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Resources for Education and Outreach Activities: Discussion Session

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Over the past few years a variety of resources have been developed, by individuals and groups, to support Education & Outreach activities in particle physics. Following short (five-minute) presentations by six speakers, a discussion session allowed the audience to go further in depth in activities they found particularly interesting. This paper presents brief overviews from each of the six speakers, followed by a summary of the ensuing discussion.

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1. Introduction to the Discussion Session

The variety of resources that have been developed for Education & Outreach purposes in the field of High Energy Physics has increased dramatically over the past decade. Dedicated web-sites, databases and European-Union funded projects have facilitated the storage and dissemination of many of these resources. Activities include the use of HEP-inspired art to attract and interest audiences, to the use of real LHC data for hands-on enquiry-based learning activities and full teaching programs for graduates.

Six experienced, active and enthusiastic speakers gave five-minute presentations on particular resources for E&O activities.

Michael Kobel has led several education projects, both within his native Germany and also internationally. Since 2005 he has been project leader for IPPOG's International Masterclasses, bringing LHC data into the hands of high school students.

Ivan Melo, IPPOG representative for Slovakia, has been involved in International Masterclasses since 2005 and has organized many follow-up "Cascade" competitions for high school students in Slovakia.

Angelos Alexopoulos has helped manage several EU outreach projects and joined the CMS experiment communications group in 2014, where he designs and implements E&O programmes, including art@CMS.

Christine Kourkoumelis has been active in HEP E&O for more than 25 years, coordinating several European Union outreach projects that produced and made available many resources for explaining/teaching HEP to a variety of audiences.

Camila Rangel Smith co-founded the CEVALE2VE virtual research and learning community that contributes to the scientific dissemination of fundamental physics and generation of new researchers in Venezuela.

Claire Adam Bourdarios began her E&O activities, like many, by becoming a guide for public visits to CERN. Building on "fun" activities from CERN open days, Claire is presently the co-coordinator of the ATLAS experiment's E&O group.

The wealth of information, ideas and tools, coupled with the accessibility of LHC data (and those from other experiments), makes designing your own E&O project easier than ever. The talks were followed by a lively discussion session, during which the audience had the opportunity to go further into depth and get inspired to realise their own activities. This paper is divided into a further seven sections, covering the six topics presented and a summary of the ensuing discussion.

2. IPPOG: Experts in bringing new discoveries to the public (Michael Kobel)

2.1 Abstract

IPPOG (the International Particle Physics Outreach Group) is a network of particle physicists and communicators with contacts all across Europe and beyond. In the last 10 years members of IPPOG have developed a wealth of tools which enable the public and especially young high school students from an age of 16 years onwards to perform their own data analysis on real scientific data

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from the LHC. In addition IPPOG is also instrumental in fostering other innovative methods for providing the public with access to cutting edge research of particle physics as well as astroparticle physics. Several programs for high school students and teachers are organized by members of IPPOG, aiming at sharing the excitement of particle and astroparticle physics research. IPPOG together with related networks like the teacher program QuarkNet in U.S., and the Netzwerk Teilchenwelt in Germany have successfully solved three related challenges: 1) What is needed to prepare research data in a way that young people grasp the aims and methods of research? 2) What is needed to follow in (nearly) real time the progress of scientific research? 3) How can one-day efforts like International Masterclasses or International Cosmic Days be complemented by sustainable context material, like the IPPOG resources database, the QuarkNet e-lab, or the school-tailored material resort of Netzwerk Teilchenwelt?

2.2 Overview of IPPOG Activities

The unique mix of scientists, educators (both formal and informal) and explainers that constitute the International Particle Physics Outreach Group (IPPOG [1]) has enabled the group to develop many tools and activities aimed at education and outreach in particle physics. These tools/activities range from multilingual brochures and fact sheets, to complete one-day hands-on analysis of LHC data - the International Masterclasses [2, 3]. All items developed by IPPOG (as well as many others) are available for anyone to use, contribute-to and improve, through a web-interface to an extensive database [4].

2.3 Challenges to authentic HEP Education activities, and Solutions found

In this context, IPPOG faced and successfully solved three challenges: 1) What is needed to prepare research data in a way that young people grasp the aims and methods of research? 2) What is needed to follow in (nearly) real time the progress of scientific research? 3) How can one-day efforts like international masterclasses or international cosmic days be complemented by sustainable context material?

The key aspect to the first question is authenticity: In all of its supported programs, IPPOG offers “hands-on” activities with use of real scientific data, applying original methods and tools. These have been simplified for students and the public, but still reflect the real scientific methods. Other important aspects are the statistical interpretation and the comparison of measurement results to theoretical predictions, making the scientific process transparent. If possible, live discussions with active scientists in person or via video connections are rounding up the authentic experience and letting the public feel as scientists for a day.

In order to follow in (nearly) real time the progress of scientific research, on the one hand a well organized network of scientists, formal and informal science educators and explainers is needed to identify suitable topics for updating and amending the existing packages. On the other hand, the scientific experiments have to give public access to at least a part of their data shortly after they have been collected. This need has been acknowledged by most particle and astroparticle experiments, and is e.g. reflected in CERN’s new Open Data Portal [5] or DESY’s forthcoming Cosmic@Web interface.

Last, but not least, one-day events, organized by scientists and “outreachers” would only have limited impact without sustainable long-term context material or activities, that can be employed

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Figure 1: High school students working on ATLAS data together with a PhD student

Figure 2: Teachers and scientists developing context and teaching material at a workshop from the German “Netzwerk Teilchenwelt”

at any time by teachers or by the interested public without the need of scientists’ support or presence. For all target and age groups IPPOG has collected a wealth of such material in an extensive and growing resources database [4]. Moreover, national networks between scientists and teachers and/or students have provided a variety of long-term sustainable formats of engagement. They range from teachers joining the research community at 52 US “QuarkNet” centers [6] over the CMS e-lab [7], a student-led, teacher guided online project for the classroom, to the broad spectrum of offers from the German “Netzwerk Teilchenwelt” [8] - see Figure 2. This network offers long-term involvement for students and teaching in a 4-level program from masterclasses to research and is developing in close collaboration with teachers and didactic experts a rich spectrum of context and teaching material, collected at [9] and at Germany’s largest school portal [10].

2.4 Acknowledgements

I would like to thank my colleagues in IPPOG and Netzwerk Teilchenwelt (BMBF grant no. 05E13ODA) for the remarkable efforts they have made in the past decade to provide resources and activities for particle physics E&O worldwide.

3. Cascade projects competition - a way to build on Masterclass success (Ivan Melo)

3.1 Abstract

Cascade projects is a popular competition for high school teams of 3-6 students. The teams with help from physicists work on projects from particle physics for several weeks and prepare 20 min presentations which they deliver in their schools. They send videos of their talks to the jury which selects the best teams.

3.2 Overview of Cascade Projects

Each year, the International Particle Physics Masterclasses (MC) [2, 3], organized by the International Particle Physics Outreach Group [1], draw 10 000 high school students from more than 40 countries to understanding the smallest building blocks of the Universe. Students come to a nearby university for a full day programme which includes lectures from experts about elementary particles, measurements on real experimental data from LHC and a final video-conference which brings together students from three to five universities from different countries and physicists at CERN to discuss the measurements and the results the students achieved. One of the highlights is the search for Higgs bosons. Masterclasses are very successful in motivating high school students. "Cascade Projects" build upon this success by offering more in-depth opportunities for those students who would like to understand more about particle physics. The format was developed at the University of Birmingham [11].

In the Cascade competition teams of 3 - 6 high school students work for several weeks on projects on topics from particle physics and cosmology. The teams are helped by mentors (volunteers from the high energy physics community who respond to the questions from the teams by e-mail) and their teachers. When the projects are completed, the teams make 20 minute presentations in front of their classmates in their schools and then send videos of their presentations plus Powerpoint files to organizers. The jury selects the best teams and either declares winners (if the Final is not organized) or invites them to the Grand Final. In the Grand Final the qualified teams start from zero with the jury now present and ready to both praise students and advise them how they could improve their work. The best team wins, for example, a trip to CERN.

The Cascade projects typically include multiple topics (students can also come up with their own topics, which the organizers have to approve):

- What are we all made of ? Atoms, Quarks, ... ?
- Particle Accelerators - How do they work?
- Medical Applications of Particle Accelerators
- Recreating the Early Universe at the LHC
- Antimatter
- Dark matter
- Quantum nature of elementary particles
- Neutrinos
- Are there more than 3 spatial dimensions?
- Search for new particles
- History of the Universe

3.3 Cascade Projects in Slovakia, as an example

In Slovakia, after many vain attempts to engage students through lectures and research projects, we started Cascade projects [12] in 2009 with four teams and it was an immediate success. The number of participating teams quickly rose and stabilized at 15-20 teams/year. We take advantage of annual International Masterclasses to advertize the projects. Three-member teams are typically mixed (boys and girls) with an overall average female participation at 40%. Students have typically four to five weeks to work on the projects. They have an opportunity to consult their mentor if they wish. Most teams exchanged a few emails with mentors, some did not contact the mentor at all. Figure 3 shows one of the teams in the Grand Final in Slovakia.

Figure 3: One of the teams in the Grand Final of the Cascade Competition in Slovakia

Given the limited time the students had, the quality of presentations was satisfactory. Some of them were very good and funny at the same time. On the other hand, many teams tried to cover too many things which inevitably led to errors. The lesson we try to teach them is that 'less is often more'. One of the winning teams, e.g., did not cover too much material but they were thorough and honest in each concept they introduced and at the same time they managed to be original and funny. 'We enjoyed it all the way', they said and so did the audience. The most positive factor of the competition is in my opinion motivation. The students are very keen to be our ambassadors in their schools and among their friends. In this way they cascade down our own enthusiasm for physics.

3.4 Conclusion

To conclude, the Cascade format is very successful. Students enjoy working in teams and presenting their projects. They enhance their own knowledge and communication skills and get enthusiastic about physics. International Masterclasses are a good springboard for Cascade. Most teams are formed from International Masterclass participants. The competition is relatively easy to organize. The first round (presentations at schools) does not require presence of the organizers nor the judges. The best Cascade projects have the qualities we had hoped for. Solid scientific content and fresh, entertaining presentations which are fun to watch. Team members are often interested in pursuing scientific career.

4. art@CMS: Connecting Science and Society through Creative Education and Outreach (Angelos Alexopoulos)

4.1 Abstract

Although significant investments have been made over the last two decades to introduce innovative approaches to science education, recent studies demonstrate that approaches based solely on inquiry and problem solving methods have a relatively low degree of adoption in school settings. In response to this, recent years have seen the emergence of a movement that seeks to encourage the public and especially young people to discover new ways to look at and understand how science works with the support of creative and artistic interventions. The so-called STEAM movement, as reflected in various national and international initiatives on both sides of the Atlantic, calls for arts integration into science teaching and learning as a catalyst for developing creative skills that are necessary to thrive in an innovation economy. One example of such initiatives is art@CMS, an education and outreach programme of the CMS Experiment at CERN. Situated within the STEAM movement, art@CMS is a dynamic international network of collaborations involving scientists, artists, students and educators, aimed at engaging the public and especially young people with scientific research in particle physics. Through interdisciplinary workshops and art exhibitions, this programme has so far helped 100,000 people, including hundreds of school students, in 12 countries to gain a better understanding of how science works and how the public can engage with it.

4.2 Towards a Creative Education and Outreach Agenda

In a recent OECD report on the impact of large research infrastructures on economic innovation and on society [13], the European Organization for Nuclear Research (CERN) is illustrated to act as an incubator for innovative ideas and projects with significant societal externalities without compromising its emphasis on fundamental research and discovery. Notable examples of those ideas and projects include the invention of the World Wide Web and more recently the development of hadron cancer therapy. According to the same report, the capacity of CERN to enable such innovations is related, among other factors, to its unique institutional culture that provides space and support for open knowledge exchange and new ideas generation. Education and outreach activities are key to this process. A recent study evaluating for the first time the socio-economic impact of the Large Hadron Collider (LHC) [14], indicates that a non-negligible portion of that impact stems from cultural benefits that, in turn, are related to education and outreach activities carried out by the LHC and its associated experiments. Specifically, the mean net present value (NPV) of the cultural benefits was estimated in this study to exceed 2 billion euros throughout the duration of the LHC project. Notably, this was almost ten times higher than the mean NPV of the knowledge output, with the latter measured by the number and impact of scientific publications signed by LHC scientists.

Following from the above, it can be argued that, especially under the current climate of economic uncertainty where government funding is under strain in many countries, large research

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infrastructures, including CERN, should not only maintain but enhance their positive societal externalities by infusing creativity into their education and outreach activities. In doing so, they can act as incubators for projects and ideas that could enable today's and tomorrow's citizens to engage further in the research and innovation process, to make evidence-based decisions, and thus to participate actively and responsibly in an open, knowledge-driven society.

4.3 art@CMS: Connecting Science and Society through the Arts

In addition to CERN's well-established and highly impactful education and outreach programme, the last few years have seen the development of several bottom up initiatives by the LHC experiments and the CERN community at large. From "colliding physics and music" [15] to "hackathons" [16] , these initiatives, to name but a few, employ a range of creative methods to engage the public and especially young people not only with the excitement of scientific research in particle physics but also with its positive societal externalities.

Being part of this creative movement, the Compact Muon Solenoid (CMS) experiment at CERN has developed over the last three years an education and outreach programme, entitled art@CMS [17],[18]. The principal aim of this programme is to act as a springboard for engagement with science, engineering and technology through the development of creative and participatory experiences for the public, especially aimed at young people. art@CMS can be viewed as a dynamic, international network that promotes multidisciplinary collaboration by bringing together scientists, artists, students and educators from around the world under a common goal: to demonstrate not only the inherent beauty and aesthetic value of science but also to raise awareness and understanding about its direct relevance to the needs and expectations of the 21st century learners. This goal is achieved through two complementary modules: exhibitions for the public, and workshops for students and teachers. art@CMS exhibitions are the outcome of collaboration between professional artists, art institutes, scientists and CMS institutes and act as catalysts for promoting public interest in and understanding of how science works at CMS and the LHC. Almost 110,000 people have so far visited more than 30 art@CMS exhibitions organised in 21 cities across 13 countries on both sides of the Atlantic. The exhibitions are often combined with LHC-related events such as public talks, conferences and science cafés with the active participation of local communities. As such, they serve as open forums for public dialogue and debate on the importance of science and its connection to society. An example of CMS-based artwork created by high-school students is shown in Figure 4.

The second component of art@CMS focuses on the design and implementation of workshops for students and educators at secondary and tertiary level. Interdisciplinary and flexible in their nature, those workshops extend beyond the development of Science, Technology, Engineering and Mathematics (STEMS) skills by offering aesthetic learning experiences that are considered to increase deep student engagement with science [19],[20]. art@CMS has so far implemented ten workshops in six countries with the participation of more than 300 students. The outcomes of those workshops, namely artworks employing different media, are incorporated in the standard art@CMS exhibitions, thereby serving as sources of motivation and inspiration for other young people from around the world.

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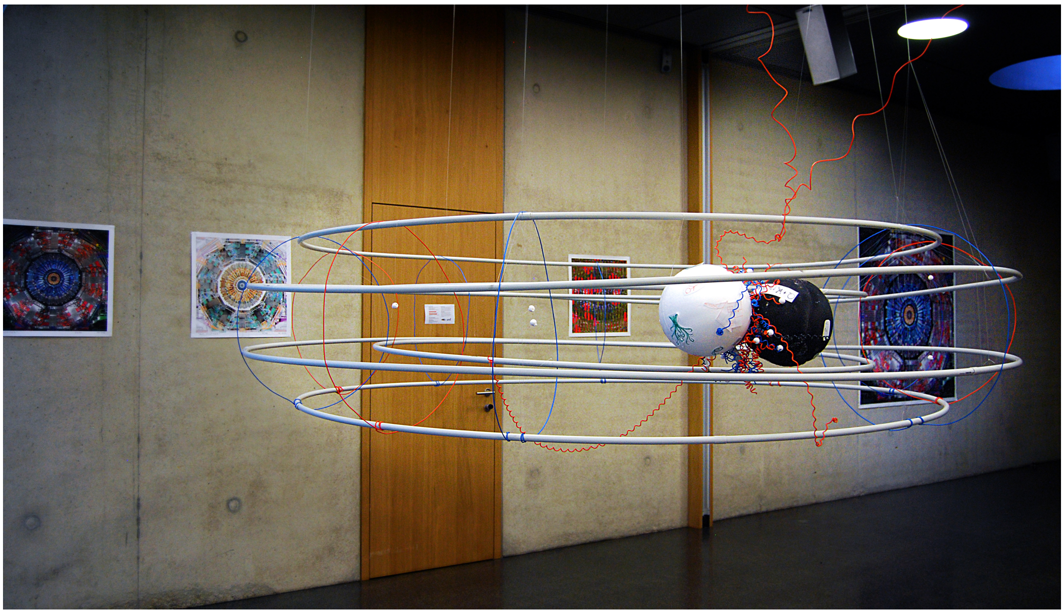

Figure 4: The "Incredible Science-Art Collider", an artwork by high-school students of BORG and GIBS who took part in art@CMS' inaugural science and art workshop in Graz, Austria (image credit: Michael Hoch)

4.4 Future Directions for art@CMS

The art@CMS programme has clearly moved beyond its nascent stage of development and has begun to receive the recognition by an increasing number of institutes, artists and educational communities across Europe and beyond. An important milestone for the programme has been the award of an EU grant in the framework of the Horizon 2020 programme. This will enable art@CMS not only to scale up its activities but also to develop them further in close collaboration with experienced partners in science education research and practice across Europe. Importantly, the participation of art@CMS in the CREATIONS EU project will provide ample opportunities for the systematic and objective evaluation of its activities by thousands of students and teachers, leading to its further improvement and growth.

4.5 Acknowledgements

I would like to thank the CMS Collaboration and my colleagues on the art@CMS project: Michael Hoch (Austrian Academy of Sciences), Achille Petrilli (CERN) and Mick Storr (CERN/University of Birmingham).

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5. Involving students in HEP research with the help of the “Go-lab” and “Inspiring Science Education” European outreach projects (Christine Kourkoumelis)

5.1 Abstract

The Inspiring Science Education and Go-lab outreach projects (funded by the European Commission) have been running for about two years. Their goal is the promotion of science education in schools through new methods built on the inquiry based education techniques and involving large consortia of European partners. The authors of this contribution have experimented for several years in finding ways to introduce High Energy Physics (HEP) in schools. They have found that the most effective way is a combination of lectures, virtual tours to specific experiments and hands-on experience. This combination has taken the form of the so called “mini masterclass” which is a half-day workshop, taking place locally at interested schools. Recent hands-on activities as well as the development and testing of the above mentioned innovative applications are reviewed in this report.

5.2 Introduction

The European Union (EU) has long recognized the decreasing interest of young people in science education (STEM subjects). An effective way to stimulate the interest and enthusiasm of the students is to share exciting top-level research and discoveries with them. Therefore, the EU has been supporting and promoting outreach projects which bridge the gap between school science education and pioneering research. The projects have been creating and testing resources which most efficiently get the students involved in real time research through hands-on activities. The authors have been involved in several such projects. Some of them are already completed: “Learning with ATLAS@CERN” (2009-2011) [21], “PATHWAY to Inquiry Based Science Education” [22] and “Discover the COSMOS” (2010-2012) [23]. There are two ongoing projects (Go-lab and ISE), which will be discussed in the next section. A new approved project called CREATIONS will be launched in October 2015. The completed projects have already created a plethora of resources classified according to subject (keywords), age, difficulty, duration and language. Most of them can be found in the Discover the COSMOS portal, which contains about 95,000 science education learning objects and activities connected to the science curriculum from Astronomy, Space Physics and HEP. All projects follow the Inquiry Based pedagogical framework. The students are encouraged to learn by making an hypothesis, performing an interactive investigation to verify the hypothesis and drawing conclusions by themselves, which are then discussed in the class.

5.3 The Go-lab and ISE projects and their resources

The Go-lab project is well into its third year, out of its four year duration. The consortium has 19 partners in 15 European countries. Its main goal is to create a federation of online labs for large scale use in science education. It is addressed to students, teachers and lab-owners. The collection of labs can be found in its portal [24]. The created repository includes remote and virtual labs as well as analysis tools and datasets in all STEM curricula subjects and in 10 languages. They are scaffolded in an easily searchable way based on subject, language, age, degree of difficulty, duration etc. Presently there are about 160 online labs. Moreover, the repository contains about 150 so called “Inquiry Learning Spaces” (ILSs) which are structured according to the following four phases of the inquiry learning approach: Orientation, Conceptualization, Investigation, Conclusion and Discussion. Furthermore, within each phase, scaffolding tools (such as the HYPATIA tool) are embedded in order to support the students’ interactive activities. Lastly, the portal contains about 30 so-called “apps”, which are tools or widgets (software applications) that support specific learning or teaching goals and tasks in online labs.

The Inspiring Science Education (ISE) project [25] began in April 2013 and will last until July 2016. The ISE partners design, plan and implement large-scale pilots to stimulate and evaluate innovative use of existing e-Learning tools and digital resources for scientific disciplines and technology, enhancing science learning in 5,000 primary and secondary schools in 14 European Countries. During its first two years of operation, the project has already reached 2,700 schools in Europe. In line with the ISE’s inquiry learning framework, the partners have been designing the so called ISE Demonstrators which are a series of success stories making effective use of a wide range of e-Learning tools and applications. Each demonstrator is a complete lesson plan structured in several phases: Orienting and Asking Questions, Hypothesis Generation and Design, Planning and Investigation, Analysis and Interpretation, Conclusion and Evaluation. In order to evaluate their benefits and effectiveness each phase of the demonstrator is accompanied by assessment questions (adopted according to the PISA 2012 Problem Solving Competence Framework) in order to measure the impact of its efficiency and effectiveness. Currently there are 120 Demonstrators in all STEM curricula subjects. In addition to the demonstrators, ISE has harvested existing repositories with 278,000 educational resources (mainly from Open Discovery Space and Discover the COSMOS).

Both projects take advantage of the access to unique facilities -offered through the partners- that exist only in very few, or even one, place such as the LHC at CERN, the IceCube experiment at the South Pole or remotely operated telescopes, to make real time observations. The students can use those resources without having to travel to their respective locations, saving considerable time and expense. A large inventory of such resources/lesson plans are available for the teachers in order to get their students introduced to “Big Ideas of Science” and the use of cutting-edge e-Science applications without having to leave their classroom.

5.4 How to Introduce HEP to schools

The introduction of HEP to schools has been a main challenge for many years, especially for countries which do not include nuclear or particle physics in their respective curricula. Thanks to the existing resources, the success stories involve students’ engagement in hands-on experimentation, analysis of data in an interactive way from the world’s most advanced experiments and active participation “virtual visits” to the experiment’s control room. The authors of this contribution have performed about eighty “mini masterclasses” during the last four years. The students have worked mainly with data from the ATLAS experiment using scenarios based on the HYPATIA analysis tool (hypatia.iasa.gr) which has been written by two of the authors (C.K. and S.V.). Figures 5 and 6 show some of participants in hands-on activities in Greece and at CERN. They have also taken part in many International Masterclasses [2, 3] organized by IPPOG [1] in Greek universities (Athens and Crete) as well as at CERN (2013 and 2014). They have also organized remote masterclasses at CERN with Polish and Dutch students.

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Figure 5: HYPATIA Hands-on activity of high school students in Argos, Peloponese

Figure 6: Greek students at CERN analysing real CMS data using the web-based event display software “iSpy online” [26]

Many hundreds of Greek students got acquainted with the top level research of CERN, and grew a real enthusiasm for it. The number of Greek school visits to CERN has increased by 50% within two years. Through these initiatives students and teachers jointly have expanded their learning horizons.

5.5 Acknowledgements

I would like to thank my colleagues at the University of Athens, who co-authored this paper: Stylianos Vourakis and Georgios Vasileiadis.

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6. Virtual Research and Learning Communities in Latin America: the CEVALE2VE case (Camila Rangel Smith)

6.1 Abstract

A virtual research and learning community can be a powerful educational environment. It has a wide range of possibilities for multi-institutional participation such as synchronous and asynchronous online engagement, decentralised student discussions and academic networking, as well as being cost effective. In this context the CEVALE2VE virtual community is a Venezuelan initiative for grooming new researchers in high-energy physics. Its goal is to contribute to the scientific dissemination of fundamental physics and the regional modernisation of university education. The members of CEVALE2VE are a sizeable group of Venezuelan researchers currently involved in projects related to this field, and located in different academic institutions of Europe and North America. The project involves several Venezuelan and Colombian academic institutions in order to reach a wide audience, and exploits current information and communications technologies (ICT) where data, software tools and information resources are shared. Several activities have been hosted

by CEVALE2VE including a series of public lectures, ATLAS virtual visits, supervision of masters theses but mainly the implementation of the virtual course “Introduction to Particle Physics” for undergraduate students. The use of ICT technologies to share material and interact with students creates a vibrant and participatory learning environment.

6.2 Introduction

The Centro de Altos Estudios de Altas Energías (CEVALE2VE) [27] is a virtual research and learning community created to steer the new generation of Venezuelan researchers in high-energy physics (HEP). It also attempts to contribute to the scientific dissemination of fundamental physics and the regional modernisation of university education; we strongly believe that the promotion of scientific communities in Latin America will lead to sustainable knowledge-based development. The project organisation involves several academic institutions in Venezuela and Colombia in order to reach a wide regional audience.

Although geographically scattered in different academic institutions of Europe and North America, CEVALE2VE integrates a group Venezuelan researchers currently involved in projects related to the Large Hadron Collider (LHC) of the European Organisation for Nuclear Research (CERN). Its main goal is to stimulate and widen Venezuelan physics postgraduate education and research, the first step of which has been the implementation of the virtual community course “Introduction to Particle Physics”. The opening edition of this course was carried out during the semester September 2014 – February 2015.

Moreover, this course was officially included in the postgraduate course portfolios of three public universities and research institutions, namely Universidad Central de Venezuela (UCV), Universidad Simón Bolívar (USB) and the Instituto Venezolano de Investigaciones Científicas (IVIC), and informally followed by several students from Universidad de Carabobo (UC), Universidad del Zulia (LUZ), Universidad de los Andes (ULA) and Universidad Industrial de Santander (UIS). This endeavour complied with new guidelines regarding higher education in a network society and was perhaps new to some universities in developing countries. We are therefore motivated to present here a concise description of this experience in order to help future regional efforts.

6.3 Postgraduate course in particle physics

6.3.1 Induction lectures

In order to promote the course — namely its content, scope and online methodology — three virtual induction lectures were given well in advance (the first fortnight of June 2014), and they were attended by both faculty and postgraduate students from IVIC, UCV, ULA, UIS and USB. This exercise led to extensive discussions on the course academic level, student interests and demands and general methodology (e.g. homework and evaluations), but also about the minimum requirements of the ICT infrastructure which in Venezuela can be fragile and restrictive. Figures 7 and 8 show some of the participants and activities of one virtual session.

6.3.2 Course methodology

The course goal was to provide students with an overview of the concepts and methods used in contemporary particle physics research. This overview included a review of the theory of the

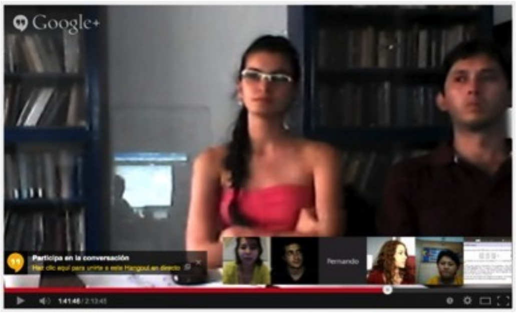

Figure 7: Remote participants to a virtual CEVALE2VE education session

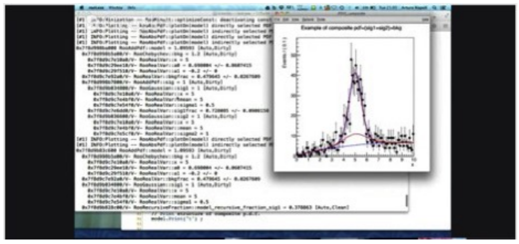

Figure 8: Learning how to reconstruct particle masses with real data

standard model and its possible extensions, a description of the sophisticated experimental instrumentation (e.g. detectors, beams and magnetic devices) and the main techniques for big-data analysis. Finally, in order to complement the topics covered during the formal lectures, a series of seminars by distinguished invited speakers was organised.

The course was divided into five topical modules involving specific instructors that delivered lectures, organised homework and supervised student progress. These modules were the following.

1. Introduction to particle physics (10 hours). Instructors: H. Martínez (Pavia U.[1]) and D. Paredes (Aristotle Thessaloniki U.)

2. Accelerator beams (6 hours). Instructor: J. Montaño (CERN).

3. Particle and radiation detectors (16 hours). Instructors: R. Camacho (Chicago U.), J. Manjarrés (York U.), L. Pérez (CNRS) and H. Torres (Simon Fraiser U.)

4. Concepts and computer tools in data analysis (12 hours). Instructors: C. Rangel (Uppsala U.) and A. Sánchez (Naples U.)

5. Seminars on HEP results and applications (12 hours). Seminars by J. Ocariz (LPNHE-IN2P3), B. Millán (Booking.com), D. Milanés, (U. Nacional de Colombia), M. Sánchez, (Iowa State U.), S. Mattei (CERN) and B. González (U. of Michigan).

6.3.3 ICT platform

Lectures were given by means of video-conferences, and the slide presentations became immediately available for downloading after each two-hour class, together with a full video recording uploaded to a dedicated YouTube channel [28]. For course management, the platform used for lectures and discussions was Google Hangouts [29], and the Moodle online platform [30] at UCV and the CEVALE2VE web page [27] for off-line discussions, homework submission and general announcements.

6.3.4 Evaluation

Course evaluation was twofold.

[1]University

1. Four sets of homework submitted via the Internet covering the topics discussed in each module.
2. A final evaluation which consisted of a small project chosen by students from a predefined list, where inter-institutional collaboration was encouraged. Student progress was guided by a tutor for a period of one month, at the end of which results were presented by the students to the plenary virtual group.

6.4 Concluding remarks

The first attempt of an online particle physics course in Venezuelan universities was successfully completed, and the students that participated in the course were given an online evaluation survey. The overall results of the experience were indeed very positive for all participants, i.e. for both instructors and students. An improved version of this virtual course will be offered again in Venezuelan and Colombian universities in the spring semester of 2016, and is expected to be continued every year.

6.5 Acknowledgements

I would like to thank my colleagues in the CEVALE2VE project: Reina Camacho (Chicago University), Joany Manjarrés (York University), Homero Martínez (Pavia University), Claudio Mendoza (Instituto Venezolano de Investigaciones Científicas), Bárbara Millán (Booking.com), Luis Alberto Núñez (Universidad Industrial de Santander), Daniela Paredes (Yale University), Luis Alejandro Pérez (Institut Pluridisciplinaire Hubert Curien - CNRS), Arturo Sánchez (Federico II Napoles University) and Heberth Torres (Simon Fraiser University).

7. Education & Outreach through Building Blocks (Claire Adam Bourdarios)

7.1 Abstract

Hands-on activities are always appealing, especially (but not exclusively) for younger audiences. One such activity is to use building blocks to engage the audience in creating something for themselves, to get a deeper understanding and appreciation of a piece of hardware or even a physics concept. The ATLAS and CMS collaborations have, over the past few years through the dedication of a few individuals, developed a couple of activities that have proven to be very popular and relatively easy to setup.

7.2 Using LEGO® for E&O Activities

Using LEGO® pieces to build models of a particle physics experiments, such as the ATLAS detector, has proven to be a perfect means to grasp people's attention and still be able to convey all the necessary details of such experiments to make it a valuable tool in explaining the detectors as well as the physics. The large ATLAS LEGO model has been a huge success and is used for outreach activities at 57 institutes in 16 countries worldwide. In the same way, it has been shown that inviting smaller groups of students to build detector models in LEGO® pieces as part of an intense outreach event or calling a broader audience to take part in competitions to build their own

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ideas of a "particle detector" in LEGO® pieces creates a unique setting to convey knowledge in particle physics to them, as shown in Figure 9. The "Build Your Own Particle Detector" [31] program is looking forward to many more events, creative and fun ideas of people taking part in the competitions, new means of using the detector LEGO models in outreach and chances to get people interested in and fascinated by particle physics.

7.3 An example of the use of Kapla® for E&O Activities

Another communication medium that has been tested during the public events at the CMS Experiment are KAPLA® wooden blocks [32]. Workshops oriented towards reconstructing parts of the CMS detector using KAPLA® were organized at CERN Open Days (September 2013) and CERN Neighborhood event (May 2014) and have proven to be very successful, especially for young audiences. Kids and their parents were invited to look at photos of the detector and then try to reconstruct them on their own using wooden blocks - see Figure 10. This activity was a perfect addition to the underground visit for the parents, who saw the CMS detector and could use the bricks to explain to their kids what the detector is like in a fun and educational way. Moreover, since the Kapla® constructions were quite spacious, they needed to work in groups, which reflected the collaboration aspect of the CMS experiment and the fact that to build a large machine such as CMS, scientists need to work together. In the souvenirs' cards collected from visitors during the events, some kids declared they enjoyed the fact they "built the detector". This confirms that KAPLA® workshops were an efficient way to reach the young audience by keeping them amused and focused on the subject.

Figure 9: Science night in Garching (DE) on June 2015

Figure 10: Children building the CMS detector with Kapla®

7.4 Acknowledgements

I would like to thank my colleagues who developed these activities: Marzena Lapka (CERN) from the CMS experiment, and Sascha Mehlhase (LMU München) from the ATLAS experiment.

8. Summary of the Discussion Session

Following short (3-5 minute) presentations, the floor was opened for questions and discussion, moderated by Dave Barney and Uta Bilow (session chairs). This lasted about an hour, during which time each of the panelists had the opportunity to respond to questions and go further into depth in parts of their work that the audience found particularly interesting. The following is the recollection of some of the discussions that were more general.

8.1 Use of Online Tools

The popularity of “online tools” for education purposes is growing significantly, particularly in developing countries. The panel was asked if the use of tools such as “Coursera” [33] and “iTunesU” [34] had been attempted and, if so, what their experiences and thoughts were. Several of the panel, and other audience members, had some little experience with such tools and a number of online courses in particle physics already exist. The completion rate for such courses is thought to be very low, less than one percent. It was felt by most people that part of the reason for this is that they lack the “personal touch”, which in itself is a powerful tool when talking to students, the public and other audiences. Indeed several surveys of visitors to CERN have shown that the most interesting part of the visit is the interaction with real physicists. Camila Rangel-Smith mentioned that the Venezuelan courses offered within the CEVALE2VE project involved almost-daily contact with participants.

8.2 Improving interactions with High-School Teachers

It was stated that a significant fraction of high-school teachers are reluctant to introduce topics that they are not familiar with as they would not be able to answer questions: it perhaps challenges their authority in the classroom. In contrast, researchers are comfortable with “not knowing the answer”; answering such questions is “what we do”! Those teachers that come to CERN are treated as “colleagues”, building bridges. Unfortunately, only a few teachers can join the CERN teachers programs. But there are several cost-effective alternatives to bringing teachers to CERN or other large laboratories. For example, some post-docs etc. make an effort to visit remote locations (examples given of Greece and the UK) to have personal contact, Q&A sessions and perform hands-on “mini masterclasses”, analysing real LHC data. Virtual visits, including Q&A sessions, are cheap, easy and effective ways to supplement school classes and support teachers.

8.3 Initiatives to address the gender imbalance in HEP

There are various initiatives, driven by individuals and groups, to understand and address the gender imbalance in HEP and other sciences. For example, Kayleigh Lampard (University of Warwick), a poster-presenter at EPS, talked about the “Xmas” project, funded by the UK Science and Technology Facilities Council, is aimed at bringing female high-school students to reasearch facilities in the UK and the synchrotron facility in Grenoble. Although a relatively new initiative, the feedback from the girls has been very positive. Kate Shaw (ICTP Trieste), another EPS presenter and winner of the 2015 EPS E&O Prize, talked about some of her work in the Middle East, where there is also a gender imbalance but in the opposite direction to most of Europe - 80% female! Ivan Melo commented that the Masterclass and Cascade projects attracted nearly a 50:50 male:female ratio, possibly because of the intrinsic hands-on nature of these activities being more appealing than theory and lectures.

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8.4 What Masterclass follow-up activities were not successful?

Ivan Melo commented that lectures, seminars and classical research projects received little interest. The hands-on competitive nature of Cascade projects is far more appealing. Indeed other talks in the E&O session provided further evidence that competition-based activities are very attractive, not only to scientific audiences but to people from other disciplines as well as the public in general. Ivan also commented that the engagement directly with students in Cascade projects receives excellent feedback, and takes the already-interested students to a far higher level than Masterclasses.

8.5 The use of art to publicize and interest people in science is growing

The audience acknowledged that art-based education and outreach activities such as **art@cms** are proving to be an effective means for informing a newer and more diverse public to how science works at large research infrastructures. The development of science and art workshops for students was considered to be particularly useful for inspiring and encouraging young people to take a wider interest in science, physics and particle physics. As with all E&O activities, feedback and independent evaluation would help tune the activities and make them even more effective. It was also suggested that follow-up activities, such as dedicated web-sites, could take the audiences deeper into the science after they have been attracted by the art.

8.6 "Presentations at the E&O session were high quality. How did we learn how to do this?"

It was stated repeatedly throughout the E&O session at EPS that taking part in E&O activities is not purely for the benefit of the various audiences, but is particularly beneficial to the people making these activities. Describing our work in simple but correct terms is crucial for other types of presentation, such as talks to peers at international conferences or just in working meetings at host institutes. Being able to get the key messages across, to peers, students, the public or policy makers, is not easy. People participating in E&O activities often undergo specific training, for example in how to talk to the media, that are beneficial in the day-to-day work of a particle physicist. E&O practitioners also often search for easier - but correct - methods of describing things, perhaps using images or animations in place of large amounts of text.

The discussion session itself also showed that a large amount of useful information can be carried in a very short presentation, of just a few minutes duration. This concept was carried-through in a separate activity - a "Physics Slam", whereby attendees to the EPS conference presented their own work in five minutes or less, with a maximum of three slides. Challenging subjects, such as CP-violation and particle tracking were tackled by enthusiastic young physicists. Experienced "outreachers" were on hand to help tailor the messages and slides, following the mantra "less is more". The overwhelming reaction was that the young physicists succeeded in their goals and the presentations were really excellent.

Other parts of the E&O session demonstrated that the "standard" presentation method of physicists - Powerpoint®slides with many bullet points - is not the only way. The tool "Prezi" was used to excellent effect by one speaker; another had very bare slides, with just a single key message and a supporting image; and another had essentially no slides at all!

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So although E&O activities are, on the surface, aimed at public audiences, the people who perhaps benefit the most are the practitioners, for their everyday lives as physicists.

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