*, aimed at the activation of *FA strategy 5*). The discussion is engineered starting from the teacher's selection of some of the received written answers, shown on the IWB. The discussion aims at highlighting (*FA strategy 3*): (a) typical mistakes; (b) effective ways of processing the tasks; (c) the comparison between the different ways of justifying claims. During the part of the discussion focused on these aspects, therefore, the criteria for success could be clarified through the analysis and comparison of the different written productions (*FA strategy 1*).

Polls (functionality *Processing and Analysing*) could also be used to prompt the discussion (*FA strategy 2*, that could lead to the activation of other FA strategies, such as 3, 4, 5) during different parts of the lessons. In this case, **worksheet 3A** could be used, as an alternative to worksheet 3, to prompt a poll. The discussion can be carried out starting from the results of the processing of the poll by the software. The software, in fact, elaborates a diagram that highlights the percentages of answers provided by students. It is also possible to highlight the answers given by the different pairs/groups.

3. Further Information

We recommend that, when the teacher introduces the worksheets that are going to be sent to the students, she stresses some aspects. This is especially crucial with younger students (grade IV and V).

As regards **worksheet 2**, for example, it is very important to discuss previously the meaning of the symbol · within the expression $7 \cdot n=k$. In Italy, for example, at primary school, students are not familiar with the symbol · because they are used to the symbol x to represent multiplication.

On the contrary, it is better to discuss **worksheet 3** after having collected students' answers. In this way it will be possible to identify all the possible mistakes that students could make.

If the choice is to prompt a poll, through **worksheet 3A**, the discussion can start focusing on those students that chose option 1, that is "$t:h=p$" in order to highlight the reasons underlying their choice.

4. References

Collins, A., Brown, J.S., & Newman, S.E. (1989). Cognitive Apprenticeship: Teaching the Crafts of Reading, Writing and Mathematics! In L.B. Resnick (Ed.), *Knowing, Learning, and Instruction: Essays in Honor of Robert Glaser* (pp. 453-494). Hillsdale, NJ: Lawrence Erlbaum Associates.

Cusi, A., Malara, N.A., & Navarra, G. (2011). Early Algebra: Theoretical Issues and Educational Strategies for Bringing the Teachers to Promote a Linguistic and Metacognitive approach to it. In J. Cai, & E.J. Knuth (Eds.), *Early Algebraization: Cognitive, Curricular, and Instructional Perspectives* (pp. 483-510). Berlin Heidelberg: Springer.

Duval, R. (2006). A cognitive analysis of problems of comprehension in a learning of mathematics. *Educational Studies in Mathematics*, 61, 103–131.

Schoenfeld, A. H. (1992). Learning to think mathematically: Problem solving, metacognition, and sense-making in mathematics. In D. Grouws (Ed.), *Handbook for research on mathematics teaching and learning* (pp. 334–370). New York: Macmillan.

Wiliam, D., & Thompson, M. (2007). Integrating assessment with instruction: What will it take to make it work? In C. A. Dwyer (Ed.), *The future of assessment: Shaping teaching and learning* (pp. 53–82). Mahwah, NJ: Erlbaum.

Further information about the software IDM-TClass can be found on the webpage http://www.tecnilabedu.com/prodotto05EN.html