Symmetries: Interdisciplinary Project-Based Learning in High School.

Abstract. Project-Based Learning methodology has been used to experiment with high school students' interdisciplinary learning crunch focused on symmetries. Students were involved in some highly symmetric solids' buildings. Symmetry has been investigated in Art, Philosophy, and Mathematics by using ICT, too. Finally, students built some symmetric electrical networks, and they verified the main symmetric properties through the equivalent resistance measurement. The students developed content knowledge as well as critical thinking, collaboration, creativity, and communication skills.
The hands-on experience increased students' motivations and participation, making them more involved in the educational process.

1 Introduction

Interdisciplinarity plays an important role in various fields for the following reasons:

a) The first step is to get students to reveal their abilities and then guide them to define their place in society.

b) it is also necessary for students to learn before acquiring any particular body of knowledge.

c) lastly and more generally, it is important to allow students to find themselves in the present-day world, to understand and criticize the flood of information they are deluged with daily.[1]

In interdisciplinary tasks, students' attitude to generalize disciplinary knowledge to new application contexts is encouraged naturally. The European Union recently published recommendations to integrate all scientific disciplines with their applications in technology and engineering and with artistic expressions (STEAM). Benefits would be, for example, the positive effects of art in interaction with different disciplines, including mathematics and physics, from the affective and motivational point of view. Moreover, it fosters the development of creativity and critical thinking. Here, we focused on the integration of Mathematics, Arts, Philosophy, and Physics in high school [2]. Starting from the symmetry properties of some highly symmetrical solids, students were asked to "reinvent" mathematical concepts [3] by counting and measuring equivalent resistances in some specific symmetric electrical networks. [4]. We asked if this Methodology helps students to understand Physics better, using resources from several disciplines.

2 Project-Based Learning

Our theoretical framework is based on Gold Standard PBL [5]. Students' projects are focused on key knowledge, understanding, and success skills, as following in figure, taking into account all the seven essential elements: A Challenging Problem or Question, Sustained Inquiry, Authenticity, Student Voice & Choice, Reflection, Critique & Revision, Public Product.

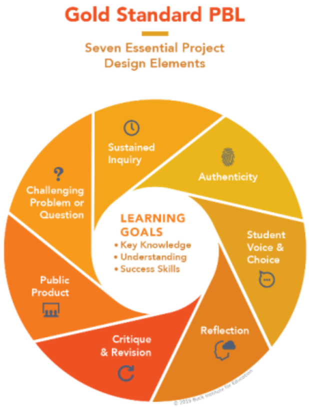

Fig. 1 Seven Essential Project Design Elements

3 Activities

The Project involved about 60 high school students. A qualitative analysis has been carried out through questionnaires concerning the student's motivation, engagement, and participation.
The activities have been divided into several steps. As the first step, cardboard models of Platonic solids were produced. The students observed some symmetries properties, analyzed the artistic features, and considered the Art and Maths history, as in De corporibus regularibus (Piero della Francesca) and De Divina Proportione (Luca Pacioli, Niccolò Tartaglia , and Rafael Bombelli). In the second step, combinatory and metric properties about highly symmetric solids have been studied by following the Fedone (Plato). Moreover, students realized in the lab some resistive networks as Platonic solids, whereas the resistances covered the edges of these solids and measured the equivalent resistance. In the third step, a mathematical model was designed to compute the equivalent resistance using specific algorithms (Laplace, Ductch) and software Mathematica. Finally, a comparison has been carried out between the theoretical results and the experimental measurements.

4 Conclusions

We deduced that students learn physics more quickly, are more motivated to ask questions and seek resources from different disciplines if they are involved in a challenging real problem.
Furthermore, by working on concrete projects, students acquire autonomy and responsibility, develop skills and apply knowledge, and learn meaningfully.

References

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