FaSMEd

Raising Achievement through
Formative Assessment
in Science and Mathematics
Education

The Archaeologist Giancarlo – Part 1

Subject:	Maths
Age of students:	9-12 years
Hardware:	Tablets, PC, IWB or data-projector
Software:	IDM-TClass
Functionalities:	Sending and displaying
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, compare and discuss three verbal representations of **relations** between two variables. The concept of **inverse relation** is introduced.

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. In particular, students are asked to interpret, compare and discuss different verbal representation of a relation between two variables. The concept of inverse relation is also introduced.

2. Activity

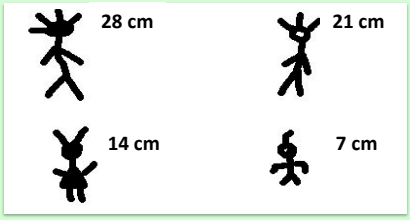
This activity is an adaptation from activities developed within the ArAl Project (Cusi, Malara and Navarra 2011). It can be developed referring to a set of *three worksheets*.

2.1 The worksheets: focus and aims

Worksheet 1 presents a problem situation through which three verbal representations of a relation between two variables are introduced. Three archaeologists discuss on a hidden relation between the heights and the number of tips on the heads of some incisions they discovered in the desert.

"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!".

(1) What do you think about Nicola, Battista and Paolo's statements? Do you agree with them? Explain why.

Fig. 1: Worksheet 1

Through *Worksheet 1*, the students are asked to identify the hidden relation between the heights of the incisions and the numbers of tips and to interpret the three verbal representations presented within the problem, with the aim of highlighting that all of them are correct. In particular, students are expected to highlight that

- the relations introduced by Battista and Paolo are the same, and
- the relation expressed by Nicola is the inverse of those proposed by Battista and Paolo.

The focus of the question is also on the justification of the given answer. Students are, in fact, asked to explain why they agree (or not) with the archaeologists' statements.

Worksheet 1A is not a compulsory one. It is conceived as a possible worksheet aimed at activating a class discussion on a specific way of looking at the incisions to identify the relation.

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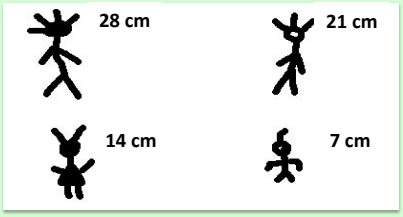

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And Paolo: "What are you saying? The number of tips is the result of the division of the height by 7!".

(1) What do you think about Nicola, Battista and Paolo's statements? Do you agree with them? Explain why.

The height increases always of 7 and the number of tips increases of 1.

I think there are 7cm more every time.

Two students from another class gave these answers. Do they contradict Nicola, Battista and Paolo's statements? Why?

Fig. 2: Worksheet 1A

Worksheet 1A could be displayed in case the students, in their answers to worksheet 1, have focused not on the relation between the heights and the numbers of tips, but on the relation between the heights of an incision and the height of the following one (or the number of tips of an incision and the number of tips of the following one). In this way, through the collective discussion, the students can be guided to focus more on the relation between the couples of numbers (1,7), (2,14), (3,21), (4,28), instead of focusing separately on the sequences of numbers 7, 14, 21, 28 or 1, 2, 3, 4.

Worksheet 1B is another not compulsory worksheet that could be displayed to introduce a discussion on the fact that Paolo and Battista express a relation that is the inverse of the relation expressed by Nicola.

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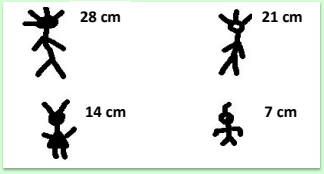

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(1) What do you think about Nicola, Battista and Paolo's statements? Do you agree with them? Explain why.

The incisions are always the same. ..you must see what is the starting point: the height or the number of tips.

Battista and Paolo say the same thing, that is the opposite of what Nicola says.

In another class two students gave these answers. What do you think about them?

Fig. 3: Worksheet 1B

Worksheet 1B could be displayed in case the students, in their answers to worksheet 1 or during the subsequent discussion, have not highlighted that the relations expressed by Paolo and Battista are the same and that the relation introduced by Nicola is the inverse of those introduced by Paolo and Battista.

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 1, 1A, 1B.

Usually the activity starts with a worksheet focused on one or more questions (in this case **worksheet 1**), 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, since it is the first problem within this series of activities, we suggest to focus on the 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. In this, the criteria for success could be clarified through the analysis and comparison of the different written productions (*FA strategy 1*).

If not all the aspects that should be highlighted arise during the class discussion, the teacher can display (functionality *Sending and Displaying*) the worksheets conceived to prompt a discussion (in this case **worksheets 1A and 1B**). These kinds of worksheets are aimed at supporting the activation of *FA strategy 2*.

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 no worksheets aimed at prompting polls were constructed, but it is possible to organize instant polls.

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 1**, for example, it is very important to stress that students are asked to analyse the statements proposed by the three archaeologists, to declare if they agree with them and, especially, to clearly explain the reasons underlying their choices. It should be clear that all the three archaeologists could be right and that their statements should be interpreted and compared looking at the drawings of the incisions.

During most of the teaching experiments, it was not necessary to use **worksheet 1A** and **1B** because the aspects on which these worksheets are focused were often highlighted during the collective discussion on worksheet 1.

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.

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