FaSMEd

Raising Achievement through Formative Assessment in Science and Mathematics Education

Scales: formative assessment through multiple-choice tests

Subject:	Mathematics and Science
Age of students:	11 - 12 years
Hardware:	Clickers, teacher PC, projector, calculator
Software:	*Je lève la main* (student response system)
Functionalities:	Sending and displaying, processing and analysing
Time:	3 lessons of 1 hour
FaSMEd partner:	Ecole Normale Supérieure de Lyon
Short Abstract:	This 3-lesson sequence is about scales and proportionality, which are jointly addressed both in Math and Science. Some multiple-choice test are proposed and analysed throughout the sequence for having an overview of the class.

1. Content

This sequence of lessons is based on scale and proportionality as tools to understand the levels of organization of living beings. In mathematics, the scale is the ratio of two lengths. The computation of a scale is normally done later, in grade 7. In grade 6 (11-12 y.o.), the scale is given to students: a segment of 1cm on the drawing with the corresponding real length of that segment. Mathematics learning is re-used in science: students draw cells that they observe in the microscope and use a scale for determining their real size.

2. Activity

2.1 Aims

This sequence has the objective of using proportionality as a tool for understanding scales. It aims at giving meaning to the writing of a scale, and finally at making the link with scales in science. Students are expected to acquire mathematical and scientific competencies such as:

- Recognising situations involving proportionality and treat them using a suitable method:
    - Use of linear ratio
    - Use of proportionality coefficient
    - Through the image of the unit
- Being able to change unit of measurement for length and mass.
- Being able to
    - observe with an optical microscope,
    - compute the enlargement used in microscopic observations,
    - draw observation drawings,
    - draw schema of different levels of organization of living beings (for the scales: ecosystem, organism, organ)

Also transversal competencies are targeted, such as being able to work in groups and to take initiatives.

2.2 Structure / Methodology

First lesson (maths)

The teacher proposes a quiz (see “scales-lesson1-quiz”) in order to verify if the students know how to use the proportionality for finding the unit by using a multiplication (question 1), a division (question 2) and if they have understood the scale notation (question 3). The teacher displays students’ answers and proposes remedying activities, such as:

- A collective work on the notion of scale and on its notation.
- Collective and individual exercises (see “scales-lesson1-activity”), using the table of proportionality for finding the real length of the corresponding segment of 1cm on a drawing/picture.

Second lesson (maths)

The teacher proposes a second quiz (see “scales-lesson2-quiz”): this is a multiple-choice test. The questions test different competencies at stake for determining the length of an object starting from a scale:

- Reading a table (questions 1 to 4)
- Calculating a proportion (questions 5 and 6)
- Representing a scale using a “segment-number” (question 7)

At the end of the quiz the teacher and the students answer the different questions. An individual activity is finally given to students (see “scales-lesson2-activity”): it consists in finding the scale of a drawing.

Third lesson (co-animated by both mathematics and science teachers)

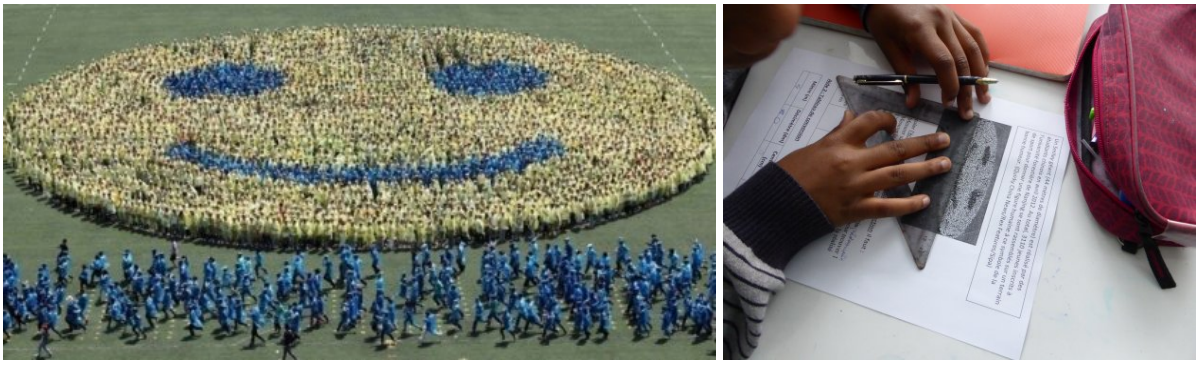


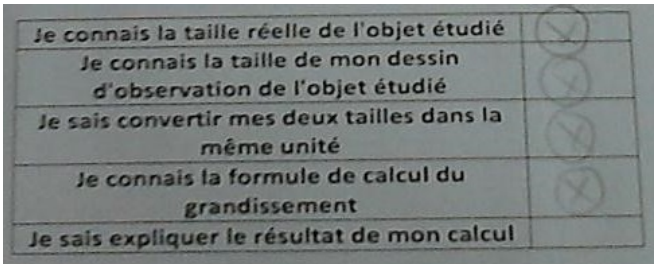
Fig. 1: The figure given to students and a student working on it.

Starting from the picture of this smiley of a diameter of 44 meters done by 3110 Chinese students (Fig. 1), the question of enlargement and reduction are asked:

- Is this picture an enlargement or a reduction of the actual smiley?
- Compute the scale of this picture.

The teachers propose a multiple-choice test (see “scales-lesson3-quiz”). Each question aims at detecting a certain type of difficulty. Questions 1, 2, 3 deal with the difficulty to give a meaning to the representation of a scale. Question 4 deals with the difficulty of using the table of proportionality to determine the scale. Question 5 is on difficulties with unit conversion. Question 6 puts all these difficulties together in a more complex task of computation of an enlargement scale with unit conversion.

Teachers comment on live the quiz results and build with the students a self-assessment grid (Fig. 2) that is used by students in the next science lessons, where students have to calculate the actual size of a cell seen in the microscope.



Je connais la taille réelle de l'objet étudié	⊗
Je connais la taille de mon dessin d'observation de l'objet étudié	⊗
Je sais convertir mes deux tailles dans la même unité	⊗
Je connais la formule de calcul du grandissement	⊗
Je sais expliquer le résultat de mon calcul	

Fig. 2: Self-assessment grid constructed by teachers and students together

2.3 Technology

The technology is present in this sequence as a communication tool allowing teachers to display questions, and to collect and display students' answers. All the questions proposed are displayed in the classroom and students have to individually answer with their clicker. The software permits to stock the results and to show them to the students (Fig. 3) for discussing the answers, question after question or at the end of the quiz. Therefore, the main functionalities exploited by the teachers are "sending and displaying" and "processing and analysing" data.

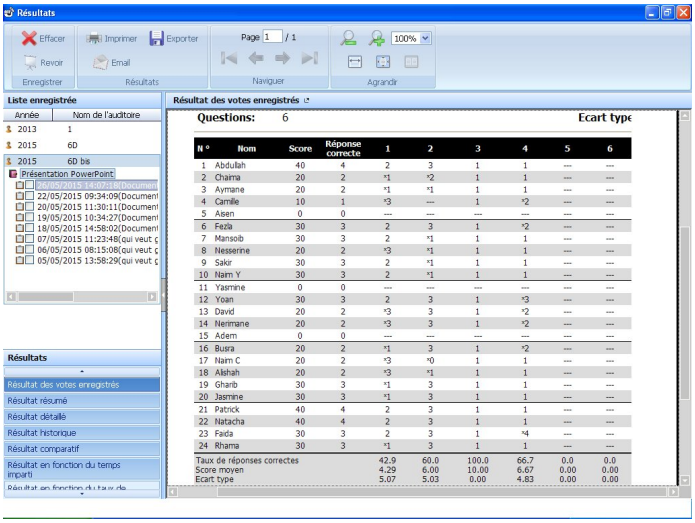


Fig. 3: Displaying of the students' answers table produced by the software

Thanks to such functionalities of the student response system, teachers can have a global overview of the students' understanding in real-time and detect specific students with whom it is necessary to work individually on the justification of their answers.

2.4 Aspects of Formative Assessment

This practice of assessing competencies through quizzes allows teachers to detect the main students' difficulties in real-time in order to propose immediately remedying activities adapted to students' need. Quizzes can be used in different moments of the lesson, according to the goal the teacher has in collecting data. Quiz1 is a very quick open test, used at the beginning of the lesson for reminding the students of what has been done the previous lessons, to recall notions and notations and to engage students in the work. Students have the possibility of self-assess what they learn and teachers can identify persisting difficulties in order to adapt the lesson to students' needs. Quiz 2 and 3 are multiple-choice tests used by teachers to have a global overview of the class and of the possible students' progressions. From the correction of quiz questions, which aim at specific competencies and difficulties, teachers and students construct together a self-assessment grid. Using this tool, students can evaluate each step of their work.

Establishing where the learners are in their learning

The concepts of scale, proportionality, unit conversion and use of formulas in calculating a magnification scale are boundary objects between mathematics and science. Students are activated as the owners of their own learning throughout the whole sequence, while answering to the proposed questions and correcting them with the teachers and the classmates; and in particular in lesson 3 when they build the self-assessment grid starting from their answers.

Establishing where they are going

The teachers clarify the learning intentions and criteria for success by analysing with the students their answers from the double point of view of mathematics, as a tool for computing scales and interpreting drawings, and of science with the notion of enlargement under the microscope.

Establishing what needs to be done to get them there.

This sequence is based on self-assessment (grid built in the class by students and teachers) and peer-assessment and the teacher ensured that students autonomously used the available tools to compute and use a scale (proportionality table, conversion chart, self-assessment grid).

Use of feedback

There evidences of the teachers' use of feedback to inform and modify their teaching. The lessons are organised around activities and surveys and the teachers analyse the difficulties encountered by students. The main difficulties are related to the unit conversion and the representation of a scale. The teachers used the analysis of students' results to adapt the current or the next lesson to students' needs. By correcting the quiz answers, teachers give a feedback to students. This feedback materializes in the self-assessment grid constructed by students and teachers together to overcome students' difficulties. There are evidences of the students' use of this feedback and tool in their work.

3. Further Information

Some lessons after, the science teacher wrote in his diary:

"This sequence of lessons shows a real and positive evolution regarding the computation by students of scale of enlargement. The self-assessment grid allowed them to be guided step by step in their work despite the persistence of technical difficulties (units conversion, representation of the scale as a segment of 1cm). However, I can observe that students have acquired a real method and a know-how that makes them autonomous in front of such a task. Students have an evident mastery of the steps required to calculate the enlargement scale corresponding to their own observational drawing. […] Struggling students present their findings to the whole class and almost all the students seem properly prepared for the realization of a summative assessment at the end of the sequence."

4. References

"Je lève la main" for clickers:

http://www.speechi.net/fr/index.php/home/evaluer/boitier-de-vote-interactif/

https://www.jelevelamain.fr/en/

For further information (in French):

https://ife.ens-lyon.fr/fasmed/spip.php?article46