"Scientific research" a project for learning how science works at 3rd year of secondary school

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KEY FINDINGS

- **Interdisciplinary projects 3rd year of secondary school.**
- **Learning the scientific method in a personal research project.**
- **Sequencing questions (from lowest to highest) to a correct student learning process.**

LOW MOTIVATION AND BELIEVE IN THEIR OWN SKILLS OF SECONDARY SCHOOL STUDENTS FOR SCIENTIFIC VOCATIONS

Institut Cardener is a state -run middle school placed in a town with a population over 10.000 inhabitants.

In our school we follow approaches that are constantly searching to assist the learning student-centred learning in order to develop individual competences and abilities. In that way we began to work in 5 fields (communicative, foreign languages, physical education, artistic-musical and STEAM) so we are able to assess the evolution of each student from different points of view and in a more objective and holistic way.

SINS CARDENER

- The SINS Cardener started its activities in September 2012. We emphasize curriculum development through projects and learning from the perspective of socioconstructivists and systemic pedagogy. Our curriculum highlights a competence vision that favours the work of languages together with all STEM subjects.
- This promotes work in real environments and encourages classroom work outside the classroom in various situations. Thus, to do so, the center is opened to projects and collaborations with companies and organizations in the environment.

Within this change, the school is organized in 4 time zones of 90 minutes which are divided in "**plans d'acció**" (action plans), which are subjects from the different fields; **projects**, in which the students work in small groups by means of cooperative work; **tutoring sessions**, where teachers guide and do the monitoring of each student; and **workshops**, in which they can experiment in different ways.

Generally, when students progress in their studies and, in particular, in their transition to secondary education, they progressively lose interest for scientific subjects. One probable cause of this detachment is how teachers conceive the assessment in school, as a tool to quantify students' performance. As a consequence, a large part of students discard scientific vocations for their future pushed by the idea that they can't do it. This fact is easily observed in the low students' percentage that choose these optional subjects in fourth secondary course and the number is even lower for the post-compulsory studies.

SCIENTIFIC'S TALKS, ACTIVITY SEQUENCING AND QUESTIONS TO IMPROVE SECONDARY SCHOOL STUDENTS' SELF-EFFICACY IN STEM

In order to improve students' own perception of their skills in STEAM, we re-designed our school project "the scientific research", which was addressed to 3rd course of secondary education. The main aim of the re-designed project was to offer students an educational scenario in which they could have a first-hand and empowering experience of how science works, by designing and conducting a scientific research related their own personal interests. To this purpose, 3 main actions of improvement were undertaken: firstly, a redesign of the questions of the research project; secondly, an arrangement of the activities in increasing order of their level of difficulty (starting from the ones having the lowest level of difficulty level, towards the highest level of difficulty), so no students were lost at the beginning of the project; and finally, setting up scientific' talks with professional of the STEAM field, so students could have a more personal approach of what people working on STEAM do. In each step, teachers provide positive support to empower students.

The final design of the project was structured into two parts: Once we introduce the project, in the first part students begin to work in small groups to learn all necessary knowledge related with the following parts; in the second part, students learn to work individually in the research of their personal investigation. The development of the project is shown in the Table 1 and it is described in the following sections.

First Part: Group Work	Project's Introduction	Starting activities: • Talks • Mystery boxes	Research questions		
Second Part individually research				Individually research: • Hypothesis • Experimentation • Results' analysis • Conclusions	Oral presentation of the results

Table 1. Representation of the project development

First part: cooperative work

The most important part of the project, in which we need to influence directly, is group work, because it is where our students learn how science progresses and what the scientific method is. For that reason two of the actions introduced (talks and sequencing activities) are in this part.

One of the first activities done in class is called "mystery boxes" (from science museum learning) in which students should deduce what is inside 6 closed boxes without opening them, only by using the tools that are at their disposal, just like scientists do. In groups, they have to reach an agreement in order to give an answer.

In second place, we carry out talks where the professional researchers answer students' questions.

Then, in groups of 5 students, they solve the starter questions in which they are supposed to learn what the scientific method is, and its specific vocabulary (hypothesis, experimental design, variables, result analysis and conclusions).

Second part: individually scientific research

Afterwards, and always with the teacher's guide and support, each student chose one research topic related with one phenomenon of his/her interest. The process of selection is open to students' preferences, so many different research topics can be found, such as: how mass affects to free fall, the liars' expressions, the influence of playing at home in sports, the candle size in an experiment of water absorption. After starting a bibliographic research, students design an experiment to confirm or reject the planned hypothesis. In the next photos are shown some of their experiments.

Figure 3. Images of some of the experiments undertaken in the Scientific Conference project carried out in the SINS Cardener

The last step of their scientific research is doing the results' analysis that are obtained in their experiment to confirm or reject their beginning hypothesis.

Results' presentations

To show the conclusions of their results, our students must record a video with their experimentation and one poster where they collect the different steps of their marked research by the scientific method: starting hypothesis, designing an experiment, making it and analysing results.

ASSESSING THE IMPACT OF THE ACTION PLAN (SCIENTIFIC'S TALKS, ACTIVITY SEQUENCING AND QUESTIONS, POSITIVE SUPPORT) IN SECONDARY SCHOOL STUDENTS AND TEACHERS

Methods and data collected were based on the work of Oñate, G. (2018). Both teachers and students were interviewed before and after their project participation. The question protocol was based on a review of theoretical conceptions about STEAM education, from a gender's perspective. For each item, a series questions

were selected to be able to test the impact of the project on students' self-efficacy. Some of this group of questions were: how they feel, their own skills, teachers' strategies and other personal datum. In addition, personal students' interviews were undertaken to confirm the datum obtained through the questionnaire and allowed the students to express themselves with no time limit.

The data analysis procedures were based on the averages of teachers and students By analysing students' answers of the questionnaire, we made a statistical analysis of the average answers, both before and after the project, and were supported by the data gathered in the interviews. In first place, we did a datum extraction from questionnaires before and after the project in order to see the changes and awareness caused by taking part of this project. To observe if it followed a normal distribution, we used an excel complement called XLSTAT Saphiro- Wilk. Once we studied the datum, we went on evaluating the obtained results as it is shown in the following graphic.

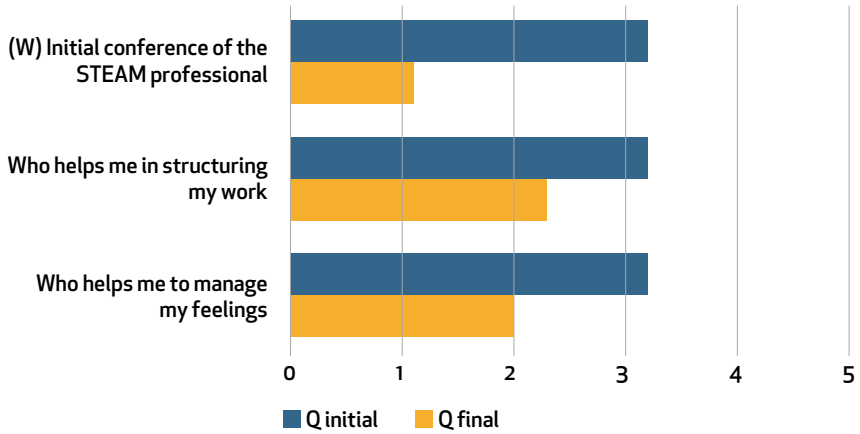

Figure 4. Results of the differences in the perceived usefulness of the learning strategies by girls. Answers to the question: Rate the influence of the following to make you feel you are able to do science; where 0 is *it does not help me at all*, 1 is *it helps me very little*, 2 is *it slightly helps me*, 3 is *it helps me moderatelly*, 4 is *it very me considerably* and 5 *it very helps me*

As we can observe in this graphic, girls' results in some questions are worse at the end. Unfortunately, we can't observe any other significant effect neither for

boys nor for girls. The fact of participating in this European Project gave an opportunity to teachers to be more conscious of their influence in a lesson. Besides, using the scientific paradigm to find answers on personal students' interests is vital to dismantle the idea of science and elitism to empower students. However, we need to continue working in this sense for reconsidering class activities and make it understandable and motivational for our students.

CONCLUSIONS

In general terms, the participation of students in the scientific project helped them to reflect on their own skills, and be more aware about their efforts to achieve the objectives. "Try it, don't be scared, if I try I can research and learn by myself" is one of their comments in the interviews.

It is necessary to emphasize that girls valued some of the improvements introduced as experts' talks and teachers' support in a negative way. It may be due to their high expectations at the beginning of the project and that they might have thought they could have needed more teachers' help.

On the other hand, we did not observe any evidence in the boys' statistical results.

KEY MESSAGES FOR EDUCATORS

- **To promote feedback actions with students**
- **To make activitiy goals clear and sequenced**
- **To promote tutoring among peers**

FUTURE STEPS

There are mainly two important considerations for the next project editions that we should bear in mind: to provide a powerful scaffolding for the STEAM activities for students who can achieve the objectives, and in this way, to make the project less open; to fragment and make concrete goals to make them more accessible.

The second aspect that we should bear in mind is trying to vary the activities and questions in order to improve students' self-efficacy by genre, since boys and

girls think they are able to do some actions more than others. So, if we want to improve both of them, we should provide differentiated activities.

TO KNOW MORE

Oñate, G. (2018). Anàlisi de l'impacte d'una activitat d'indagació i comunicació científica en el posicionament STEAM des d'una perspectiva de gènere; 2018.