"A scientific congress to improve the science self-efficacy of Secondary School students"

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KEY FINDINGS

- **Scientific Education on Secondary school: a different approach focused on the process that science follows to create new knowledge**
- **Interdisciplinary project working together experimental science (Physics, Chemistry and Biology) and Music.**
- **This is a specific version of a STEAM project created and implemented by secondary school teachers with 3rd ESO (9th Grade) students.**
- **Example of application of strategies to improve self-efficacy and its results.**
- **Empirical results obtained in the improvement of self-efficacy.**

LEARNING THE PROCESS OF RESEARCH IN SCIENCE THROUGH A STEAM CHALLENGE ON 3RD ESO

The Scientific Congress project from Florida Secundària is the result of a fundamental strategy (Arandía, 2004) of collaboration teamwork of 4 teachers from different disciplines with the idea of improving the interest and involvement of their students to learn in a deeper way Physics and Chemistry, Biology and Music curriculum together, as a specific way to respond the growing disinterest of students towards scientific studies (Solbes & Vilches, 1999).

Getting the 3rd ESO students to develop a real scientific Conference to internalize the process followed by science to generate knowledge has been the main goal of this interdisciplinary project. The success factors of this project have been based on students' curiosity, as a strategy of intrinsic motivation, on teamwork as an element of social learning, and on external collaboration to give meaning to the whole process.

The project has been developed on the academic courses 15/16, 16/17 and in the 17/18 course with new improvements resulting from STEAM4U E+ project.

FLORIDA SECUNDÀRIA: A COOPERATIVE HIGH SCHOOL

- Florida educational group is a Valencian worker co-operative created in 1977 working in the field of education. From its origins, Florida has worked in order to provide a high quality, participative and innovative education project, in close contact with companies and the society. The education and training provided to youngsters and professionals are based on the acquisition of skills and knowledge enabling them to successfully participate in the new business, professional and social scenes of current society.
- Florida is used to apply innovative methodologies to promote the socioeconomic development of the territories by generating inter cooperation experiences. Most of these methodologies are a result of a wide trajectory of participation on cooperation and research projects at regional, national and international levels.

A scientific congress also with music research?

The team of project teachers had detected the need to ensure that students could write an intellectual work where they really delve into the investigation of a specific topic. This work started from their own interest - choosing between thematic proposals marked by the team of teachers-, with the aim of avoiding superficial theoretical productions and with the intention of improving their capacity for synthesis. Knowing that the students have a big amount of information sources at their disposal and therefore it is relevant that they can learn to discern, to organize and synthesize it with their own criteria (Ten Dam, & Volman, 2004).

This situation generated the creation of a 4 hour weekly project module including the contents and learning standards of the 3 subjects mentioned above. This project module had a semester complement of 2h per week for Physics and Chemistry from September to February and 2h of Biology from February to June.

To establish links between the work done in the Secondary school and at University in order to cultivate scientific vocations and guide future studies to our students, one of the objectives set was also to design a project that could establish a bridge between both realities (Union européenne Commission européenne, 2007).

"The Scientific Congress" takes place during a two months period of the year. It comes out from the shared reflection of the team of teachers in which they agree the main framework of the learning objectives for 3rd ESO: put into practice the real process that science follows to generate knowledge. This agreement follows the idea that the reproduction of the scientific process by the students is an important base for the construction of the models that constitute scientific knowledge (Domenech-Casals, 2017, Caamaño, 2012; Llewellyn, 2005). From the epistemology of science it is a priority that students get to know this process starting with the steps of the scientific method and moreover, achieve the improvement of the rigor in their researches due to the fact that they are going to be evaluated by external experts. Another big priority of the project was to place Music in the same level of 'importance' that science to promote the relevance of this subject on the secondary students. The inclusion of Music as representative of the arts is a way to invite those students who do not feel comfortable in these disciplines and at the same time, a way to carry out a strategy to improve their self-efficacy (Zimmerman and Campillo, 2003). This is one of the reasons why it was decided to open the possibility of researches related to music in the frame of the Scientific Congress.

Likewise, artistic subjects have been losing prestige in recent years, passing to a second stage of importance for students and for general public as well. A proof of this situation is the change of compulsory to optional subjects in the Spanish regulation L.O.M.C.E. Arts subjects have become optional in many levels, so the inclusion of Music into this project also aims to integrate this subject, as a representative of arts, at the same level as sciences and thus shows the need for rigor and method in its development.

Apart from that, including music in this project tries to be an 'open door' for those students feeling low self-efficacy on science. The homogeneous types of students interested in science disciplines need to be amplified giving opportunities to others to feel capable into these areas. The presence of music on the project works as an attraction for their interest.

Curiosity is an internal human engine that helps to generate intrinsic motivation on students (Satiro, 2009) as an opposite approach to the repetitive, mechanical and memory tasks. Providing learning strategies that start from it –curiosity- is a key element that can push the work of students in this area in order to deepen the scientific literacy necessary for the citizens of 21st century (Vázquez & Manassero, 2008).

PROJECT STRUCTURE INCLUDING FORMATIVE EVALUATION STRATEGIES

The methodology and the different steps defined into the project were based on the purpose of teaching science developing creativity, problem solving, communication and metacognition in an integrated manner and not as differentiated actions in other spaces, as proposed by Pellegrino, Hilton and Learning (2012) and also with the objective of using evaluation as a learning strategy to ensure that students became able to regulate their own research process (Sanmartí, 2007). This principle supposed that the structure of the project has to ensure that students know:

1. Where they are, within the whole process: which is the point and moment of the project where the student are working
2. What they have learned: From the beginning of the project until the point where they are.
3. What remains to be learned: until the end of the project.

This objective requires preparing a flexible planning of the stages of the project to ensure that mechanisms have been established to generate metacognition in students (Campanario, 2009). It also implies that situations in which the teacher provides feedback to students must be established in order to ensure that they are aware of their mistakes. This structure generates improvements (Sanmarti, & Simón, 2006). This also means that every important aspect is evaluated during the work process and not only the final product.

The phases of the project must be structured taking into account the possibility of achieving these situations. Based on these criteria, the schedule was defined according to the sequence described below (every week takes 4 lessons):

PRESENTATION OF THE PROJECT *[1 LESSON]* • Initial moment where teachers explain the challenge of this project.
UNIVERSITY SCIENTISTS CONFERENCE *[2 LESSONS]* • Motivational talk where University professors explain what it is a Scientific Congress showing examples of conferences where they have participated.
RESEARCH QUESTION SELECTION *[1 LESSON]* • The team of teachers prepares a catalogue of questions on which students can investigate.

TEAM WORK *[1 LESSON]*: Depending on the students' selection, teachers organize the work teams to start the research.
RESEARCH PHASE *[8 LESSONS]*: The students inquire about the previous ideas to be able to decide the aspects that will be investigated on the chosen topic that will serve as the beginning for the realization of the subsequent investigation.
PREPARATION OF THE THEMATIC RESEARCH WORK (TIT*) *[8 LESSONS]* • The instructions on the contents and sections of the so-called TIT are given by teachers and the students start to elaborate the first draft. • The first draft is presented to the thematic mentor (one of the teachers of the teachers' team). • The project teacher evaluates this draft and gives feed-back with the improvement proposals. • The students start making the final version of their TIT. • *TIT: from Catalan acronym "Treball d'Investigació Temàtic"
EXPERT PHASE *[8 LESSONS]*: Students develop different scientific products related to their research. The group assigns roles to their members so that each student assumes a responsibility within the group. • *Scientific article*: In the lessons of English subject students get help to write their Abstract.. • Scientific poster: In the lessons of Arts subject students get help to make their scientific poster. • Multimedia Presentation: The students get help from to prepare their Multimedia file that will serve as a support during the defence of their research on the ICT lessons.
DEFENSE OF THE RESEARCH *[4 LESSONS]* • The students prepare a preliminary script to ensure that all group members participate in the presentation?. • Oral defense in front of a tribunal of experts formed by University professors.
RESULTS *[2 LESSONS]*: The project teacher explains the results of each group and a qualitative and quantitative evaluation (on-line form) of the work is done by the students. The students also carry out a self-evaluation of teamwork and an evaluation of the phases of the project. .

Table 2. Structure of the project

Results of the Research

Throughout the 3 project editions carried out the most chosen subjects by the students have been:

Are there two formulas that explain the Universe?	Can I get the Zika virus?	Who were the Castrati musicians?
Is the sky blue?	How are sea turtles oriented?	How is music learned through the BAPNE method?
How can we know the age of the Tyrannosaurus Rex?	How do Sharks and Whales sleep?	Why do we tune the instruments to 440 Hz?
How can a spacecraft fly?	Can I be daltonic?	What is the mystery of the theatre of Epicurus?
How do emoticons travel?	Is the sweat of the hippos pink?	What is curiosity?

Table 3. Most selected research topics

Methodology

With the aim of collecting data to analyse the impact of the changes in the self-efficacy of the students who participated in the congress, a combination of quantitative and qualitative instruments were used. There were individual questionnaires before the project and after the project. There were also group interviews before and after the completion of the project. Methods and data collected have been based on the work of Oñate, G. (2018).

Improving students' self-efficacy strategies

The Scientific Congress was part of the STEAM4U E+ project and thanks to this participation it has incorporated various strategies to improve self-efficacy in students. These improvements focused on this objective were the following:

- To classify and sequence the learning objectives inside the steps of the project with an increasing difficulty, establishing an initial level accessible to all students.
- Use of different strategies to promote self-regulation to make them more aware of their own abilities, emphasizing their achievements.
- To involve students in exchanges with scientific professionals who show confidence and ability to adapt to failure.
- To prepare a list of topics at different levels to respond to the different learning curiosity and rhythms of the students.
- To promote collaborative activities instead of competitive activities through peer learning and decrease the tension inside the classroom.
- To pay special attention on verbal and non-verbal judgments to emphasize positive messages that recognizes the effort of students.
- To overcome the anxiety before the defence of the research they are prepared by doing rehearsal for this action.

RESULTS

After the introduction of the strategies mentioned above to improve the self-efficacy of the students, we found specific differences on important aspects of the project objectives when we compare the pre-test and post-test results.

Arguing in public the results of the own research, giving scientific explanations of different phenomena and obtaining conclusions from collected data have had some improvements after the process of the project and all these results together

show a general improvement on the average of students' self-efficacy as we can see on the following figures.

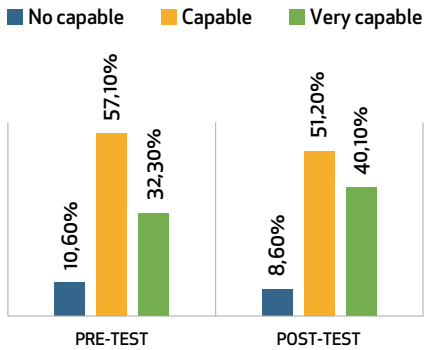

Figure 5. General improvement on self-efficacy

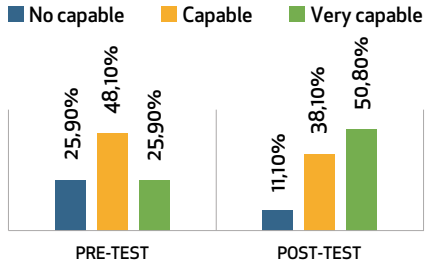

Figure 6. Self-efficacy to argue in public

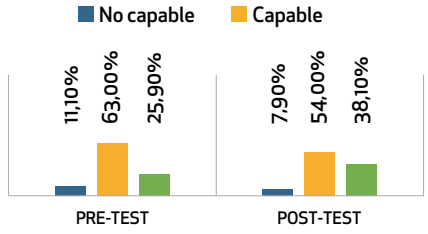

Figure 7. Self-efficacy to explain natural phenomena

CONCLUSIONS

The design of the didactic sequences is one of the most important teaching actions for the proper development of the pedagogical objectives of a discipline in the classroom. This process is usually carried out individually and without a pedagogical reflection process of quality due to the lack of time with which the teaching profession coexists. The possibility of designing a project in a cooperative way by a team of teachers coming from different disciplines is a motivational experience for participant teachers. Finding the time and the strategies to share proposals and elaborate them together supposes an extra cohesion to the defined project. Its execution in the classroom and the evaluation of the students' response provide a very positive feedback because it validates the design from practice.

Broadening this reflexive perspective by integrating it into a wider team, within the European project STEAM4U, has supposed a real improvement and it has allowed to provide broader pedagogical reflection to the learning process designed. An example of combined action and research that has made the project grow in the quality of its implementation inside the classroom.

When all this reflective contribution of teamwork is focused on a specific objective such as improving the self-efficacy of students in a scientific research, the results give a positive feedback to the work done. So far, with this practice, we have confirmed the importance of giving students the opportunity to choose their own research topic connecting it with their daily lives. Apart from this, the inclusion of Music within the Scientific Conference has provided more opportunities for success to more types of students and the opportunity to explain their own work to external professionals increases the importance of the student's achievement.

KEY MESSAGES FOR EDUCATORS

- **Give a link between everyday life of students and science it's a way to connect the students on the learning propose.**
- **Including Arts with science it's an open door inviting those students who feel low self-efficacy on science learning**
- **To invite external evaluators to give feed-back to the students research work it's a way to amplify the relevance of the students results**
- **Give the students the option to choose their own question to start their research it's a motivational factor that push them to stay connected on the whole process of research**

FUTURE STEPS

The project has easy transfer possibilities because its established structure allows any other school to incorporate it into its planning to be carried out in parallel, synchronously or asynchronously. This possibility would broaden the objectives of the project giving greater significance to the work carried out and would allow cross-evaluations between the students of the different schools.

TO KNOW MORE

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