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Construction and calibration of an electronic weighing machine

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We present the structure of a STEM project in which middle school students (i.e., thirteen to fourteen-year-old mandatory secondary school students) must build and calibrate an electronic weighing machine to contextualize the mathematical notion of linear function. During the calibration process, the didactical situation may overcome students' algebraic knowledge; therefore, dynamic software is used to aid what students cannot do for themselves.

Keywords: Secondary school mathematics, STEM education, 8th grade.

Theoretical frame

Let's consider a STEM project as a *didactical situation* (Brousseau, 1997) where students apply their personal mathematical knowledge and use a number of basic strategies to solve a particular task. The mathematical knowledge students are required to face in STEM problems mostly regards measurements, elemental geometrical language and arithmetical operations with numbers (Lasa, Abaurrea & Iribas, 2020). Finally, the STEM notion of *technological literacy* in a mathematical context naturally brings us to Instrumental Theory, since dynamic models can operate as antagonistic milieu, giving students the necessary feedback of their performance (Lasa & Wilhelmi, 2013).

Experimentation

Laboratory work (science) involves measurement of quantities in scientific notation and the use of the international unit-system, laboratory work (technology) to design an electric circuit prototype, the calibration of the scale by technological means (engineering) and the modeling of linear functions in real contexts, where students obtain numerical values out of algebraic expressions (mathematics).

Theoretical basis

The experiment is based on the assumption that the scale can be calibrated from a linear relationship between the known weight of predetermined objects and the variation in the resistance of an electric circuit embedded on the metal piece, which forms the deformation gauge (figure 1).

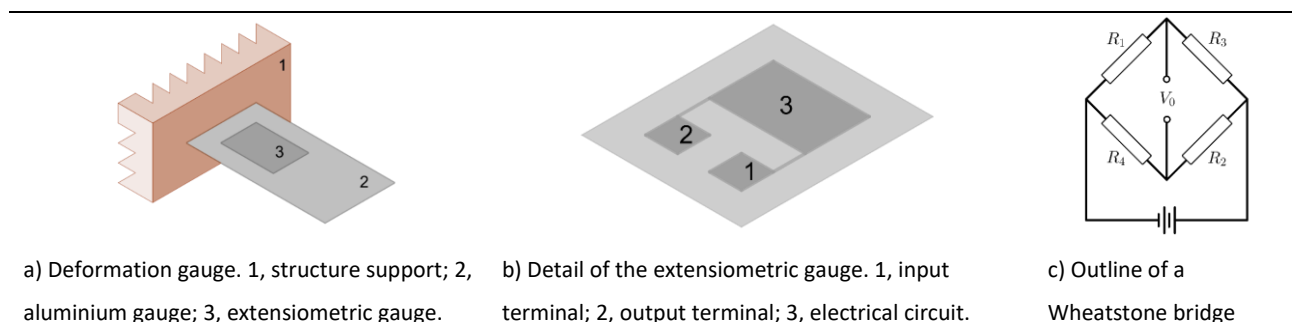


Figure 1: Outline of a deformation gauge and Wheatstone bridge

Experiment

Predetermined experimental phases in both schools avoid phase-order variability:

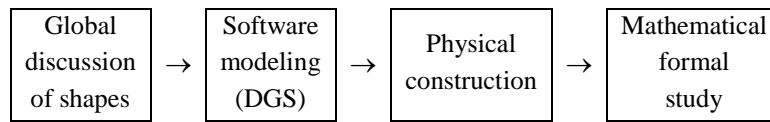


Figure 3: Project steps (Lasa et al., 2021)

Results

Students have built a personal knowledge regarding the equation of the line, and are receptive to address the mathematical formalization of the line from a theoretical point of view. The mathematics teacher will now assume leadership and institutionalize the notion of linear function.

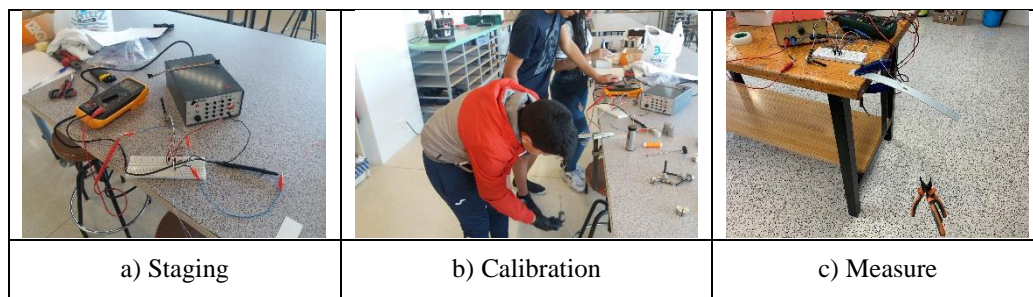


Figure 5: Student working at the lab

Conclusions

This experience confirms that it is possible to integrate formal mathematics in the context of STEM projects, beyond its usual assistant character. Furthermore, the key notion of didactic situation has led us to an adapted structure for STEM project with a final formal mathematical component.

Acknowledgment

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