Let’s Investigate the LHC Interactive Tunnel

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Abstract

The “ Let’s Investigate the LHC tunnel” CREATIONS demonstrator employs an interactive ICT-enhanced exhibit created by CERN’s media-lab in order to bring students closer to the scientific endeavours taking place at the world’s largest particle physics laboratory. By having students to “kick” protons in order to produce simulated high energy proton collisions and observe the products of them and by having students experiment and perform in a visualization of a world with and without the Higgs boson, their interest in science is sparked and the complex subatomic phenomena are addressed in a fashion understandable by them. This is a student activity taking place in both formal and informal settings, promoting the connection of school and research center and can take place both in local and in national level.

The demonstrator was implemented with students of Ellinogermaniki Agogi during the period 28 March – 23 April 2018. The interactive exhibit was setup in the premises of Ellinogermaniki Agogi and a guided tour was arranged for 12 to 18 year old students. The exhibit was also open to the public (http://cern.ea.gr/content/lhc-interactive-tunnel).

In total more than 600 students visited the tunnel and overall more than 800 individuals, included parents, teachers, visitors from other schools or interested citizens were able to experience the LHC Interactive Tunnel and learn more about CERN, its purpose and Frontier Physics research.

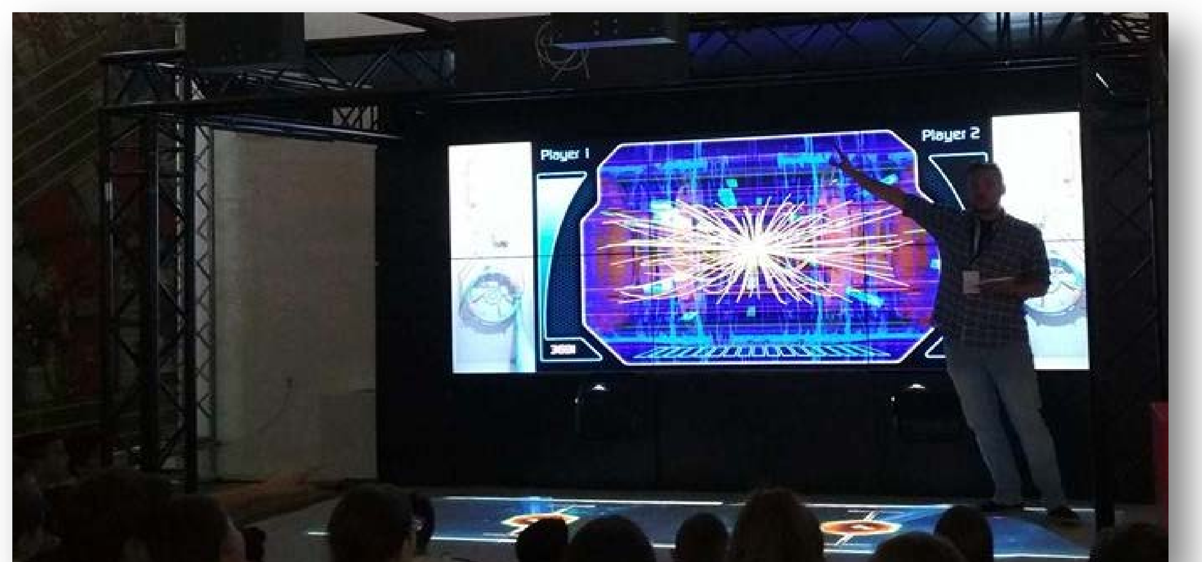
Objectives

By immersing students in a fully interactive gaming experience, the Interactive LHC Tunnel touring exhibition manages to bridge the gaps between science education, interactive media and information visualization, creating an entertaining and memorable tool for learning.
The learning objectives of this demonstrator are:

- Introduce Frontier Science to students using a game based approach.
- The students to understand the principles of particle acceleration, collision and detection at CERN. This is achieved through a gaming experience called “Proton Football”: Students become particle accelerators themselves by kicking protons. By varying the force of their “kick” they vary the energy offered to a proton and thus the collision energy of the protons.
- Students learn about Einstein’s famous $E=mc^2$ equation and learn that higher collision energies can result in the production of heavier particles.
- Students learn about components of a modern particle detector including the tracker and the calorimeter and learn how these detectors can provide us with information regarding the collision process and products.
- Students understand experientially the effect of the Higgs field on matter and understand the main difference between massive and massless particles.

Methods

A guided tour was arranged in a per-class basis for all classes of Ellinogermaniki Agogi (EA) starting from the sixth grade of elementary school to the third class of upper high school.
The students visited the LHC tunnel in groups of 20 and experienced the LHC tunnel first through an introductory lecture and then through an interactive playful learning experience consisting of guided exercises and then free inquiry on proton football and Higgnite.
The students were tutored by three Physicists of the RnD Department of EA with experience in Science Education, one with a PhD in Science Education and a PhD in Astroparticle Physics, one with a MSc in Particle Physics and one with MSc in Science Education. The average duration of a session was 45 minutes.



The tour was organized in the following modular approach:

- Introduction to the features of the LHC Tunnel exhibition.
- Introductory lecture about CERN, LHC and its experiments.
- Proton football and introduction to aspects of particle acceleration, collision and detection.
- Introduction to the Higgs boson through the artistic impression of Higgnite.
- Follow-up activity: Students choose one fundamental physics property (electric charge, mass, spin) and create an artwork inspired by Higgnite to demonstrate how they believe the world would be without these properties.

The content of the introductory lecture and the complexity of the student activities were adapted to their age. In order to assess the impact of the LHC tunnel an SMQ questionnaire was implemented in a pre- and post-fashion. The students filled the pre-questionnaire 1 day before the implementation activity and the post- questionnaire 1 day after the implementation of the activity. Further qualitative data regarding students’ motivation and knowledge acquisition were collected in interviews taken at a long period after the implementation.

Results

In the following analysis, only questionnaires with matching pre-post answers were chosen (503 overall).
The pre-post comparisons per gender and per age were done using a Student’s t-test. A 95% Confidence Level was applied to determine statistical significance.

Table : Student Sample

Gender\Age	11	12	13	14	15	16	17
Female	59	49	57	37	30	13	8
Male	57	49	34	46	27	18	18
All students	116	98	92	83	57	31	26

The plots presented display the mean values of each sample with the standard errors.

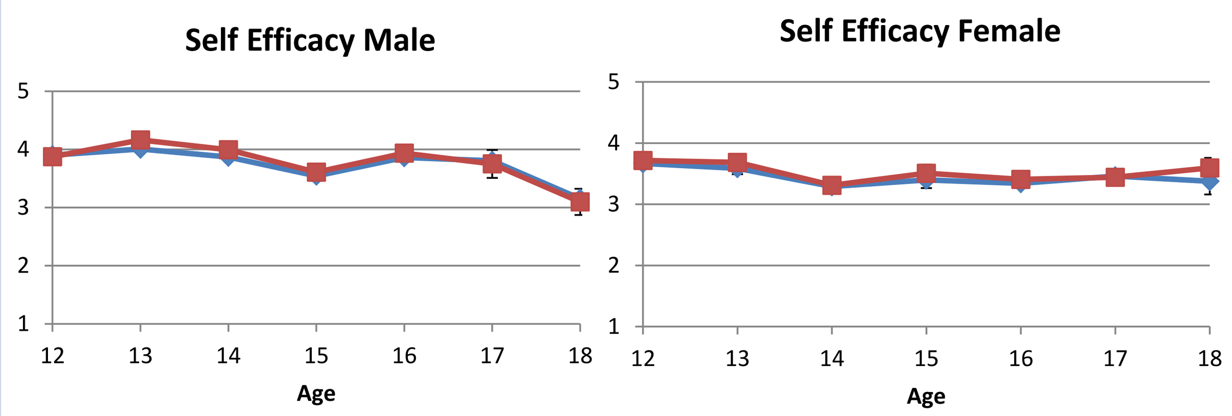


Figure 1: Male (left) and female (right) students’ self efficacy in science (blue –pre, red- post) with respect to age

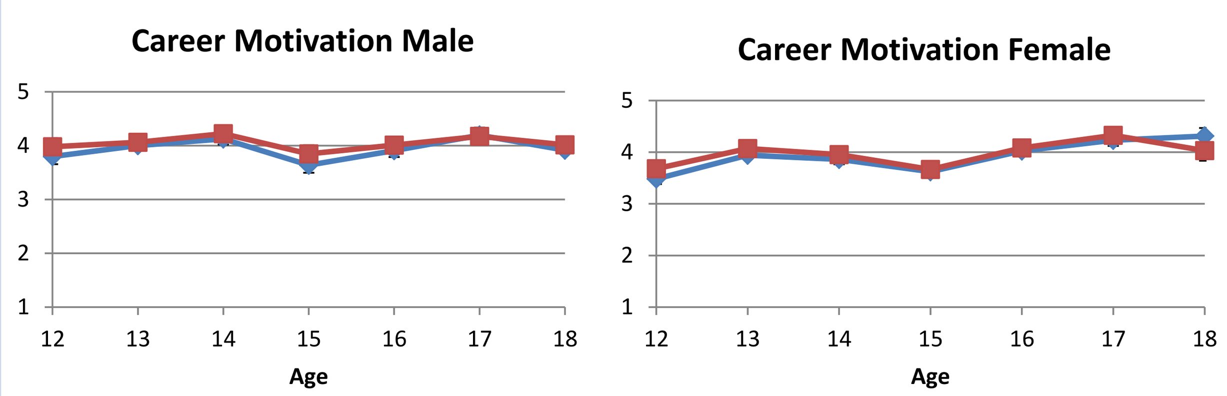


Figure 2: Male (left) and female (right) students’ self efficacy in science (blue –pre, red- post) with respect to age

The plots presented above show marginal increase in career motivation and self efficacy mainly in low ages. Figure 3 displays the overall change in student career motivation and self efficacy for all ages with respect to gender.

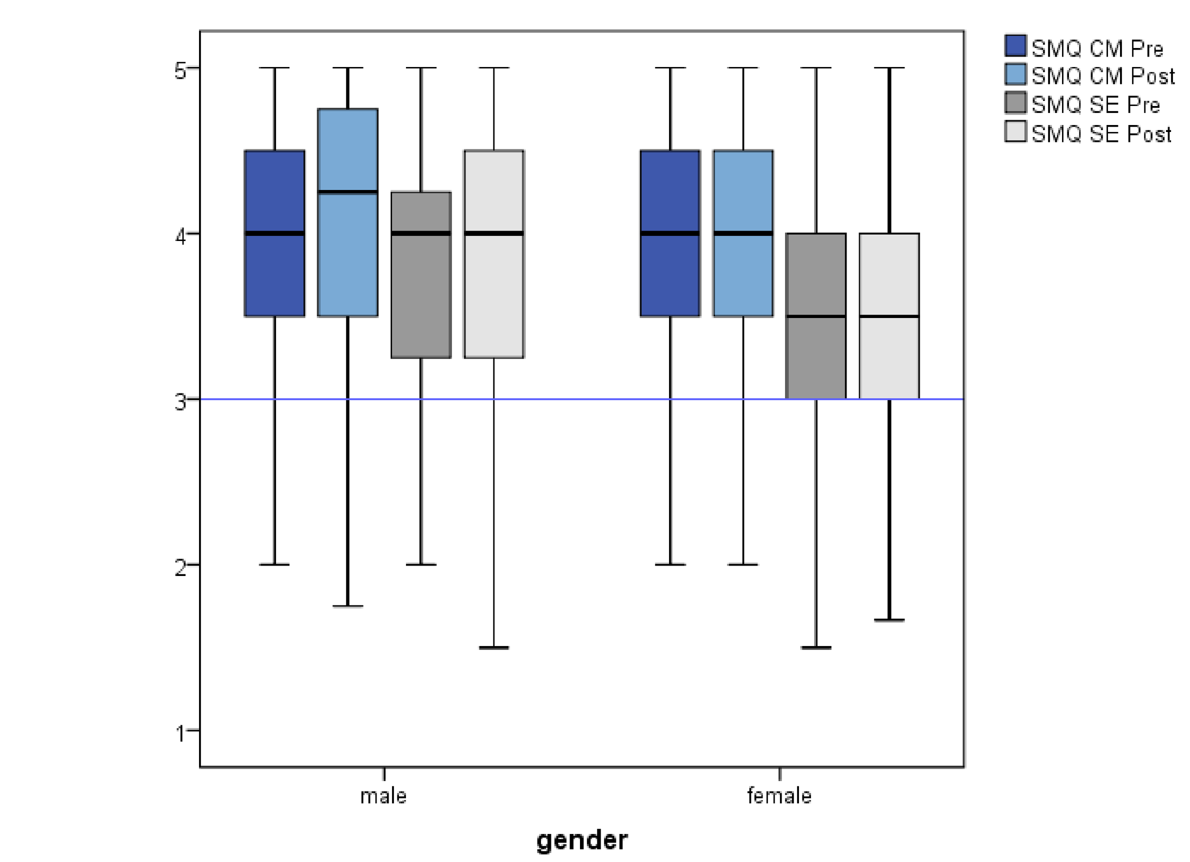


Figure 3: Career motivation and self efficacy for male (left) and female (right) students before and after the intervention.

Conclusion

- Ellinogermaniki Agogi (EA) is a STEM-specialized school which offers students opportunities to explore Science through numerous activities. Students are first introduced to CERN at the age of 11, they re-visit relevant topics at the age of 15 and visit CERN at the age of 17 while many of them participate in events such as Particle Physics Masterclasses. As a result, it is expected that indicators regarding science motivation will be high before an intervention such as the LHC tunnel.
- The effect of the LHC Tunnel Demonstrator intervention seems to have small effect in this sample’s students’ career motivation and self efficacy in science, with the differences being more prominent in younger ages**.** It can be argued that the short duration of the intervention (45 minutes per class) is correlated to the small effect observed in this study. We propose that future LHC tunnel demonstrator interventions have a longer duration and that they can be integrated with other CERN related initiatives (such as e-masterclasses, Cultural Collisions events) as introductory activities for students to explore CERN related Physics.
- Overall, male students’ career motivation seems to be affected by the LHC Tunnel Intervention, while girls’ career motivation remains unaffected. Self efficacy in science remains the same both in boys and girls, with boys scoring systematically higher than the girls. As a result we believe that the LHC tunnel might not be an optimal way to tackle gender differences in STEM.
- The lesson plans used varied with respect to age. Field observations by the LHC Tunnel tutors show that students were very enthusiastic about the game-based approach of the Interactive tunnel exhibit, while older students seemed to asked deeper content-related questions and were enthusiastic both for the game-based approach and for the Physics content discussed.

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